BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

Beak Consultants Limited - Hat Creek Project - Detailed Environmental Studies - Fisheries and Benthos Study - March 1978

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Beak Consultants Limited

Montreal
Toronto
Calgary
Vancouver

Suite 602/1550 Alberni Street
Vancouver/British Columbia
Canada/V6G 1A5
Telephone (604) 684-8361
Telex 04-508736

beak
Environmental Specialists

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HAT CREEK
FISHERIES AND BENTHOS STUDY

A Report for:
B.C. HYDRO AND POWER AUTHORITY
Vancouver, B.C.

Prepared by:
BEAK CONSULTANTS LIMITED
Vancouver, B.C.

A MEMBER OF THE SANDWELL GROUP

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1.0 SUMMARY

The Hat Creek Valley is located on the Interior plateau of British Columbia within which the Fraser and Thompson Rivers are the major drainage systems. By considering the existing environmental setting on a regional, offsite and local basis, the environmental impacts associated with the construction, operation and decommissioning of a thermal power generating plant in Hat Creek Valley have been assessed. Specific reference has been addressed to impact assessment within the local geographical context: Hat Creek Valley.

The conclusions of the study regarding the local environmental setting at the present time and in the future with no project development are unitary. Hat Creek was found to be a system of stable aquatic communities. Rainbow trout were the dominant fish species found. Mountain whitefish were present in the creek's lower reaches, as were bridgelip sucker, longnose dace, leopard dace and redside shiner. The rainbow trout in Hat Creek numbered approximately 20,000 with one-third to one-half occurring in the lower reaches.

Approximately 25% of the rainbow trout were longer than 150 mm. Densities in this size class were higher in the upper reaches of Hat Creek and rainbow trout longer than 250 mm or older than six years were uncommon throughout the system. The trout probably spawn throughout Hat Creek between mid-June and late July with fry emerging in late July through September. It is possible that the lower reaches are utilized as spawning ground by rainbow trout migrating upstream from the Bonaparte River. Further upstream movements are probably limited by natural barriers. The rainbow trout in Hat Creek fed primarily on aquatic insects and in general utilized these foods in the same proportion as they occurred in the natural environment.

With the development of the Hat Creek Project, the fisheries and benthic resources of the valley will be altered. An aquatic system partially integrated will become two distinct systems: Upper Hat Creek and Lower Hat Creek.

Within Upper Hat Creek the system should remain relatively unchanged. Habitat and flows will be generally as they have been in the past except for the addition of reservoir habitat. Rainbow trout will continue to be the dominant fish. Changes will be more apparent in Lower Hat Creek. Generally rainbow trout should continue to dominate fish population therein and species distribution and population will remain approximately the same. Overall habitat with regards to water quality may be degraded insofar as suspended materials will be discharged from the project areas but the levels of these materials should be such that significant alterations in the system will not occur. The quantity and pattern of flows in the lower Hat Creek System will be altered by the development. Presently, the exact nature of this alteration is not defined and hence any associated impacts are designated as ambivalent. Nevertheless, the probability of maintaining or possibly enhancing the flow characteristics with respect to fish requirements are recognized.

The major direct impact of the Hat Creek Project on the aquatic resources of Hat Creek Valley is the alienation of seven km of stream habitat resulting in the total loss of the fish populations therein. Within this alienated reach approximately 3,000 to 5,000 rainbow trout reside. Estimates of fish larger than 150 mm vary from 400 to 1,200 individuals. The loss represents a reduction of approximately 17% of the aquatic habitat of Hat Creek and 15-16% of the systems rainbow trout. The loss of this resource cannot be mitigated. Thus, procedures of compensation should be considered.

In the regional context, specific major impacts are not identified in this report. Rather, potential interactions between the project's actions and the region's resources have been characterized as ambivalent for the purposes of this report. Further environmental assessment in the regional context is provided within the air resource component of the detailed environmental studies. Notwithstanding the designation of regional impacts as ambivalent, the region has been characterized as an area containing major pacific salmon and rainbow trout resources.

2.0 INTRODUCTION

The Hat Creek Project involves the development of a 2,000 MW thermal power generating plant in the Hat Creek Valley, British Columbia. Plant energy will be provided by an open pit coal mine located in the valley. Basic offsite services to the plant and mine complex will entail an access road, a pipeline from the Thompson River and a canal to divert Hat Creek from the mine area.

The rationale for the preparation of this Fisheries and Benthos Study is to determine the baseline aquatic resources of the region such that the impact of the proposed project can be assessed. The ultimate objective of the study is to provide a description of the present environmental setting and future setting with and without project development.

In July 1976, a detailed baseline study specific to the Hat Creek Valley and the fisheries and benthic resources therein was undertaken by Beak Consultants Limited. Field activities were completed in August, 1977. During initial stages of the local study, certain information gaps became apparent regarding regional aquatic resources. A need to assess impacts associated with the provision of offsite services to the project was also recognized. In June 1977, a review of available information on the regional water and fish resources commenced. Special emphasis was placed on documenting salmon resources of the area and in recognition of this emphasis the defined regional study area was broadened to encompass the Adams Lake System. In August 1977, a field reconnaissance of the offsite development components was carried out. Detailed terms of reference for the Fisheries and Benthos Study are presented in Appendix A.

The structure of the report reflects the natural sequence with which an environmental impact assessment is carried out. First, the methodology used in the study components is introduced in the geographical context of regional, offsite, and local areas. Following this, a description of the existing environment as comprehended through the study design is provided. Given that existing environmental characteristics are thus defined, an assessment of the impacts associated with the Hat Creek Project on the fisheries and benthic resources is provided in the context of the construction, operation and decommissioning phases of the development.

3.0 STUDY METHODOLOGY

The rationale and methodological approach to the study are discussed herein. Fundamentally, the study area encompasses three interrelated geographic areas: Regional, Offsite and Local (Figure 3-1). Study methodology implemented in each area differs in recognition of the purpose to which the information is to be utilized.

The localized Hat Creek Valley study, commissioned in July 1976, entails detailed analysis of the fisheries and benthos resources therein utilizing the literature, field and laboratory methods and statistical analytic techniques.

The offsite area portion of study encompassed a field reconnaissance. On a regional basis, the study methodology was distinct and of a broader context than that undertaken locally. Published information composed the major data source with no field activities being undertaken. The basic objective of the regional component was to assess the areas of sensitivity in the regional aquatic resources. Finally, as different methodological approaches can be applied to the process of impact evaluation, an introduction to the techniques utilized for this study are included.

3.1 REGIONAL STUDY

Meteorological characteristics were a prime determinant in defining the regional study area. The central British Columbia plateau near Cache Creek is such that impacts of the development would not be expected beyond a maximum distance of approximately 100 km. Regional resources of that geographical area extending approximately 100 km north and south, 50 km west and 100 km east of Hat Creek Valley have therefore been included in studies leading to the environmental impact assessment of the proposed project. This geographical

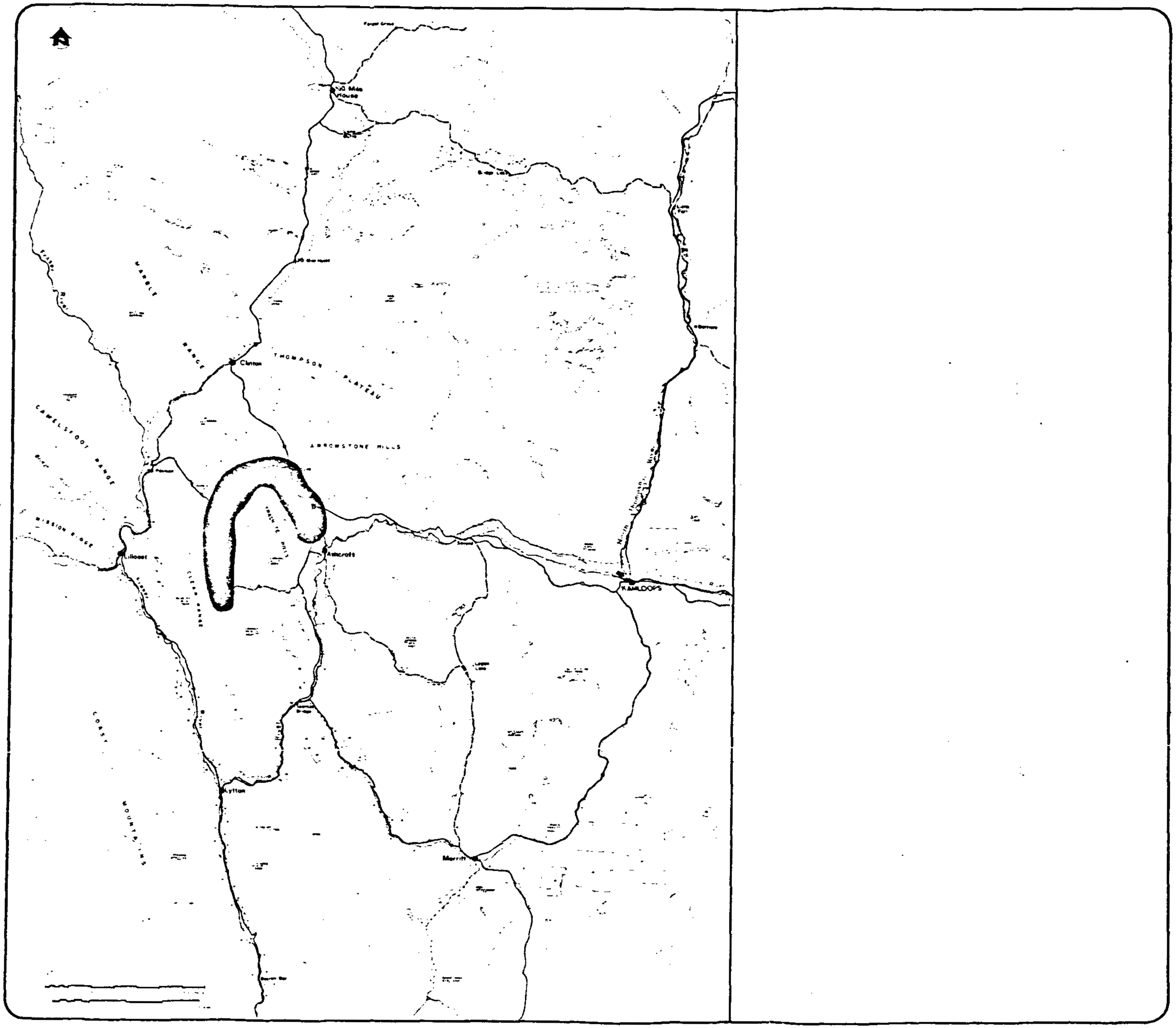

figure 3·1

OUTLINE OF STUDY AREAS

legend

REGIONAL

OFFSITE

LOCAL

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area, in addition to the Adams River system which is located 50 km further east, form the study area.

In compiling the information for the regional review, efforts were made to contact all pertinent governmental agencies, institutions, and individuals who could provide information describing the nature, extent and value of fish resources in the study area. Published and unpublished information was reviewed, and personal interviews conducted to provide as current information as possible on catch statistics, aspects of fish life histories, resource use and future possibilities of sport and commercial fish enhancement. The B.C. Fish and Wildlife Branch, Fisheries and Marine Service, and the International Pacific Salmon Fisheries Commission were major sources of information pertaining to sport, commercial and subsistance fisheries. Steelhead catch statistics taken by the commercial fishery was provided by the B.C. Marine Resources Branch. Discharge and water quality information was obtained through the B.C. Pollution Control Branch.

Field studies were not carried out during this component of the study. In addition, a comprehensive assessment of regional impacts of the project are not included herein, but rather are presented in separate reports relating to water intake on the Thompson River and regional air quality.

3.2 OFFSITE SURVEY

A field reconnaissance of the proposed plant site and station reservoir access road was conducted 22-23 September 1977 to ascertain potential aquatic concerns in areas parallelled or crossed by the proposed road. During the field survey, opportunity was taken to review the locations of the plant site and station reservoir and make observations relative to fisheries interest at Harry Lake and a small unnamed pond located west of the plant site. Access to the proposed route was gained by a 4-wheel drive vehicle along existing ranch and forestry roads. Information characterizing habitat conditions including water depth, stream width, bottom type and fish potential were noted; however, no biological sampling was undertaken. Although a ground survey was not conducted along the proposed make-up water pipeline route, sites of major stream crossings were surveyed.

3.3 HAT CREEK VALLEY STUDIES

Of the three geographical areas defined for the Fisheries and Benthos Study, the local area defined primarily as the Hat Creek Valley was studied in greatest depth. The intensive nature of the study was a direct reflection of the need for comprehensive information and analysis on the actual location of the development. Indeed, the ultimate purpose of the study is to provide a definitive assessment of the present fisheries and benthic resources of Hat Creek and thereby impart the future of the system with and without project development. Sampling stations were selected on the basis of proposed development guidelines provided by B.C. Hydro. It was anticipated that these stations would serve as both background data sources as well as sights to evaluate future project effects.

(a) Physical Habitat

Physical habitat surveys were conducted in September 1976, June 1977 and August 1977 in recognition of potential seasonal variances in the system. Habitat surveys occurred in parallel with the fish and benthos field programs.

(i) September 1976

Habitat surveys were conducted at biological sampling stations (Figure 3-2) during 15 - 18 September 1976. Observations were made on substrate composition, bank stability and vegetation, stream width, depth, velocity and pool-riffle ratio. In-depth surveys were conducted at all Hat Creek and Bonaparte River stations (except 1 and 14A), while general observations were made at remaining sites. Because of excessive water velocities and depth, observations on habitat at Station 1 were of a general rature. Station 14A (beaver pond) was added to the regular stations for fish sampling in late September.

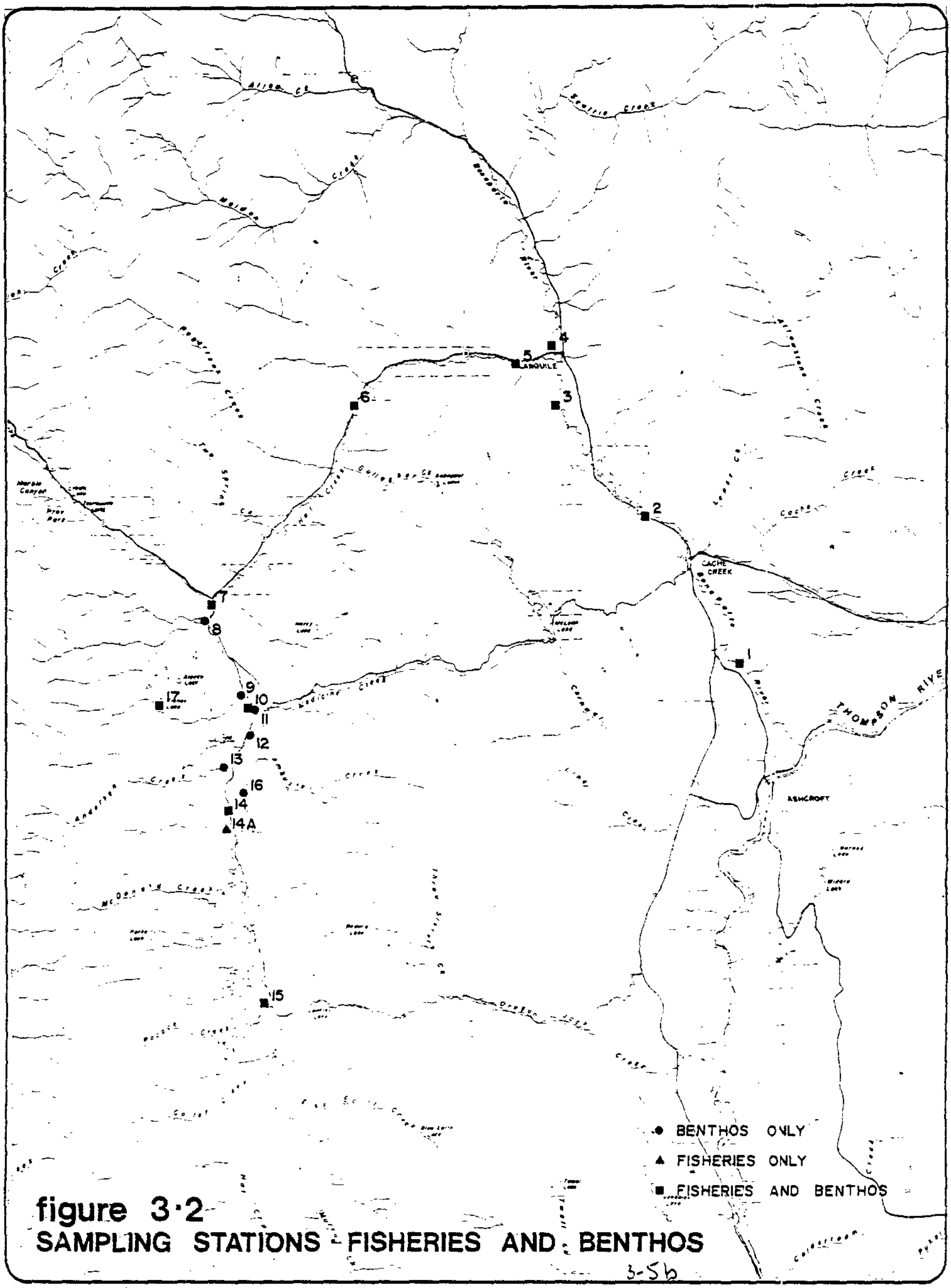

figure 3·2
SAMPLING STATIONS - FISHERIES AND BENTHOS

A 15.2 m (50 ft) reach of stream was examined at all Hat Creek stations (except) 14A) and Station 4 on the Bonaparte River. Six cross-stream transects located 3.0 m (10 ft) apart were established in each 15.2 m (50 ft) reach, and stream width recorded. Stream depth was measured at 0.6 m (2 ft) intervals along each transect. Water velocity was measured with a current meter at a depth of 80 percent from the surface at 0.6 m intervals along the downstream-most transect. Substrate size and percent substrate composition in each 15.2 m (50 ft) reach was estimated qualitatively based on the following criteria as modified from Lagler (1966): boulder (>30.5 cm), pebble (7.6 - 30.5 cm), gravel (0.3 - 7.6 cm), sand-silt (<0.3 cm), and other (plants, sunken logs, debris). Bank stability was noted as stable or unstable and riparian vegetation was noted. Pool-riffle ratio (percent) was estimated qualitatively in each 15.2 m reach.

Because of increased current and water depth at Stations 2 and 3 in the Bonaparte River, only one cross-stream transect was established. Depth and velocity measurements were taken at 0.6 m (2 ft) intervals at Station 3 and, because of stream width, at 1.5 m (5 ft) intervals at Station 2. Physical characteristics outlined above were noted along each transect and in areas extending approximately 7.6 m (25 ft) upstream and downstream of the transect. Station 1 in the Bonaparte River exhibited deeper and considerably faster water than upstream stations. Physical characteristics at this station were determined from shore.

Physical habitat was described in Hat Creek tributaries at Stations 8 (Unnamed Creek), 11 (Medicine Creek), 12 (Ambusten Creek) and 13 (Anderson Creek). Observations were of a more qualitative nature at these than at other creek and river stations. Approximate substrate size ranges, stream width, depth and pool-riffle ratio were recorded at each along with information on bank stability and vegetation. Velocities at tributary stations and at Stations 1 (Bonaparte River) and 14A (Hat Creek) were expressed as sluggish, rapid or torrential based on estimated surface currents. Lagler (1966) presented the following criteria for classifying streams according to velocity:

sluggish - those with velocity less than 0.15 m/s (0.5 ft/s);
rapid - those with velocity greater than 0.15 m/s (1.6 ft/s) and a regular succession of pools and riffles; and
torrential - those with velocity greater than 0.5 m/s, a steep gradient, and few or no pools.

General observations on depth, substrate and aquatic vegetation were also made at lake stations 16 and 17 (Goose/Fish Hook and Finney Lakes). Water temperatures were recorded during each sampling period. In September, they were recorded during the habitat survey and/or during the fisheries survey on 28 - 30 September 1976.

To facilitate presentation of September habitat data, stream width is given as a mean if measurements were made at more than one transect. Depth and current velocity represent ranges measured at a station. Comments on substrate composition, bank stability and vegetation, and pool-riffle ratio reflect general characteristics for the entire 15.2 m (50 ft) reach of stream rather than a particular transect.

In addition to detailed observations made at individual stations, more general information was obtained through helicopter surveys. Physical habitat along Hat Creek and between Stations 1 and 4 on the Bonaparte River was described during a helicopter flight on 23 September 1976. Observations were made on pool-riffle ratio, stream substrate, bank stability and vegetation, barriers (such as beaver dams) and fish occurrence. During the flight, general distinction was made between pebble (approximately 7.6 - 15.2 cm) and cobble (approximately 15.2 - 30.5 cm) to better characterize stream substrate for evaluating potential spawning habitat.

(ii) June, 1977

Observations on habitat were made at biological sampling stations during 14 - 16 June 1977. Because physical conditions were similar to those during

September, 1976, June observations were of a more qualitative nature. Information on substrate composition, bank stability and vegetation, and pool-riffle ratio was determined visually as in September. Water temperatures were recorded. Any changes in stream depth or width from September data were noted. Sampling was not conducted at Stations 16 and 17 (Goose/Fish Hook and Finney Lakes) since no fish were collected there during the September 1976 survey, or at Station 12 (Ambusten Creek) as all water had been diverted for irrigation.

Cross-stream transects were not established during the June 1977 survey since water levels, and consequently stream width and depth, were similar to those during September 1976. Water velocity at Hat Creek and Bonaparte River stations was determined at the surface by the float method (Rounsefell and Everhart, 1966) and rates expressed as m/s. Velocity was calculated from the following formula:

$$V = L/T$$

where L = distance (m) float is carried; and
T = time (sec) for float to cover distance L.

Velocities at Hat Creek tributary stations were expressed as torrential, rapid or sluggish after Lagler's classification.

A second helicopter flight was made on 13 June 1977. The path of flight was identical to that followed during September 1976. The primary objective was to gather information on fish occurrence and, if possible, location of rainbow trout spawning sites. General notes on physical habitat were also recorded.

(iii) August, 1977

General observations on habitat were made at biological sampling stations during 3-5 August 1977. Information recorded and techniques used were identical to those of the June survey. Sampling was not conducted at Stations 16 and 17

(Goose/Fish Hook and Finney Lakes) since no fish were observed there during the September 1976 survey, or at Station 12 (Ambusten Creek) since water was still being diverted for irrigation purposes.

(b) Benthic Invertebrates

Benthic invertebrates form an integral portion of the food of indigenous fish species. On this premise, invertebrates were studied to provide a measure of food availability as well as an index of system dynamics. Methodological approaches of the benthic invertebrate components of the study are presented within a sequential framework of field phase, laboratory phase and analytical approach.

(i) Field Phase

On 15 - 18 September 1976, seventeen stations were examined with 16 stations actually sampled on the Bonaparte and Hat Creek systems (Figure 3-2). Station 9 was not sampled as Finney Creek was dry at the time of the field survey. During the 14 - 16 June 1977 and 3 - 5 August 1977 sampling periods, Stations 9 and 12 were also dry and hence not sampled. Stations 16 and 17 (Goose/Fish Hook and Finney Lakes, respectively) were not sampled for benthos because they did not contain fish resources.

Six replicate samples were taken at each station. BEAK employs six replicates in the majority of the biological monitoring studies and has found this number to provide an informative data base. At lake Stations 16 and 17 in 1976 a Ponar dredge was employed to collect sediments. The Ponar dredge is most effective in soft fine substrates which were characteristic of Stations 16 and 17. The Ponar dredge effectively raises for collection of 523 cm^2 area of lake substrate, approximately 15 to 25 cm in depth. All remaining stations in 1976 and 1977 were sampled with a Surber sampler. This unit samples a 929 cm^2 area of stream bottom to a maximum water depth of 30.5 cm. The area encompassed by this device is manually disturbed dislodging invertebrates which are subsequently collected in a downstream net.

Subsequent to collection, each replicate sample was gently washed through a U.S. Standard No. 30 sieve (595 μ). Organisms retained by this sieve are categorized as macro-invertebrates (Weber, 1973). Contents of the No. 30 sieve were washed into polyethylene jars and preserved with 10% formalin containing rose bengal stain. This stain is absorbed by organic materials consequently making invertebrates more conspicuous, thereby accelerating sorting and enumeration procedures.

(ii) Laboratory Phase - Sample Treatment

In the laboratory all macro-invertebrates were sorted from debris, enumerated and categorized as to tolerance to environmental pollutants (Biotic Index: Beak, 1965). To obtain more detailed data on invertebrate samples at each station, organisms were identified to genus, and species where possible.

Weber (1973) stated that analyses of benthic data for diversity and equitability should be performed on samples which contain a minimum of 100 organisms. The number of replicate samples collected at each station that were selected for detailed identification varied in order to compute reliable ecological statistics. Replicates were selected at random in order to provide a minimum of 100 organisms for detailed identification at each station. Following the selection of a replicate the recorded number of individuals was checked; if the number did not meet the required number, another replicate was selected at random and combined with the first selection. This procedure was repeated as necessary. During the identification phase of organisms to genus and/or species, the following taxonomic references were employed: Altman (1936), Ricker (1944), Burks (1953), Pennak (1953), Edmondson (1959), Jewett and Stanley (1959), Johannsen (1969), Saether (1971, 1973) Usinger (1971), Bryce and Hobart (1972) and Mason (1973).

(iii) Analytical Approach

An analysis of community structure was undertaken on benthic invertebrate data by employing a series of indices which consolidate several data units into a single comparative index. The data were subjected to five analyses which were interpreted with regard to system condition. These analyses included the biotic index, dominance, diversity, equitability, and richness.

(A) *Biotic Index*

Benthic organisms exhibit varying degrees of sensitivity to changes in the conditions of an aquatic environment. Beak (1965) has categorized benthos into three groups: those typical of clean water are categorized as pollution sensitive organisms - Group 3; those typically found in moderately polluted waters are labelled as moderately tolerant or facultative - Group 2; and those inhabiting highly polluted waters being classed as pollution tolerant organisms - Group 1.

Group 3 organisms contain aquatic larval stages of insects which are sensitive to adverse changes in water quality and are the first to experience declining populations if conditions deteriorate. The prime representatives of Group 3 are the mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). These organisms require clean water conditions which include high concentrations of dissolved oxygen, relatively swift currents, low turbidity and relatively low concentrations of toxic chemicals. Group 3 organisms respire primarily by external gill structures. The respiratory surfaces of these organs are extremely sensitive to the abrasive action of fine sediments and the physiological effects of chemical pollutants.

Group 2 consists of a number of organisms such as leeches (Hirudinea), midges (Diptera), water mites (Hydracarina), clams (Pelecypoda) and others. These organisms can tolerate a moderate amount of water quality degradation. The degree to which tolerance to pollutants is expressed varies according to individual levels.

Group 1 organisms are tolerant of some toxic conditions and low concentrations of oxygen and will survive in areas where less tolerant organisms would be eliminated. Within this group, for example, are the annalids (Oligochaeta), some leeches, and some chironomids (Diptera).

The biotic or tolerance index is not a rigid classification scheme. Independent research studies have revealed a hierarchy of invertebrate taxa based on sensitivity to environmental degradation. Consequently, use of these categories has found wide application in the study of aquatic systems that may potentially be impacted by industrial activities.

(B) *Dominance Index*

Natural biological communities include groups of organisms that are not equally successful. This is a function of the biotic and abiotic restrictions of an environment. A few may dominate a community with the spectrum then extending to groups of intermediate abundance and finally to rare organisms. An index used to measure relative abundance in biological samples was proposed by Simpson (1949) and is:

$$C = \sum_{i=1}^{s} \left(\frac{Ni}{N} \right)^2$$

where C = Dominance index;
s = number of groups;
Ni = importance value (e.g. % or numbers) for each biotic group; and
N = total of importance values.

The function was used to compute a measure of dominance from biotic index data (i.e. Groups 3,2 and 1). The expression of C is related to percent composition. The advantage of employing this index is that it provides a single objective value describing proportionate relationships of various categories of invertebrates being considered in the analysis. The maximum value of C is 1.00 where a community is composed of one group of organisms.

(C) *Diversity Index*

An index of diversity was also calculated for each sampling station based on the detailed identification of invertebrates. The method used was adopted from information theory in communication engineering (Shannon and Weaver, 1949) by Margalef (1958) and MacArthur (1955) and applied to biological systems.

A simplified biological interpretation of information theory would be that ecological systems such as streams act as a source of information and the output of information containing characters are the biological organisms themselves. A definition of ecological diversity is:

> "*Diversity is thus equated with the amount of uncertainty (information) which exists regarding the species of an individual selected at random from a population. The more species there are and the more nearly even their representation, the greater the uncertainty (information) and hence the greater the diversity*" (Pielou, 1966).

The formula used to compute the diversity index ($\bar{d}$) is:

$$\bar{d} = \sum_{i=1}^{s} \frac{Ni}{N} \log_2 \frac{Ni}{N}$$

where $\bar{d}$ = Diversity Index;
s = number of genera;
Ni = Number of individuals of the th genus; and
N = total number of individuals in sample.

(D) *Equitability Index*

An important characteristic of the diversity index is that it provides an objective measure of community complexity by incorporating within this single measure several variables that affect community structure. The primary components of diversity are equitability, or the evenness with which individuals are distributed among sampled genera, and richness, or the number of different genera sampled. A measure of equitability used in this study (Pielou, 1966a) is:

$$J = \frac{\bar{d}}{\log_2 s}$$

where J = Equitability Index;
$\bar{d}$ = diversity value obtained from sample data; and
s = number of different genera in sample.

In general, the more complex a system, the greater its stability due to alternate routes of energy transfer (MacArthur, 1955). However, there are limits to the magnitude of change that any system can withstand. Beyond some maximum tolerance level, negative environmental forces will be evidenced in the biotic community by a decrease in stability and a decrease in overall community complexity.

(E) *Richness Index*

Richness or variety in its simplest form is the number of genera encountered without considering the number of individuals actually examined. It is an indicator of the relative wealth of species or genera in a community (Peet, 1974). This function has been utilized in some studies as a measure of diversity. However, it is not an entirely correct approach to diversity since it does not incorporate the variable of equitability as does the Shannon-Weaver function.

Any richness measure is inherently dependent on sample size; the larger the sample size the greater opportunity to sample greater number of species. This *sample size - species number* relationship is asymptotic. At some point additional sampling does not result in an increase in the number of species.

An index of richness is, therefore, best expressed with the inclusion of numerical abundance in the sample (Hurlbert, 1971; Shafi and Yarranton, 1973).

The index employed in this study was (Margalef, 1958):

$$R = \frac{s - 1}{\log_e N}$$

where R = Richness Index;
s = number of genera in sample; and
N = total number of individuals in sample.

(c) Fisheries

As with benthic invertebrates, the methodological approaches to the fisheries component of the study are presented as field phase, laboratory phase and analytical approach.

(i) Field Phase

Fisheries surveys are conducted at Hat Creek and Bonaparte River stations (Figure 3-2) during 28 - 30 September 1976, 14 - 16 June 1977, and 3 - 5 August 1977. Surveys or visual observations for fishes were made at lake and stream stations during 15 - 18 September 1975 and at stream stations during 14 - 16 June 1977 and 3 - 5 August 1977.

An electroshocker, powered by a 2500 kilowatt alternating current generator, was used to sample fish at Hat Creek and Bonaparte River stations. Attempts were made to sample a large enough area at each station to characterize species composition and abundance. In Hat Creek, a 3.22 mm (1/8 in) square mesh net measuring 4.27 m (14 ft) long x 1.22 m (4 ft) deep was used to block the upstream end of the area to be shocked. Shocking proceeded in an upriver direction to the net. Length of stream (m) and time (min) shocked were recorded. Surface area of stream (m^2) shocked at a particular station was calculated from measurements of stream length and width. Because of swift, deep water, electroshocking in the Bonaparte River could be conducted usually no more than about 2 m from shore. River conditions also prevented seine-sets to block fish movement. Shocking was also conducted at the mouth of Medicine Creek, a tributary of Hat Creek. A barrier approximately 2 m (6.5 ft) high located about 10 m (33 ft) upstream from the mouth of this tributary limited further fish movement.

Number of each species (Carl *et al.*, 1973), individual total lengths (mm), and wet weights (g) were recorded at each station. Sex (when distinguishable) was determined visually and the presence of parasites and general condition of each specimen was noted. Stomachs and scales were removed from rainbow trout and mountain whitefish (when these species were present) at Stations 1, 3, 4, 5, 6, 7, 10 and 14 for use in food habit, age and growth studies. During each survey, ten fish of each species (when present) in the following length categories: 0 - 100 mm, 101 - 200 mm, and >200 mm were sampled per station. Stomachs were individually wrapped in gauze with an identifying number and preserved in 10% formalin. Approximately 20 scales were taken from the left side of the fish midway between the dorsal fin and lateral line (Larkin *et al.*, 1957) and stored dry in paper envelopes. All fish not retained for stomach and age analyses were measured and released alive.

Electroshocking was conducted in the same area of stream as habitat surveys and benthic sampling, but extended upstream and downstream from these locations in order to sample a larger area. Pool-riffle ratios were noted in the entire area shocked.

Visual observations were made for fish life at tributary stations (8, 11, 12 and 13) during each survey and in Goose/Fish Hook Lake (Station 16) and in littoral areas of Finney Lake (Station 17) in September. Observations were made for fish life at Station 12 in September, 1976, but not in June or August, as water had been diverted for irrigation. A Fyke net was employed to sample shore areas of Finney Lake. The net was set overnight for 18 hours on 16 - 17 September, 1976. The body of the net was 2.44 m (8 ft) long and constructed of 6.44 mm (1/4 in) square mesh nylon net. The wings and lead measured 3.66 x 1.22 m (12 x 4 ft) and 12.20 x 1.22 m (40 x 4 ft), respectively, and were constructed of 12.8 mm (1/2 in) square mesh nylon net. The net was set perpendicular to the shoreline, with the lead toward shore, in water approximately 1.0 - 2.0 m (3.3 - 6.6 ft) deep.

(ii) Laboratory Phase

Stomach contents were identified according to procedures described for benthic studies (Section 3.3 (b) ii). Empty stomachs were noted. Number and volume of each food item was determined for use in numerical and volumetric analyses of food habits (Rounsefell and Everhart, 1966; Ricker, 1971). Volume was determined from water displacement in a graduated cylinder and recorded to the nearest 0.01 ml. Food items with volumes less than 0.01 ml were recorded as 0.01 ml. After completing analysis, stomach contents were stored in individual containers for future reference should they be required.

Scales were examined with a Bausch and Lomb Tri-Simplex Micro-Projector at a magnification of 45x. Scales were aged independently by two individuals. If readings disagreed, the scales were read a second time. If readings were still in disagreement, scales were not used in age and growth analyses.

Scale measurements were recorded to the nearest mm after magnification on representative, nonregenerated scales for use in back-calculating growth rates. Measurements were made from the center of the focus to the outer margin of the scale along the most anterior scale radius. Individual annuli were distinguished as occurring between a series of closely spaced circuli followed by widely spaced circuli, and as exhibiting a corresponding cutting-over of circuli in lateral fields of the scale.

(iii) Analytical Approach

Stomach content data for rainbow trout were analyzed with a Computer Sciences Corporation (CSC) Univac 1107 computer. Food habits of fish in the following size categories were described by station during each survey: 0 - 50mm, 51 - 100 mm, 101 - 150 mm, 151 - 200 mm and >200 mm. Numerical analyses of stomach content reflected the percent a particular food item comprised the total number of food items. Volumetric analyses were expressed similarly, except the basis was food volume rather than number. Frequency of occurrence analyses reflected the percent of stomachs containing a particular food item.

Fish densities during each survey were determined from number of specimens captured at a station and length of stream (m), area of stream (m^2) and length of time (min) electroshocked. They were expressed as number/m, number/m^2 and number/min. Population estimates for each survey were based on fish densities (number/m) at a particular station and length of stream (m) that station appeared to represent.

Regression lines for body length-scale radius and length-weight relationships were determined using a CSC STAPK program. Specific equations used to describe these and other relationships are presented with the discussion of analysis results (Section 4.3 (b)).

3.4 IMPACT ASSESSMENT

Given the complexity of the task of synthesizing an areas environmental character with a project's development activities such that impacts can be recognized and assessed, the need for a rational, methodological approach to impact assessment is apparent. To meet this need, matrix techniques were utilized in the assessment portions of the study.

The matrix technique selected (ELUC, 1976) entails the formation of two axes: project activities and environmental characteristics. Within each element (E_{ij}) of potential interaction an assessment of impact is made on a broad classification scheme of negative impact (major/minor), beneficial impact (major/minor), ambivalent impact or no impact. Ambivalent impacts were stated where an absolute impact was not evident due to insufficient data and/or the possibility of precautionary measures outlined in the project development failing. A summary pictoral presentation is prepared from wh-ich a logically structured discussion may proceed.

Within the context of the matrix technique used, geographical specificity is also introduced. For each element in which a non-null impact is assessed, the general location of the specific impact identified is noted.

4.0 PROJECT SETTING

In the process of environmental impact assessment, the initial task is to describe the present resources with which the development may interact. Sufficient and necessary information is provided with which impacts may be assessed and procedures for mitigation and compensation recommended. This section of the report is directed towards this initial task in the geographical context of regional, offsite and local environment.

4.1 REGIONAL ENVIRONMENT

The orientation of the regional environment description is towards physical habitat and the fisheries resources therein. The perspective to be gained is general rather than specific in that the ~~aerial~~ extent of the study is large. Thus, the detail of information found in a description of a local regime is not present. Rather, the purpose is to designate general zones of environmental sensitivity.

(a) Physical Setting

Situated largely within the Interior Plateau of British Columbia the study region encompasses an area of approximately 37,296 km^2 (14,400 $miles^2$) and includes most of the Thompson River watershed. Major tributary streams of the Thompson River which drain much of the study region include the North Thompson, South Thompson, and Nicola Rivers. Other secondary, but important river systems are the Bonaparte, Salmon and Adams Rivers. The Bonaparte River flows directly into the Thompson River near Ashcroft, British Columbia, and serves as the principal stream drainage in the Cache Creek area including the Hat Creek system. The Salmon and Adams Rivers flow into Shuswap Lake, the largest lake system in the study region.

Located in the eastern most portion of the study region, Shuswap and Adams Lakes serve as the major basins receiving waters draining the western slopes of the Monashee Mountains. Adams Lake, the second largest in the region, flows into the western arm of Shuswap Lake. Kamloops Lake, Bonaparte Lake, Loon Lake, and Nicola Lake are other relatively large lake systems in the study region.

Along the western border of the study region the Fraser River cuts a deep, narrow canyon along the base of the Coast Mountains. All waters of the Thompson system enter the Fraser River at its confluence near Lytton, British Columbia. Other important tributaries of the Fraser River which drain portions of the study region are the Nahatlach, Stein and Bridge Rivers.

To the west of the Fraser River the high mountains of the Coastal Range form the western border of the study region. These mountains and those of the Monashee and Columbia Mountains east of Adams Lake govern, to a great degree, the prevailing climate and recent geological characteristics. Most influencial is the Coast Range, which lies south west of the Fraser River, and reaches summit elevations in excess of 1828 m (6,000 ft). This massive geological barrier forces prevailing warm, wet coastal air to rise rapidly, cool, condense, and fall as precipitation on the western slopes. In the higher elevations, annual total precipitation in excess of 250 cm per year is common. This loss of moisture results in relatively dry air being carried eastward over the interior of British Columbia.

Since much of the study region lies in the "leeward influence" or "rain shadow" of the Coast Range, most areas typically receive low amounts of total annual precipitation. Valleys below 914 m (3,000 ft) in elevation are particularly warm and dry while more upland areas are generally cooler and receive greater amounts of moisture. In the deep valleys of the Thompson, South Thompson and Nicola Rivers, less than 25 cm of precipitation generally falls per year. On the surface of the Interior Plateau conditions remain comparatively dry (25-50 cm per year); however, upwards to 100 cm may fall in higher elevations.

Summer temperatures in the study region vary considerably, as does precipitation, because of the great range in elevations encountered over the terrain. Midday summer temperatures may reach 21°C to 32°C in river valleys, and occasionally exceed 38°C. During winter, temperatures are generally on the order of -6°C to 2°C; however, occasional masses of cold polar air spill into the Interior Plateau from arctic regions in northern Canada and Alaska causing temperatures to fall as low as -29°C to -34°C; cold spells, however, generally last for only a few days.

Altitudinal differences (610 m - 2,743 m) which occur in the study region also influence to a great degree the prevailing forest and range cover. Because of their effect upon moisture availability, vegetative characteristics range from primal rain forests in the extreme southwest corner of the study region in the Coast Range to dry, semi-arid cold desert associations found in the Nicola, Thompson and South Thompson River Valleys. These zonal differences are best described on the basis of the biogeoclimatic zone in which they are found.

Eight major vegetation or biogeoclimatic zones, are represented within the study region. The Ponderosa Pine-Bunchgrass Zone, the driest and warmest in British Columbia, occupies the deep valleys of the Thompson, Nicola and portions of the Fraser and North Thompson Rivers between 275 and 915 m in elevation. Within this zone the major vegetation types are drought tolerant shrubs such as sagebrush and various species of bunchgrass. Low moisture availability is reflected in sparse vegetative cover and tree growth is restricted to open savanna-like stands. Between 300 m to 1525 m above sea level the Ponderosa Pine-Bunchgrass Zone gives way to an association of Douglas fir, and ponderosa pine, described as the Interior Douglas-fir Biogeoclimatic Zone. This zone covers much of the study region and is characterized by a relatively warm, dry climate. Forested areas tend to be open, with little understory vegetation. Bunchgrass and other shrubs are found at lower elevations and are common cover types in the open rangeland.

The most predominant vegetative zone which occurs in the study region is the Engleman-Spruce-Subalpine Fir Biogeoclimatic Zone. This zone lies between

1,225 m in elevation to treeline and is characterized by a mixed forest cover. Engleman spruce, and subalpine fir are the major cover types, however in the lower elevations lodgepole pine is common in areas previously logged or burned out by forest fires.

In the highest elevations of the Coast Range and Cascade Mountains, vegetation is reduced by heavy accumulations of snow, ice and prevailing low temperatures. The zone, which generally occurs about 2,150 m is described as the Alpine Tundra Biogeoclimatic Zone. Vegetation is predominated by herbaceous plants such as heather, various species of sedges, and other small alpine flowering plants. Tree growth is restricted by the severe climatic conditions, however, growths of white-bark pine and sub-alpine fir occasionally take hold in protected, moist areas.

In the more northern and northwestern areas of the study region a zone described as the Cariboo-Aspen-Lodgepole Pine-Douglas-fir Biogeoclimatic Zone predominates. This zone, although similar to the Interior Douglas-fir Zone is characterized by colder more severe climatic conditions. Forest cover varies from dense timbered stands to open park-like grassland. Three other biogeoclimatic zones are represented in the study area, but all are restricted to small isolated locations where moisture and soil conditions favour their respective forest associations. These include the Coastal Western Hemlock Zone, which is represented in the Nahatlatch River Valley and along the western slopes of the Cascade Mountains; the Mountain Hemlock Biogeoclimatic Zone, which can be found on the upper slopes of the Coast Range; and the Interior Western Hemlock Zone which occurs in the extreme northeast of the study region.

(i) Drainage Basins

The major drainages in the study area are the Fraser and Thompson Rivers. Several tributaries of the Thompson River including the Bonaparte River (with Hat Creek), Deadman Creek, Tranquille River, North Thompson, Campbell Creek, Nicola River and Murray Creek and two tributaries of the Fraser River, Stein River and Bridge River, are designated on Figure 4-1.

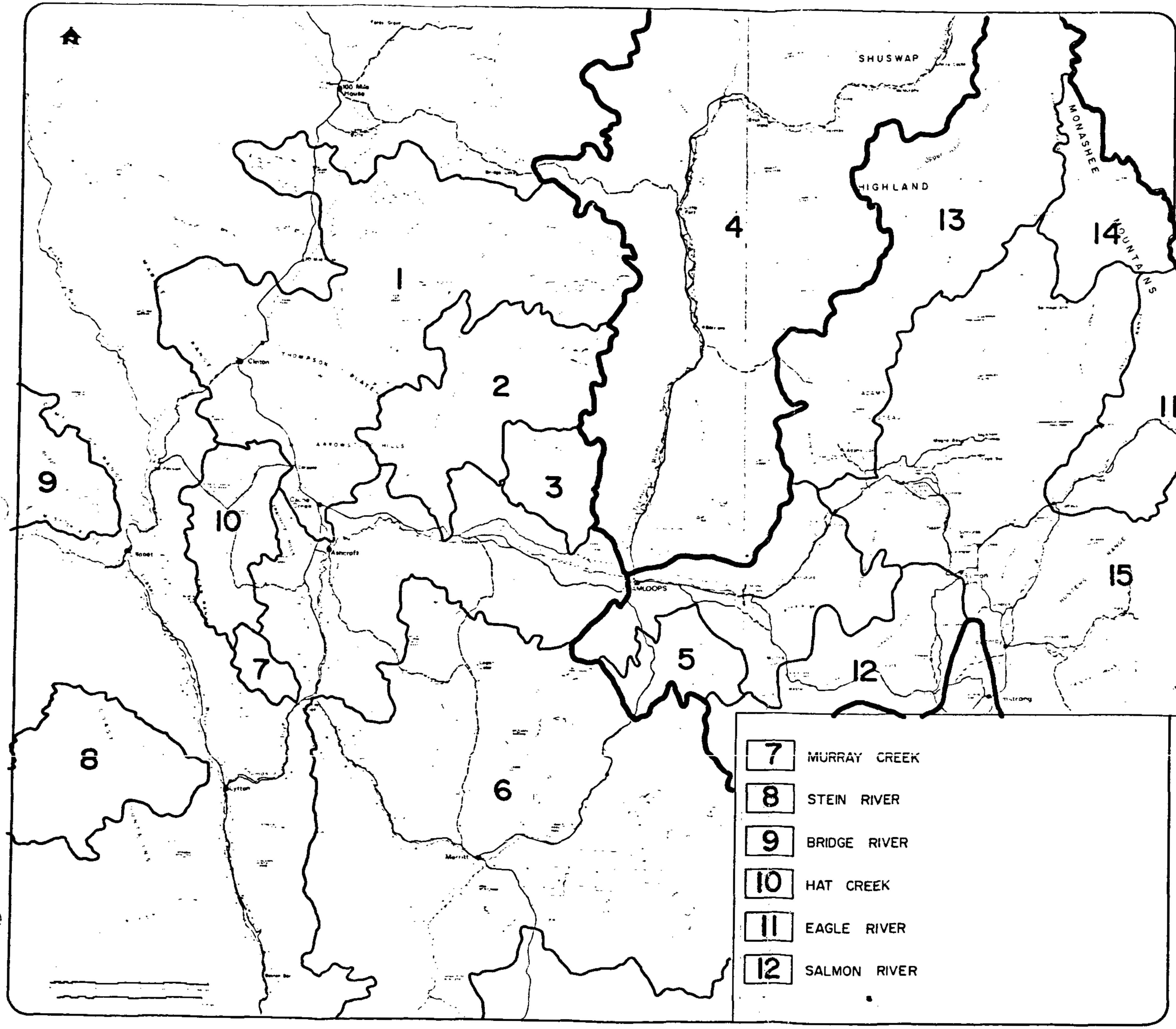

figure 4·1

DRAINAGE BASINS OF MAJOR TRIBUTARIES OF THE THOMPSON AND FRASER RIVERS IN THE REGIONAL STUDY AREA

legend

1	BONAPARTE RIVER
2	DEADMAN CREEK
3	TRANQUILLE RIVER
4	NORTH THOMPSON RIVER
5	CAMPBELL CREEK
6	NICOLA RIVER
7	MURRAY CREEK
8	STEIN RIVER
9	BRIDGE RIVER
10	HAT CREEK
11	EAGLE RIVER
12	SALMON RIVER
13	ADAMS RIVER
14	SEYMOUR RIVER
15	SHUSWAP RIVER (INCLUDES 11, 12, 13, 14)

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Drainage basins provide one means of sub-dividing the regional study area. In addition, the area of study can be sub-divided in terms of management units (MU) as defined by the B.C. Fish and Wildlife Branch. Designated management units within the study area are shown on Figure 4-2.

Hundreds of lakes and streams which support various populations of sport and commercial fish species are found within the study region. The greatest number are found in the Bridge Lake, Bonaparte Lake and Green Lake areas. Lakes or streams which receive greater than 2,000 angler days of effort each year, support a major salmonid fishery (Steelhead, Pacific salmon) or are lakes greater than 6.4 km long, have been classified for the purposes of this study as primary lakes and streams. This primary group is listed in Table 4-1, and lakes shown in Figure 4-3.

(ii) Water Quality

Water quality information for lakes and streams in the study area is summarized in Appendix D, Table D-12. Considering the pH and alkalinity (expressed as mg/ℓ $CaCO_3$) characteristics of the regions water resources, pH levels tend to be in the 7.0 to 8.0 range and alkalinity values range upwards to over 400 mg/ℓ.

In watersheds, the degree to which incoming acids are neutralized depends on the physical and chemical nature of soils, bedrock, and overburden (Wright and Gjessing, 1976), and is described as buffering capacity. Within local and regional areas variations in buffering capacity occurs as changes in the mineral composition of soil, soil depth, subsurface flushing rates and major geological characteristics differ. The buffering capacity in natural waters is largely dependent upon the salts of carbonic acid, particularly bicarbonates because of their universal abundance. In areas where carbonate bearing materials are lacking, chemical weathering and ion exchange proceed to slowly neutralize incoming acid (Wright and Gjessing, 1976), hence these areas become susceptable to acidification by the addition of acid.

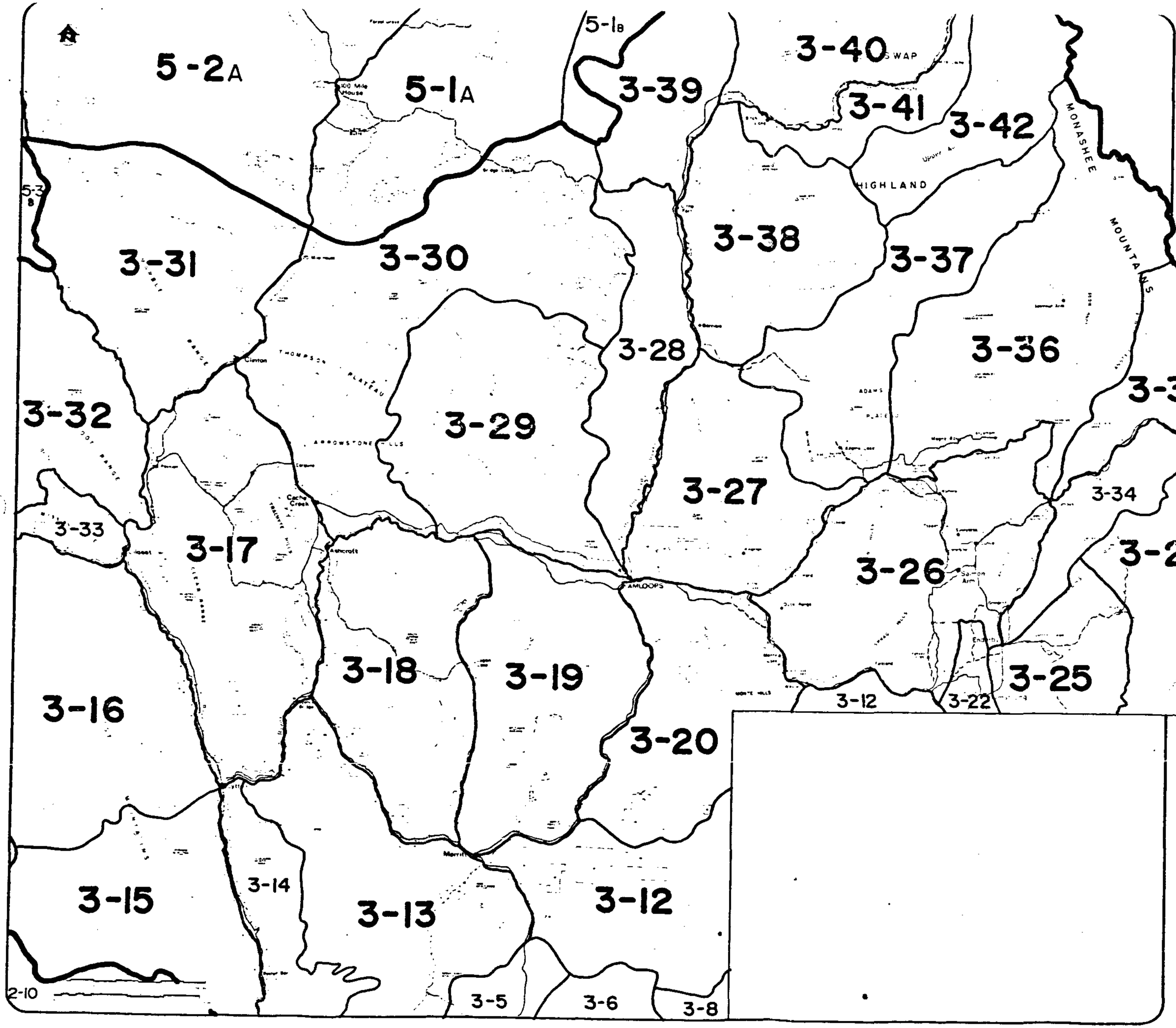

figure 4·2

WILDLIFE MANAGEMENT UNITS

legend

RESOURCE REGION BOUNDARY

WILDLIFE MANAGEMENT UNIT BOUNDARY

3-20 WILDLIFE MANAGEMENT UNIT NUMBER

DATA SOURCE
British Columbia Recreational Atlas

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TABLE 4-1

PRIMARY LAKES & STREAMS IN REGIONAL STUDY AREA[1]

Management Unit[2]	Primary Lake or Stream
3-12 (7)	Courtney Lake Hatheume Lake Jackson Lundbom Minnie Pennask Pinnacle
3-13 (7)	Harmon Lake Kane (left) Lake Kane (right) Lake Lily Lake Murray Lake Nicola River Spius Creek
3-14 (1)	Fishblue Lake
3-15 (2)	Kwoiek Lake Stein River
3-16 (2)	Seton Lake Seton River
3-17 (6)	Crown Lake Fraser River Kwotlenemo Lake Pavilion Lake Thompson River Turquois Lake
3-18 (6)	Barnes Lake Bose Lake Chataway Lake Coldwater Creek Leighton Lake Tunkwa Lake
3-19 (12)	Duffy Lake Face Lake Jacko Lake Lac le Jeune McConnel Lake Nicola Lake Paska Lake Pat Lake Stake Lake Surrey Lake Sussex Lake Walloper Lake
3-20 (9)	Black Lake Ernest Lake Frisken Lake Glimpse Lake John Frank Lake Peter Hope Lake Plateau Lake Roche Lake Trapp Lake
3-26 (1)	Salmon River
3-27 (8)	Badger Lake Heffley Lake Knouff Lake Little Heffley L. Louis Creek Paul Lake Spooney Lake S. Thompson River
3-28 (2)	Thuya Lakes N. Thompson River

TABLE 4-1 Cont'd.

PRIMARY LAKES & STREAMS IN REGIONAL STUDY AREA

Management Unit	Primary Lake or Stream	Management Unit[2]	Primary Lake or Stream
3-29 (8)	Bare Lake	3-32 (3)	Bridge Lake
	Deadman River		McKay Lake
	Fatox Lake		Yalakom River
	Gordon Lake		
	Red Lake	3-38 (2)	Barrier River
	Tranquille Lake		Genier Lakes
	Tranquille River		
	Kamloops Lake	3-39 (11)	Brookfield Cr.
			Emar Lake
3-30 (8)	Bonaparte Lake		Epcee Lake
	Bonaparte River		Grizzley Lakes
	Bridge Lake		Lemieux Creek
	Hammer Lake		Lost Horse Lake
	Hihium Lake		Mann Creek
	Hoopatatkwa Lake		Moose Lake
	Loon Lake		Moosehead Lake
	Young Lake		Sock Lake
			Surprise Lake
3-31 (1)	Big Bar Lake		
		5-1 (2)	Green Lake
			Horse Lake

[1] Primary as defined by one or more of the following:

(a) ≥2,000 angler days;
(b) a steelhead sport fishery;
(c) a spawning salmon population;
(d) a lake >4 miles long.

[2] Numbers in parentheses represent the number of lakes or streams presented in that given management unit. Location of Fish & Wildlife Branch Management Units presented in Figure 4-2.

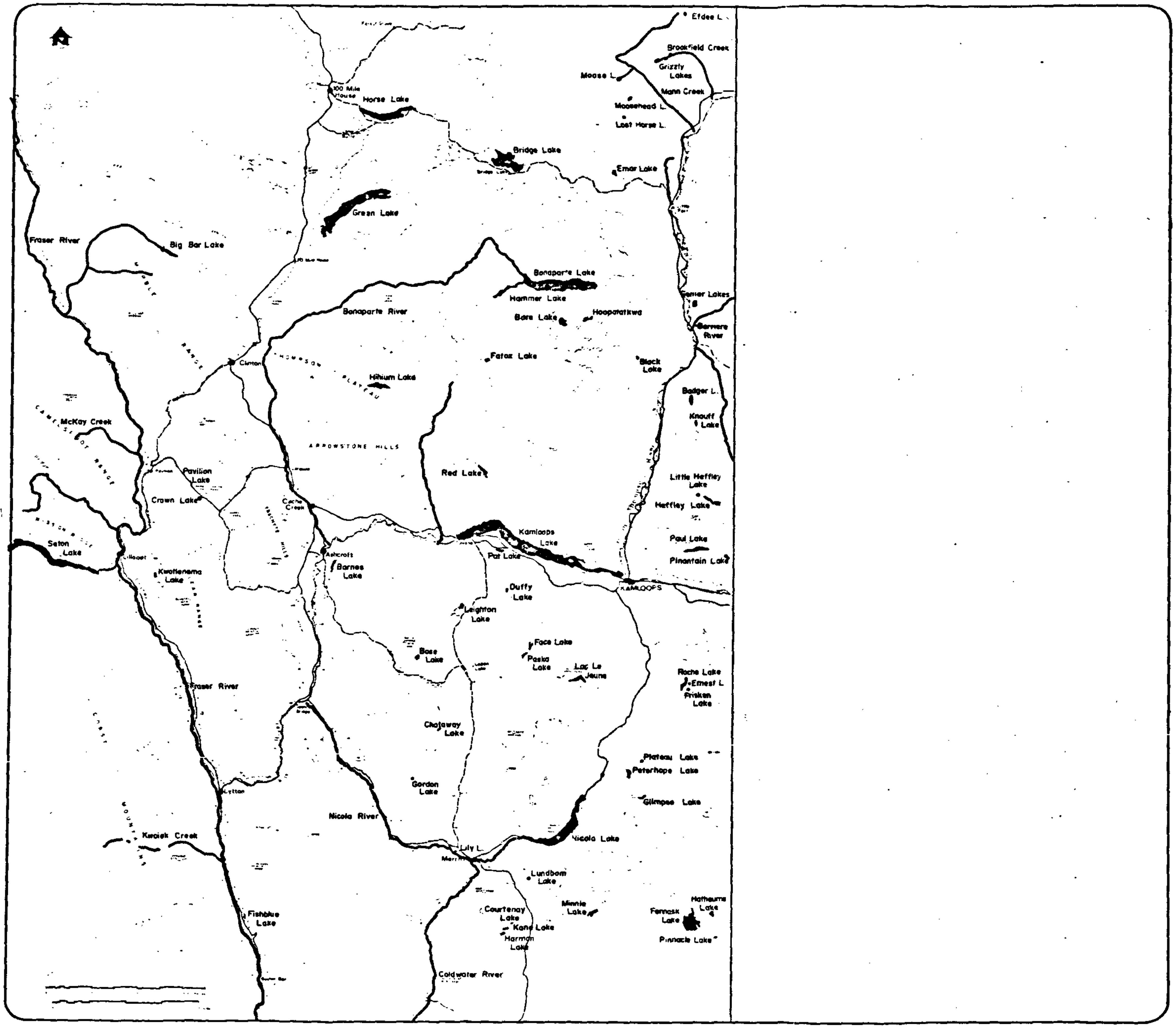

figure 4·3

PRIMARY LAKES AND STREAMS IN REGIONAL STUDY AREA

legend

PRIMARY LAKE

PRIMARY STREAM

Primary is defined as
- (a) ≥ 2000 angler days sport fishing , or
- (b) steelhead sport fishery , or
- (c) salmon spawning , or
- (d) > 10 Km long

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To evaluate the ability of an area to buffer incoming acids, measurements of alkalinity are particularly useful since alkalinity is an indicator of the quantity of bicarbonates and carbonates available to enter into reaction with an acid and bring about a neutral state. In this sense, the alkalinity of a water is a measure of its ability to neutralize acid (Sawyer and McCarthy, 1967) and therefore can be considered a practical indicator of buffering capacity.

In the regional study area measurements of total alkalinity for water bodies have been compiled and summarized to present a generalized view of the buffering capacity of the study area and identify those areas which lack the necessary water quality to resist changes in their pH. (Appendix D, Table D-12). Three categories, or levels of sensitivity as suggested by Newcombe (1977) have been adopted to classify water bodies. These are defined as having measured alkalinity values which fall into the following categories:

Category I - less than or equal to 50 mg/ℓ
Category II - greater than 50 mg/ℓ but less than or equal to 100 mg/ℓ; and
Category III - greater than 100 mg/ℓ

The minimum value established in Category I was arbitrarily chosen greater than that considered critically low (20 mg/ℓ, McKee and Wolf, 1963) in order to identify lake and streams which may be vulnerable to acidification by acid rain. Waters containing a total alkalinity of 100 mg/ℓ or more (Category III) are generally considered as the best for supporting diverse aquatic life (McKee and Wolf, 1963). Lakes falling into Category II contain sufficient alkalinity to buffer incoming acids in all except unusually high concentrations.

Within the regional study area (Figure 4-4), available alkalinity data indicates the region is characterized by lakes and streams which are considered either sensitive to acidification (Category I) or have high buffering capacities (Category III). Water bodies located within the immediate environs of the proposed Hat Creek Thermal Plant and those originating in much of the Thompson Plateau reflect similar geological and soil conditions (Figure 4-5) and contain waters of high alkalinity. The Thompson Plateau near Cache Creek is character-

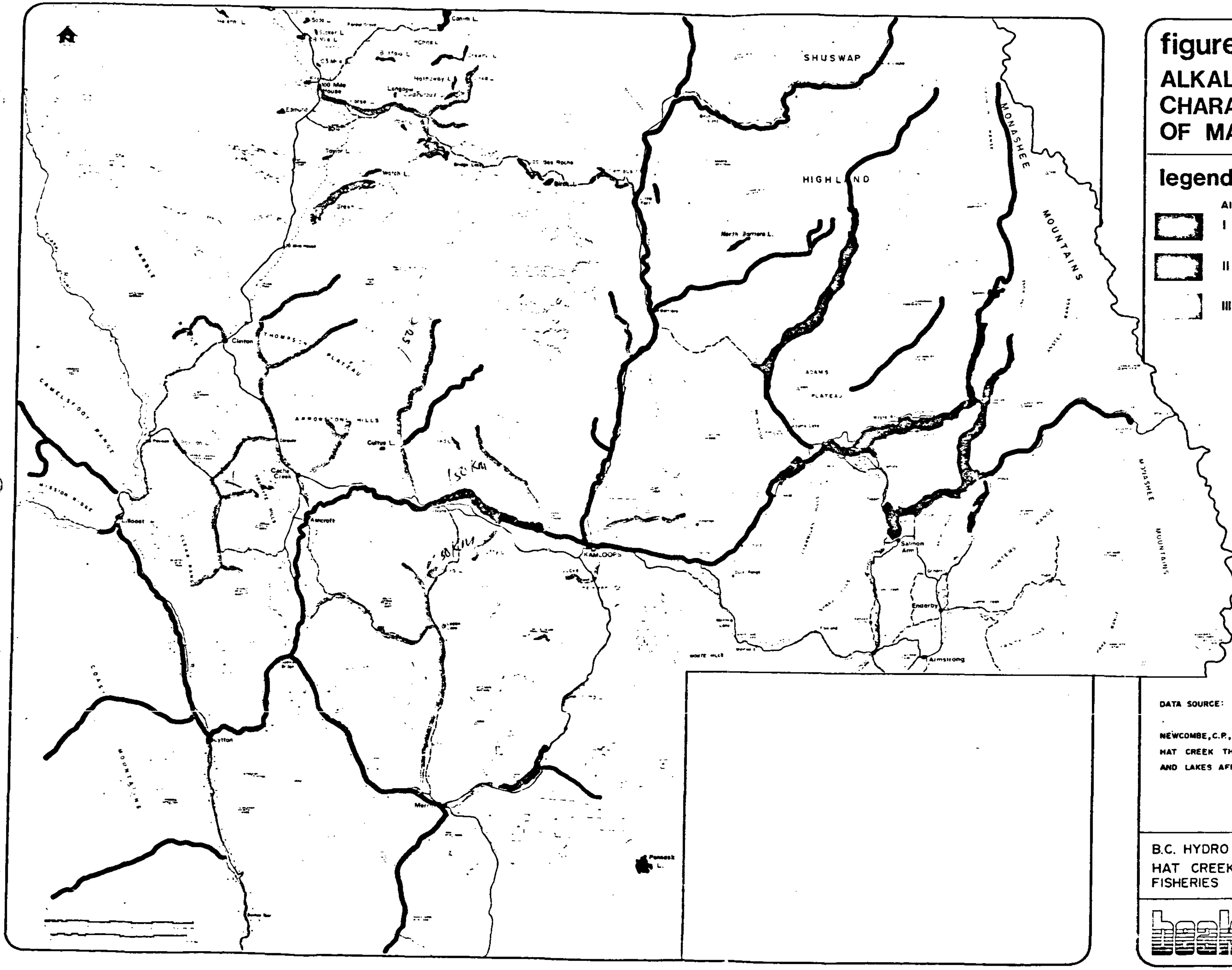

figure 4·4
ALKALINITY CHARACTERISTICS OF MAJOR WATER BODIES

legend

Alkalinity Category

I	≤ 50 mg/l	
II	50 - 100 mg/l	
III	> 100 mg/l	

DATA SOURCE:

NEWCOMBE, C.P., 1977, WATER QUALITY NEAR THE PROPOSED HAT CREEK THERMAL GENERATING STATION : POTENTIAL STREAMS AND LAKES AFFECTED BY ACID PRECIPITATION

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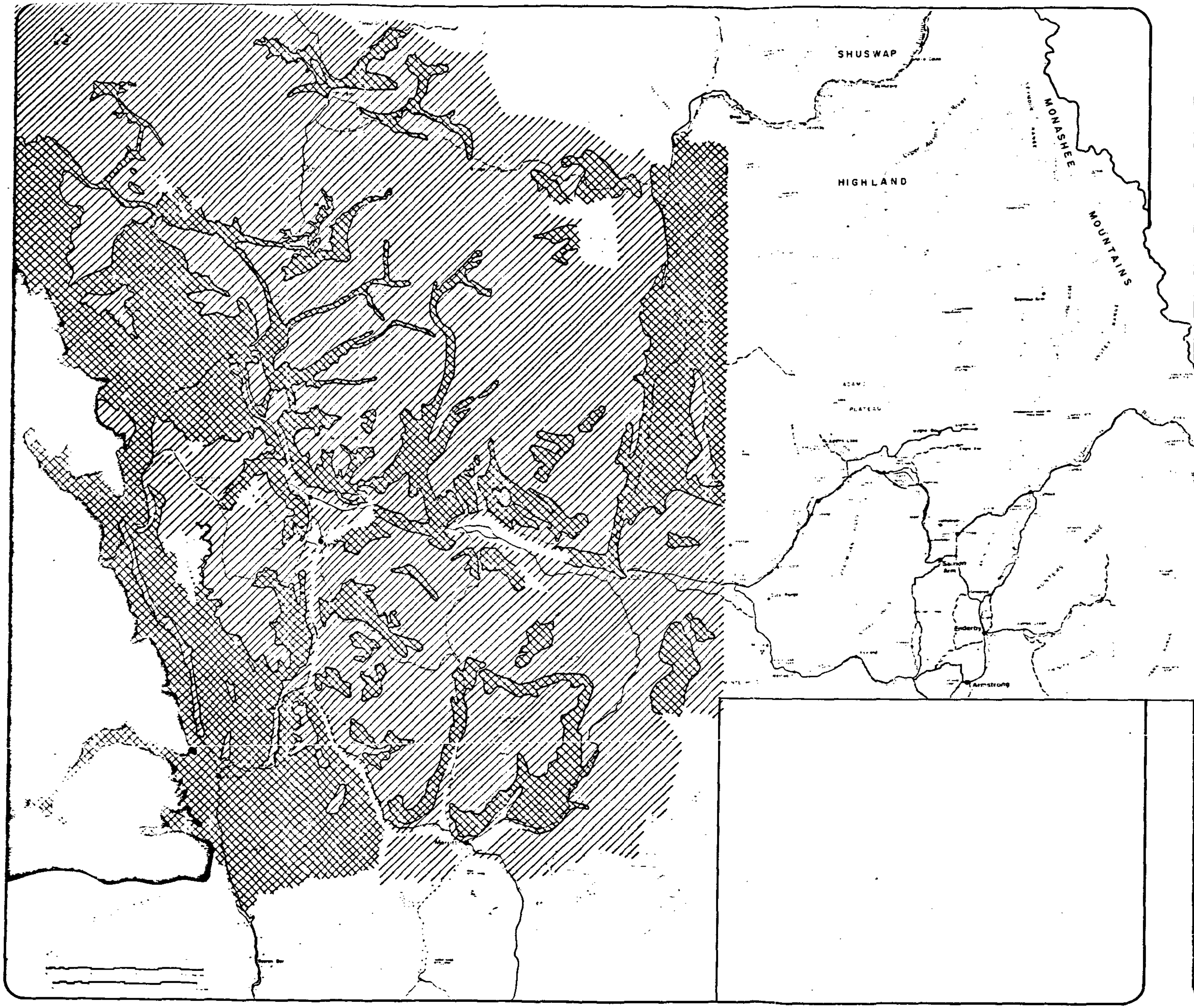

figure 4·5

SOIL BUFFERING CAPACITY

legend

- LOW (Podsols)
- MODERATE (Brunisols, Regosols)
- HIGH (Chernozems, Luvisols)
- Data not available

DATA SOURCE
TERA CONSULTANTS LIMITED

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FISHERIES AND BENTHOS STUDY

BEAK CONSULTANTS LIMITED
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ized by recent and metamorphic sedimentary rock rich in limestone deposits. The Marbel Range north of Hat Creek Valley and the Trachyte Hills east of Hat Creek consist primarily of limestone deposits which contribute large quantities of bicarbonates to the watershed. This chemical nature is reflected in other stream systems which drain similar deposits throughout the Thompson Plateau. Sp ?

In the western and southeastern extremes of the study region, weather resistant plutonic rocks prevail which lack appreciable deposits of limestone. High rainfall and low dissolved solids reflect the low alkalinities prevailing in most systems. The Seymour River, Eagle River and Adams River, for example, contain alkalinities which are significantly less than 50 mg/ℓ (12.1 to 22.5 mg/ℓ; Appendix D, Table D-12).

On a regional basis the entire Adams River system is characterized by waters containing alkalinities of 50 mg/ℓ or less. Ranked as one of the most important sockeye producing systems in the Province of British Columbia, the Adams River system provides spawning area for approximately 44% of the total sockeye utilizing the Fraser River system (1,192,966). Waters of the Adams system as well as those of the major streams the North and South Thompson Rivers are all considered susceptable to acidification by acid rain (Newcombe, 1977). "tributary to"?

Other major aquatic systems which contain few dissolved solids and have alkalinities which classify them as susceptable to acidification include the Stein River, Nahatlatch River and Seton River. All drain weather resistant plutonic rocks of the coast range, and occur in regions of high rainfall. Only the Seton river supports salmonids of regional importance.

b) Biological Setting

The study region supports a large variety of freshwater and anadromous fish species. Some 29 species of warmwater and coldwater fishes have been identified in its lake and stream habitats. The region is primarily noted for its anadromous fish populations (those which spawn in freshwater but spend one or more years of their life cycle in the sea) of pacific salmon and rainbow trout (steelhead). Four species of Pacific salmon (coho, pink, sockeye and chinook) ascend major stream systems of the study region to spawn. Because of their overlapping migratory patterns, spawning adult salmon may be found in the study region in all except a few months of the year. The major river systems of the Thompson, North Thompson, Nicola and Adams Rivers all support populations of anadromous salmonids which contribute significant numbers to the sport and commercial fisheries and provincial indian food fishery.

Both resident and anadromous rainbow trout are present in the region and are taken as the principal sport fish. The Thompson River is noted for its excellent steelhead fishery and attracts anglers from throughout Canada and the United States. There are no known rare or endangered fish species in the study region (McPhail, pers. comm.)

(i) Resident Fishes

A total of 25 resident freshwater fish species are found in the study region (Table 4-2). Many are small minnows and coarse fish that lack commercial value but act as key forage species which convert energy at lower aquatic trophic levels to food utilized by sport fish, small mammals, and birds. Their distributions are generally ubiquitious, however, most are confined to lower stream reaches, sloughs, and lake shores, and along large rivers where waters remain relatively warm throughout the year. Most can tolerate or even thrive in moderately polluted waters. Minnows commonly found include bridgelip sucker (*Catostomus columbianus*), longnose dace (*Rhinichthys cataractae*), leopard dace (*Rhinichthys falcatus*), lake chub (*Couesius plumbeus*), peamouth chub (*Mylocheilus caurinus*), redside shiner (*Richardsonius balteatus*), largescale sucker

TABLE 4-2

RESIDENT FISH FOUND

WITHIN THE REGIONAL STUDY AREA

aleution sculpin	*Cottus aleuticus*
brassy minnow	*Hybognathus hankinsoni*
bridgelip sucker	*Catostomus columbianus*
brook trout	*Salvelinus fontinalis*
brown trout	*Salmo trutta*
burbot	*Lota lota*
carp	*Cyprinus carpio*
chiselmouth	*Acrocheilus alutaceus*
largescale sucker	*Catostomus macrocheilus*
Dolly Varden	*Salvelinus malma*
goldfish	*Carassius auratus*
kokanee	*Oncorhynchus nerka*
lake chub	*Couesius plumbeus*
lake trout	*Salvelinus namaycush*
leopard dace	*Rhinichthys falcatus*
longnose dace	*Rhinichthys cataractae*
mountain whitefish	*Prosopium williamsoni*
northern mountain sucker	*Catostomus platyrhynchus*
northern squawfish	*Pychocheilus oregonensis*
peamouth chub	*Mylocheilus caurinus*
prickly sculpin	*Cottus asper*
pygmy whitefish	*Prosopium coulteri*
rainbow trout	*Salmo gairdneri*
redside shiner	*Richardsonius baltectus*
torrent sculpin	*Cottus rhotheus*

From: BEAK field studies, 1977; B.C. Ministry Recreation and Conservation, Fish and Wildlife Branch, 1977C; Carl *et al.*, 1967; S. McDonald personal communication.

(*Catostomus macrocheilus*) and chiselmouth (*Acrocheilus alutaceus*). Larger coarse fish such as carp (*Cyprinus carpio*), burbot (*Lota lota*) and squawfish (*Ptychocheilus oregonensis*) are found in moderate numbers in the larger stream and lake systems.

Brook trout (*Salvelinus fontinalis*), Dolly Varden (*Salvelinus malma*), rainbow trout (*Salmo gairdneri*) Kokanee (*Oncorhynchus nerka*), and lake trout (*Salvelinus namaycush*) are resident salmonids which are found in the study region. Brook trout, a native to north-eastern North America, was introduced to western Canada in the early 1900's. Transplants in British Columbia have become established in some streams and lakes of the region. A single brook trout was taken in the Bonaparte River during the Beak field studies.

Dolly Varden are a char common to the region and are found in close association with spawning salmon populations. In many areas of North America Dolly Varden are reputed to be notorius predators of young salmon particularly at the time of downstream migrations and of salmon eggs during the spawning period (Scott and Crossman, 1973). However, in this region little is known of their predation and feeding habits. Dolly Varden are occasionally taken by sport anglers but are not considered a regionally important sport fish. (In the eastern extremes of the study area kokanee (land locked sockeye salmon)) have become established in Adams Lake and are taken in large numbers by the sport fishery. Two forms of rainbow trout are present within the study region, a resident form which remains throughout its life cycle within freshwater and another which decends to the Pacific Ocean where it spends most of its adult life before returning to freshwater to spawn.

General life histories of resident fish, common to both the local Hat Creek Valley and regional area, are provided in Appendix B. These life histories are based on literature and are intended to familiarize the reader with information describing their distribution, spawning and food habits, and age and growth characteristics. A summary presentation is given on Table 4-3.

TABLE 4-3 Summary of life history parameters for fish collected in the Bonaparte River and Hat Creek, September 1976

Species	Where Collected[1]	Importance	Preferred Habitat	Spawning Season	Spawning Habitat	Nursery Period	Age-length Relationships	Food Habits	Additional Notes
Rainbow trout	BR, HC	Most important sport fish in British Columbia	Lakes as well as streams with moderate flows, gravel bottoms & riffles; best suited to water temperatures ranging from 3.3°C in winter to 21.1°C in summer	Primarily after ice break-up in May or June in British Columbia	Bed of gravel or small rubble in a riffle usually upstream of a pool; in smaller tributaries of rivers or inlet or outlet streams of lakes.	Young hatch about 4-7 weeks after spawning & emerge from redds about 2-3 weeks later; fry of stream-resident fish may remain in tributaries during summer or begin downstream migration after emergence.	Age 1, 53-103 mm Age 2, 136-318 mm Age 3, 182-468 mm Age 4, 192-551 mm	As fish size increases diet progresses from plankton to insects & crustaceans to fish.	Life expectancy about 6-7 years and maximum weight about 3.6 kgm in interior B.C. Dwarf forms generally exhibit shorter life span & slower growth
Mountain Whitefish	BR, HC	Food & game fish.	Lakes & rivers preferring larger to smaller streams; appears adaptable to a changing environment	Mid-November in Okanagan system	Over gravel or rubble without constructing a redd; at depths of 127-1219 mm in Montana	Young hatch in March in Okanagan system; fry remain in stream shallows until 30-40 mm long, then move offshore	Age 1, 66-135 mm Age 2, 107-224 mm Age 3, 163-297 mm Age 4, 196-328 mm Age 5, 221-330 mm Age 6, 284-358 mm Age 7, 325-391 mm Age 8, 351-417 mm Age 9, 376-442 mm	Primarily insect larvae & occasionally fish	Maximum age 17 or 18 years; maximum size 2.0 kgm; can compete for food with other salmonids
Brook Trout	BR	Food & game fish.	Clear, cool, well oxygenated lakes & streams with water temps- below 20.0°C	Fall	Bed of gravel in shallow headwater streams or over gravel in a lake shallows where a current exists.	Young hatch in spring & become free swimming at a length of about 38 mm.	Age 0+, 35-45 mm Age 1+, 90-155mm Age 2+, 130-295mm Age 3+, 180-390mm Age 4+, 220-440mm Age 5+, 260-490mm Age 6+, 300-535mm	Primarily insects, larger fish consume amphibians, reptiles & small mammals.	Seldom live longer than 5 years or grow larger than 4.5 kgs
Bridge-lip Sucker	BR, HC	Forage fish	Colder waters of small, swift rivers with gravel to rocky substrates; seldom in lakes	Early June in B.C.	Probably the same as preferred habitat	-	Young attain lengths of 40-80 mm at end of 1st summer, maximum size of adults to 381 mm.	Algae, occasionally benthic invertebrates	-
Longnose Dace	BR, HC	Possible forage & occasional bait fish	Clean, swift-flowing stream with gravel to boulder substrate	May to late August	Riffles over a gravel substrate	Young hatch in 7-10 days then rise to surface about 1 week later; inhabit shore waters for about 4 months, then move to stream bottom	Age 1, 48 mm Age 2, 61 mm Age 3, 74 mm Age 4, 86 mm Age 5, 99 mm	Primarily aquatic insect larvae	Adults usually occur near stream bottom; maximum length reported in Manitoba & Lake Erie is 124 mm
Leopard Dace	BR, HC	Possible forage fish	Running water, occasionally in shallows of large lakes	Early July	-	-	From 9-18 mm in August of 1st year to 80-120 mm at age 4+	Aquatic & terrestrial insects, earthworms	Leopard dace & longnose dace often occur in same river system with the former preferring slower currents & the latter swifter currents
Redside Shiner	BR	Forage fish	Lakes & streams	May to early August	Riffles over gravel in spawning tributaries, over submergent vegetation near lake shores	Young hatch in 3-15 days in streams, young are carried downstream by currents about 10 days after hatching	From 5-10 mm during midsummer of 1st year to 110+ mm at age 4+	Aquatic & terrestrial insects	Redside shiner can be serious competitors with trout for food and space

[1] BR - Bonaparte River
HC - Hat Creek

(ii) Anadromous Fishes

Major populations of 5 species of anadromous fish are found within the study area. These include sockeye salmon (*Oncorhynchus nerka*), pink salmon (*Oncorhynchus gorbuscha*), coho salmon (*Oncorhynchus kisutch*.), chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*Salmo gairdneri*). Described as the greatest salmon river in North America (International Pacific Salmon Fisheries Commission 1974a) the Fraser River and its system produces an estimated annual commercial catch of 7,094,000 salmon (Environment Canada, Fisheries and Marine Service, 1974). Because of their major significance to the study region and the need for a thorough understanding of their life cycles, brief reviews of the life history of each pacific salmon found in the study region are presented in Appendix B and summarized in Table 4-4. Detailed information describing distribution, escapement and migratory characteristics are presented in the following sections.

(iii) Salmonid Escapement and Migratory Characteristics

Estimated average annual spawning escapements of salmon during 1957 - 1976 are given for all streams in the Fraser River System in Table 4-5. Escapement estimates for streams occurring within the regional study area and those located upstream or downstream of the region have been grouped separately for comparison. As pink and sockeye salmon are the major species in the Thompson system, major spawning locations are shown in Figure 4-5a.

(A) Pink Salmon

Although pink salmon spawn during odd years only, they are by far the most abundant salmon found within the study region. During odd years pink salmon account for nearly 85% of the total salmon escapement to the region (Table 4-6). The largest spawning runs occur in Thompson and Bridge Rivers where an estimated 264,901 and 9,611 respectively, migrate to spawn (Figure 4-6). Secondary spawning streams include the Bonaparte (788), Nicola River (1,034) and South Thompson (101). All escapement figures given are based on averages for the period 1957 to 1976 (International Pacific Salmon Fisheries Commission, Annual Reports, 1957-76).

TABLE 4-4

SUMMARY OF LIFE HISTORY PARAMETERS

FOR SALMON AND STEELHEAD

Pink Salmon (*Oncorhynchus gorbuscha*)	Egg/Embryo - freshwater rivers and streams, subgravel; fall (Sept.-Oct.) through winter (Dec.-Feb.)
	Larvae/Alevin - freshwater rivers and streams; subgravel; spring (Feb.-May)
	Fry/Parr - freshwater-estuarine, fry outmigrate (April-May) to sea; life stage missing or very brief
	Smolt - freshwater rivers and streams through estuarine waters to marine habitat; April and May, immediately after emergence; migrate at 4.5°C
	Juvenile - inshore water near mouth of river for several weeks or months, migration to deeper open sea waters by September; remain at sea until maturity at age two
	Reproductive Adult - migrate from open sea to freshwater rivers and streams for spawning (Sept.-Oct., second year of life)
Sockeye Salmon (*O. nerka*)	Egg/Embryo - freshwater streams, subgravel; fall and winter (as early as July) incubation from 50 days to 5 months
	Larvae/Alevin - freshwater streams, subgravel; spring (Feb.-Mar.-April) 3-5 weeks duration
	Fry/Parr - migrate to lakes or occasionally rivers without lakes, found along shoreline of lakes initially before movement to deeper water after a few weeks; this stage commonly lasts one year until spring following hatching
	Smolt - lake water till temperature ranges from 4-7°C at surface, then downstream through streams

TABLE 4-4 Cont'd.

SUMMARY OF LIFE HISTORY PARAMETERS

FOR SALMON AND STEELHEAD

Sockeye Salmon Cont'd.	migration at 3-4 km/day; spring of second year of life, leaves Fraser River by early May Juvenile - inshore areas during late spring - early summer, later offshore; statistics suggest fish leave vicinity of Fraser River by mid-late May; fish remain at sea for more than two years until maturation occurs Reproductive Adult - mature adults begin an inshore migration during summer of the fourth year; a pre-spawning migration occurs in the river during July for early run and August or September for later run; spawning occurs in the fall in the tributaries or outlet streams of lakes
Chinook Salmon (*O. tshawytscha*)	Egg/Embryo - freshwater streams subgravel, eggs spawned July-Nov. (several runs); hatching several months later in the spring Larvae/Alevin - freshwater streams, subgravel; stage lasts 2-3 weeks (emergence Jan.-March) Fry/Parr - freshwater streams and rivers; variable stage duration; usually migration begins soon after emergence, but freshwater stage may last one year or more Smolt - freshwater streams and rivers to estuarine to marine water; emigration occurs in the spring with the young appearing off the mouth of the Fraser River in April Juvenile - juveniles appear to remain inshore during the first summer outside the river; later go to open ocean; probably leave in fall and spend 2-3 years at sea until maturity

TABLE 4-4 Cont'd.

SUMMARY OF LIFE HISTORY PARAMETERS

FOR SALMON AND STEELHEAD

Chinook Salmon Cont'd.	Reproductive Adult - mature fish return at age 4 or 5, appear off the mouth of the Fraser as early as Jan., with maximum in Aug./Sept.; spawning is generally in the fall
Coho Salmon (*O. kisutch*)	Egg/Embryo - freshwater, subgravel in streams and some larger rivers (to a lesser extent); fall and winter (Sept. on).
	Larvae/Alevin - freshwater rivers and streams, subgravel; winter and early spring (emergence between early March and late July)
	Fry/Parr - freshwater rivers and streams for approximately one year
	Smolt - freshwater rivers and streams through estuarine waters to marine habitat; migration to salt water begins in March or April; arrive at mouth in May
	Juvenile - lower river, estuarine and inshore areas through spring and summer; migration to open sea in fall; ocean water until 3 or 4 years old when maturation occurs (at age two for some males)
	Reproductive Adult - migrate from open sea south along Alaskan and B.C. coast; enter main stream of Fraser between July and November
Steelhead (*Salmo gairdneri*)	Egg/Embryo - freshwater stream, subgravel; mid-April to May spawning and 4-7 weeks to hatch
	Larvae/Alevin - freshwater stream, subgravel; late spring-summer; 3-7 days to absorb yolk sac; emergence from mid-June to mid-August

TABLE 4-4 Cont'd.

SUMMARY OF LIFE HISTORY PARAMETERS

FOR SALMON AND STEELHEAD

Steelhead Cont'd.	Fry/Parr - from 1-4 years (fry generally 2 years) spent in freshwater streams or lakes
	Smolt - freshwater streams, lakes through estuary to sea; migration generally during spring
	Juvenile - the young are found in the less saline waters of the Strait of Georgia off the outlet of the Fraser; they remain at sea (and may make extensive migrations) for various periods, returning to spawn after 1-4 years at sea
	Reproductive Adult - mature adults return to spawn at ages ranging from about 3 years tc 7 years with repeat spawning common

TABLE: 4-5

SUMMARY OF AVERAGE SALMON ESCAPEMENTS (1957-1976) IN STREAMS LOCATED UPSTREAM WITHIN AND DOWNSTREAM OF THE REGIONAL STUDY AREA.

	Escapement				% of F.R. System[1]			
Location	PK	SO	CH	CO	PK	SO	CH	CO
Streams Upstream of Study Region	140,481	1,050,543	18,271	8,282	9	88	36	13
Streams of the Study Region	276,659	11,569	13,139	6,215	17	1	26	10
Streams Downstream of Study Region	1,224,035	130,854	18,843	47,517	75	11	37	77
TOTALS	1,641,175	1,192,966	50,253	62,014	101	100	99	100

CODE NAME:

1. PK = Pink; SO = Sockeye; CH = Chinook; CO = Coho
   F.R. = Fraser River.

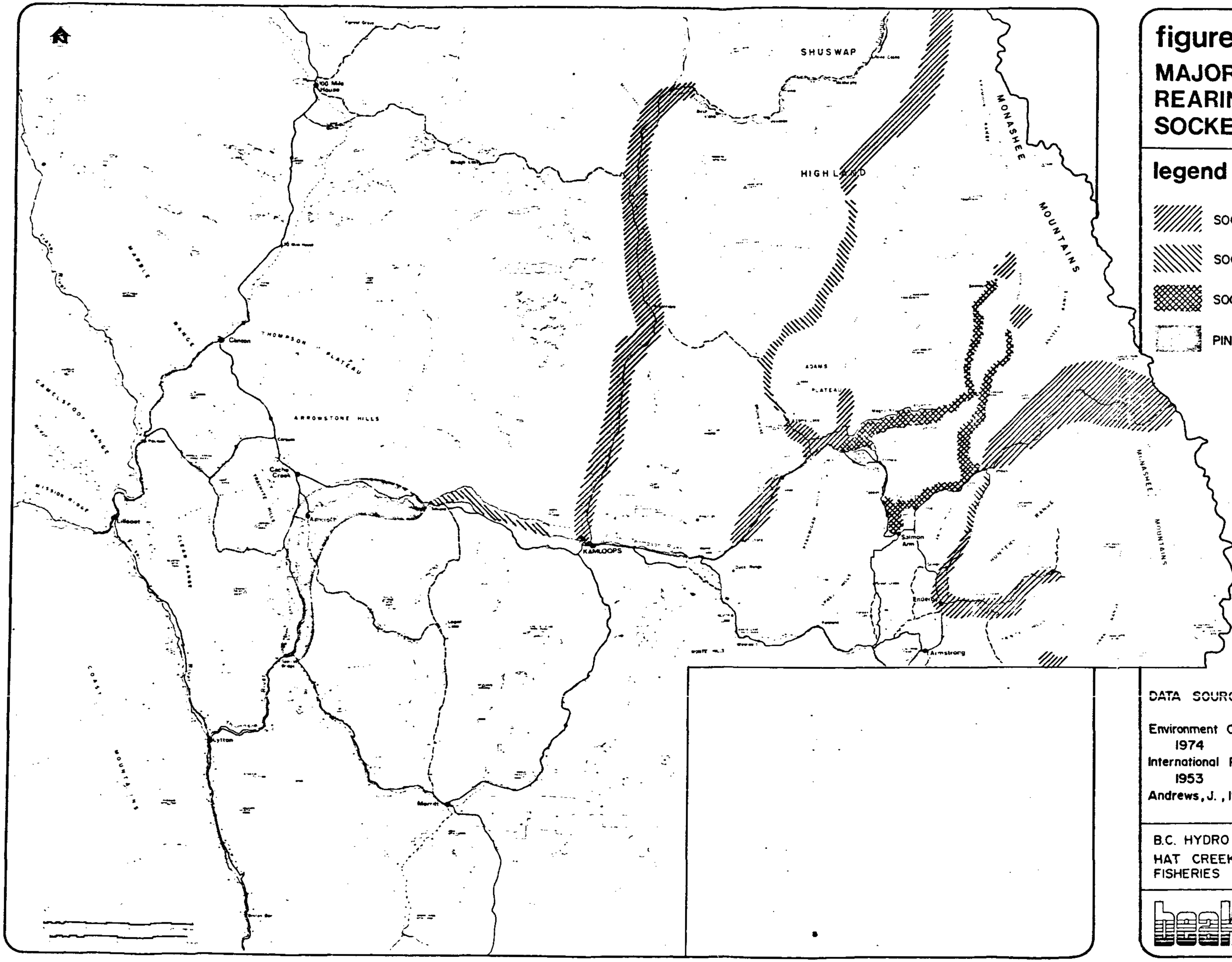

figure 4·5a

MAJOR SPAWNING AND REARING AREAS OF SOCKEYE & PINK SALMON

legend

- SOCKEYE SPAWNING
- SOCKEYE REARING
- SOCKEYE SPAWNING AND REARING
- PINK SPAWNING

Page 4-25

DATA SOURCES

Environment Canada, Fisheries and Marine Service 1974

International Pacific Salmon Fisheries Commission 1953

Andrews, J., 1977 personal communication

B.C. HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT
FISHERIES AND BENTHOS STUDY

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TABLE 4-6

AVERAGE PINK SALMON ESCAPEMENTS (1957-1976) IN STREAMS

LOCATED UPSTREAM, WITHIN AND DOWNSTREAM OF THE REGIONAL STUDY AREA[1,2]

	Average Escapement		
	Number	Percent of Regional	Percent F.R. System
Streams Upstream of the Study Region[3]			
Seton River	133,882	95.3	8.1
Portage River[4]	3,473	2.5	<1
Quesnel River[5]	3,126	2.2	<1
Total Escapement	140,481		9
Streams of the Study Region[6]			
Thompson River	264,901	95.7	16.1
Bridge River	9,611	3.5	<1
Nicola River (incl. Spius & Coldwater Creeks)	1,034	<1	<1
Bonaparte River[4]	788	<1	<1
Middle Fraser River[4] (minor tributaries)	224	<1	<1
South Thompson River (minor tributaries)	101	<1	<1
Total Escapement	276,659		17
Streams Downstream of the Study Region[3]			
Fraser River lower (mainstream)	771,243	63.0	47.0
Harrison River	228,973	18.7	14.0
Chilliwack & Vedder Rivers	187,406	15.3	11.4
Chehalis River	11,618	1	<1
Coquihalls River	8,611	<1	<1

(a)

TABLE 4-6 Cont'd.

AVERAGE PINK SALMON ESCAPEMENTS (1957-1976) IN STREAMS

LOCATED UPSTREAM, WITHIN AND DOWNSTREAM OF THE REGIONAL STUDY AREA

	Average Escapement		
Streams Downstream of the Study Region Cont'd.	Number	Percent of Regional	Percent F.R. System
Sweltzer Creek	5,600	<1	<1
Fraser River lower (minor tributaries)	5,540	<1	<1
Jones Creek	2,741	<1	<1
Stave River	1,661	<1	<1
Weaver Creek	642	<1	<1
Total Escapement	1,224,035		75
GRAND TOTAL	1,641,175		

---

1 International Pacific Salmon Fisheries Commission, 1957-74 and 1975-77.

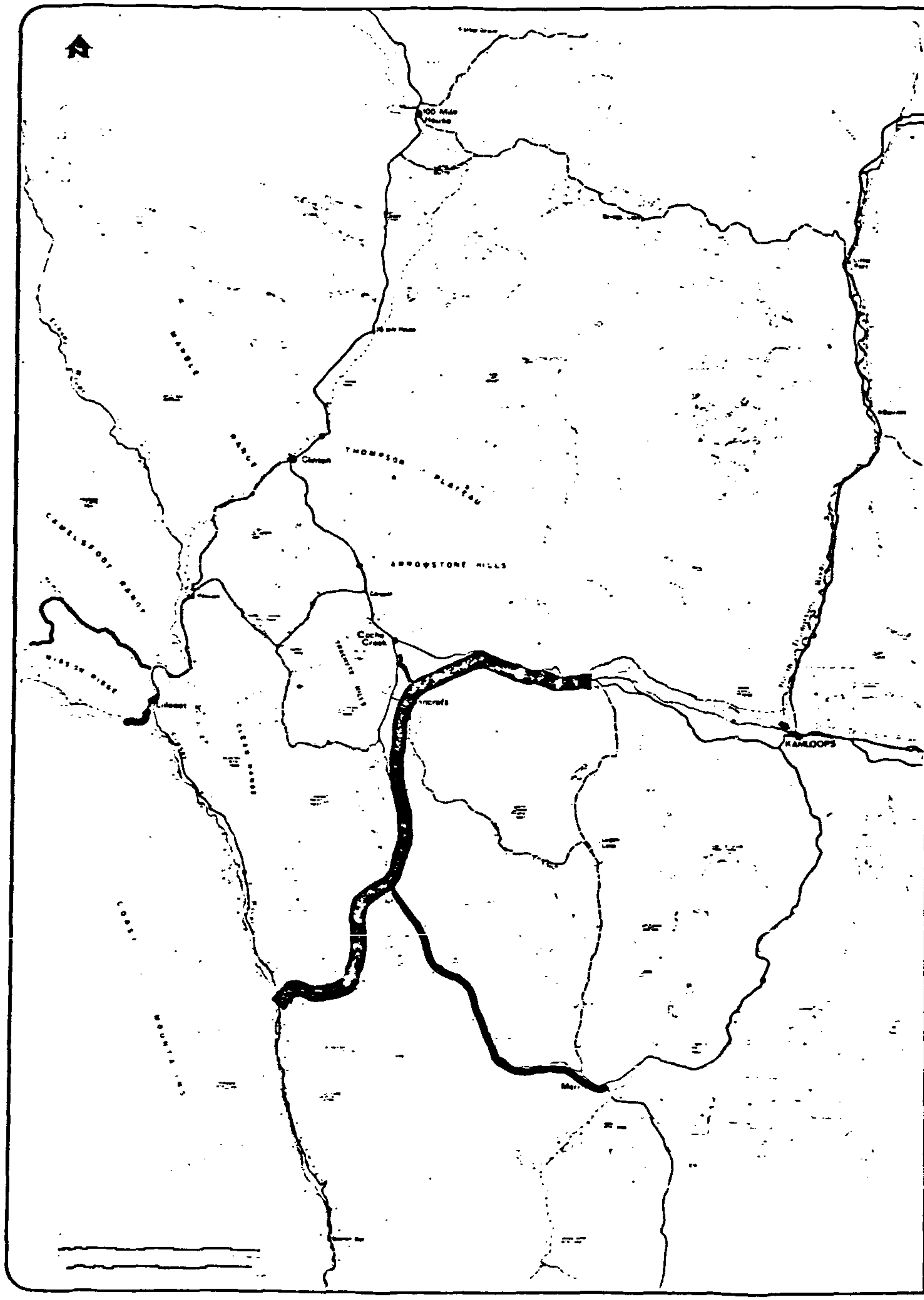
2 Escapement is a measure of the number of spawning fish and does not include migrants to other streams. Pink salmon occur only in odd years, the cycle average is given (i.e. not annual average).

3 Average for 1957-1972

4 Average for 1957-1971

5 Average for 1965, 1967 and 1971

6 Average for 1957-1976. Escapement refers to entire stream; where a stream is only partly within the boundaries of the regional base map area, escapement may apply to areas outside of the zone.



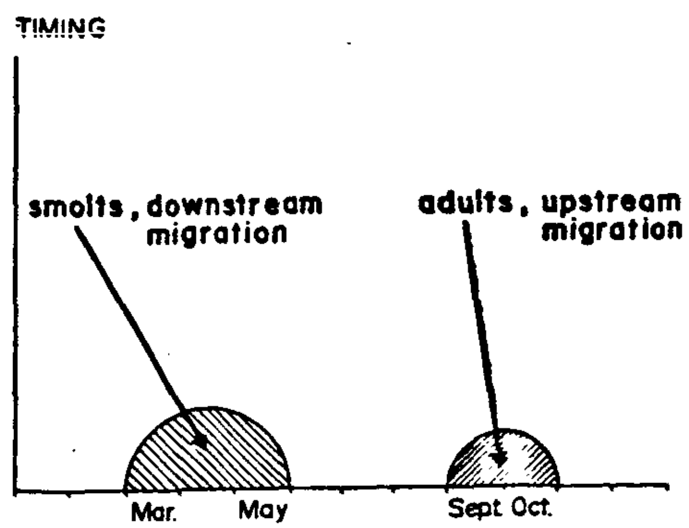


figure 4·6

PINK SALMON ESCAPEMENT AND TIMING (odd years)

legend

ESCAPEMENT (odd years only)

- <1,000
- 1,000 - 10,000
- 100,000 - 500,000

DATA SOURCES

International Pacific Salmon Fisheries Commission, Annual Report

Northcote, T.G., 1974

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Pink salmon spawn during odd years in the Fraser River from September to October and downstream fry migrations take place from March to May depending upon winter conditions (Northcote, 1974). In the Thompson River, peak spawning occurs in October (International Pacific Salmon Fisheries Commission, 1967-1976) and downstream fry migrations in April and May (Pyper, 1976).

Unlike chinook, sockeye and coho salmon which remain in freshwater to rear, pink salmon migrate to the sea soon after emergence. Fry migration monitored at Spatsum in the Thompson River (19 km below Ashcroft) in 1974 illustrate the relative abundance and frequency of occurrence of pink fry in the Thompson River (Figure 4-7) during the downstream migration (Pyper, 1976).

In the Thompson River, pink salmon spawn from Spences Bridge to Kamloops Lake with the highest density (78%) occurring upstream of the Bonaparte River (Figure 4-6) (B.C. Research & Dolmage Campbell & Assoc., 1975). The following spawning densities for the Thompson River between the Fraser River and Kamloops lakes has been reported by B.C. Research and Dolmage Campbell & Associates Limited (1975):

Latitudinal Distribution	Estimated Escapement	
Nicola River (km 37) to km 56	18,543	(7 percent)
km 56 to km 68	31,788	(12 percent)
km 68 to Bonaparte River (km 77)	7,947	(3 percent)
Bonaparte River to Kamloops Lake	206,623	(78 percent)
Total Escapement	264,901	(100 percent)

(B) Sockeye Salmon

The major sockeye salmon producing stream in the regional area is the South Thompson River which supported an estimated annual escapement of 10,053 individuals. Minor rivers utilized by sockeye for spawning include the Barriere River (75), Clearwater River (250), and the North Thompson River (164) (Table 4-7).

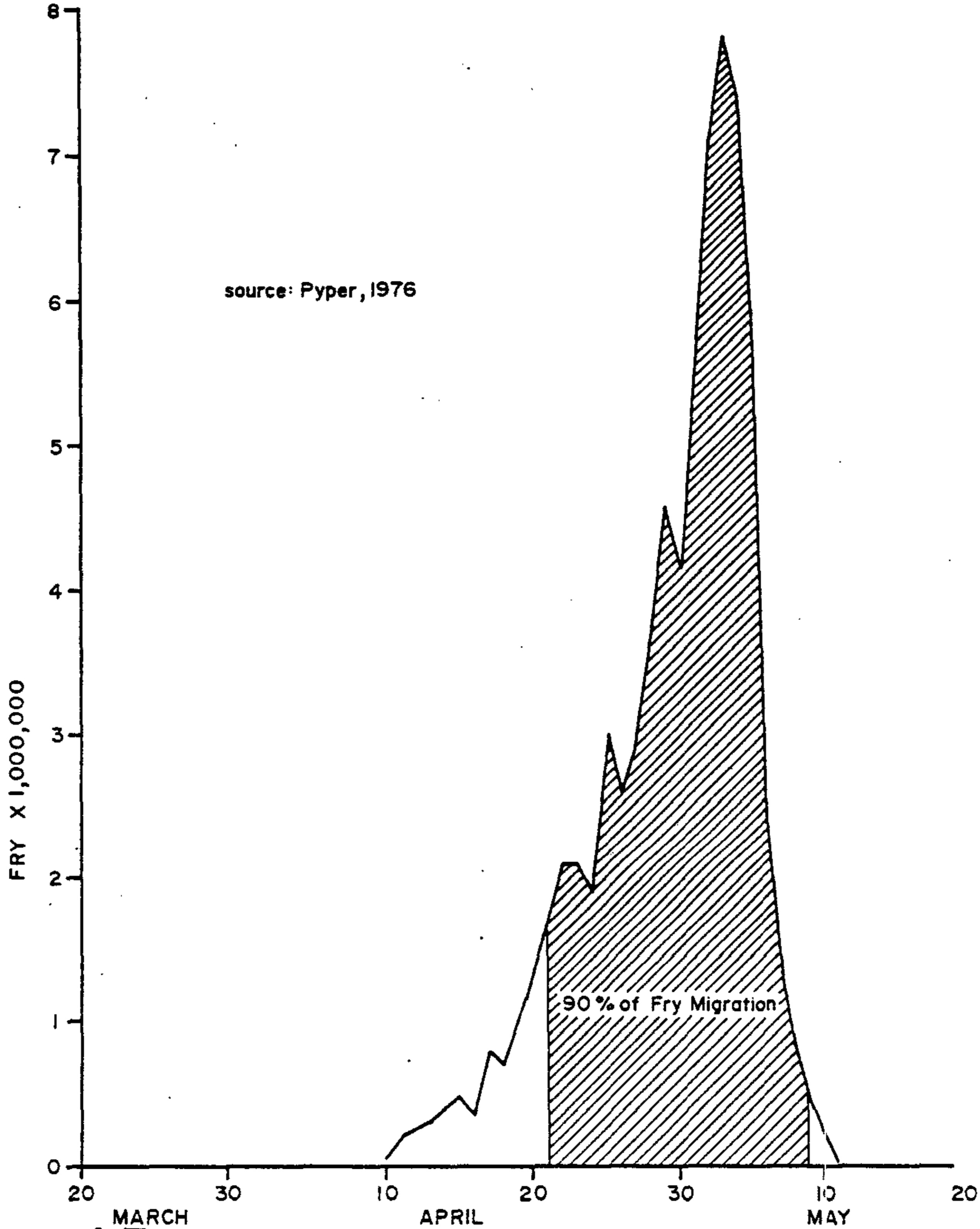

figure 4·7
PINK SALMON FRY MIGRATION IN THE THOMPSON RIVER (1974) IN REGIONAL STUDY AREA

TABLE 4-7

AVERAGE SOCKEYE SALMON ESCAPEMENT (1957-1976) IN STREAMS

LOCATED UPSTREAM, WITHIN AND DOWNSTREAM OF THE REGIONAL STUDY AREA[1,2]

	Number	Percent of Regional	Percent of F.R. System
Streams Upstream of the Study Region[3]			
Adams River (upper)	22	<1	<1
Adams River (lower)	431,372	41.1	36.2
Adams River (tributaries)	492	<1	<1
Bowron River	11,220	1.1	<1
Chilko River	272,533	26.0	22.8
Fennel Creek	357	<1	<1
Gates River	3,775	<1	<1
Horsefly River	74,338	7.1	6.2
Little River[4]	57,716	5.5	4.8
Little Horsefly River	37	<1	<1
Mitchell River	1,503	<1	<1
Nechako (incl. Endako, Nadina Nithi Rivers and Ormand Creek)	13,403	1.3	1.1
Portage River	4,236	<1	<1
Raft River	6,332	<1	<1
Seymour River	23,808	2,3	2,0
Shuswap River (lower)	6,649	<1	<1
Shuswap River (upper)	462	<1	<1
Stuart River	142,924	13,6	12.0
Taseko River	5,975	<1	1
Total Escapement	1,057,655		88
Streams of the Study Region[4]			
Barriere River	75	<1	<1
Clearwater River[5]	250	2.2	<1
North Thompson River	164	1.4	<1
South Thompson River	10,053	86.9	<1
South Thompson River (minor tributaries)	1,027	8.8	<1
Total Escapement	11,569		1

TABLE 4-7 Cont'd.

AVERAGE SOCKEYE SALMON ESCAPEMENT (1957-1976) IN STREAMS

LOCATED UPSTREAM, WITHIN AND DOWNSTREAM OF THE REGIONAL STUDY AREA

	Number	Percent of Regional	Percent of F.R. System
Streams Downstream of the Study Region			
Birkenhead River	56,761	45.9	4.8
Cultus Lake	18,501	15.0	1.5
Fraser River (lower - minor tributaries)	941	<1	<1
Harrison River	15,408	12.4	1.3
Pitt River (upper)	15.286	12.3	1.3
Weaver Creek	16,846	13.6	1.4
Total Escapement	123,743		10
GRAND TOTAL	1,192,967		

[1] Sockeye escapements from International Pacific Salmon Fisheries Commission, Annual Reports, 1957-1976

[2] Escapement is a measure of the number of spawning fish and does not include adults migrating to spawning areas in other streams

[3] Average for 1957 - 1972

[4] Average for 1957-1976

[5] Estimate only

The Thompson River also serves as a major migratory pathway for sockeye salmon enroute to spawning locations in the Lower Adams River (Figure 4-8). Considered one of the most important salmon runs in North America, the Lower Adams River accounted for approximately 50% of the total Fraser River Sockeye escapement (827,000) in 1976 (International Pacific Salmon Fisheries Commission 1977).

In the Fraser River, spawning occurs between June and October (Northcote, 1974). After remaining in freshwater for one to two years, juvenile sockeye salmon outmigrate as smolts from March to July (Northcote, 1974). In the Thompson River the main upstream spawning migration takes place from late July to late October with smolt migrations occurring from mid-April to mid-June at Spences Bridge (Fred Andrews, pers. comm.).

(C) Chinook Salmon

The North Thompson River, Thompson River, South Thompson and Clearwater Rivers are the major chinook spawning streams in the study area and receive estimated annual escapements of 1,090, 2,122, 3,975 and 1,629, (including Mahood River), respectively (Table 4-8 and Figure 4-9). Other streams utilized for spawning include Barriere River (67), Deadman River (256), Lemieux Creek (18), Louis Creek (227) and Mahood River.

Upstream spawning migrations take place between March and June in the Fraser River (Northcote 1974). In the Thompson River spawning takes place from early September to mid-October and peaks in late September (Fisheries and Environment Canada, Fisheries and Marine Service, 1977a). At one to three years of age, juvenile chinook migrate as smolt between May and September (L. Goodman & D. Aurel, pers. comm.).

(D) Coho Salmon

The Nicola River and Lemieux Creek are the major coho salmon spawning streams in the regional study area. These streams receive estimated annual escapements

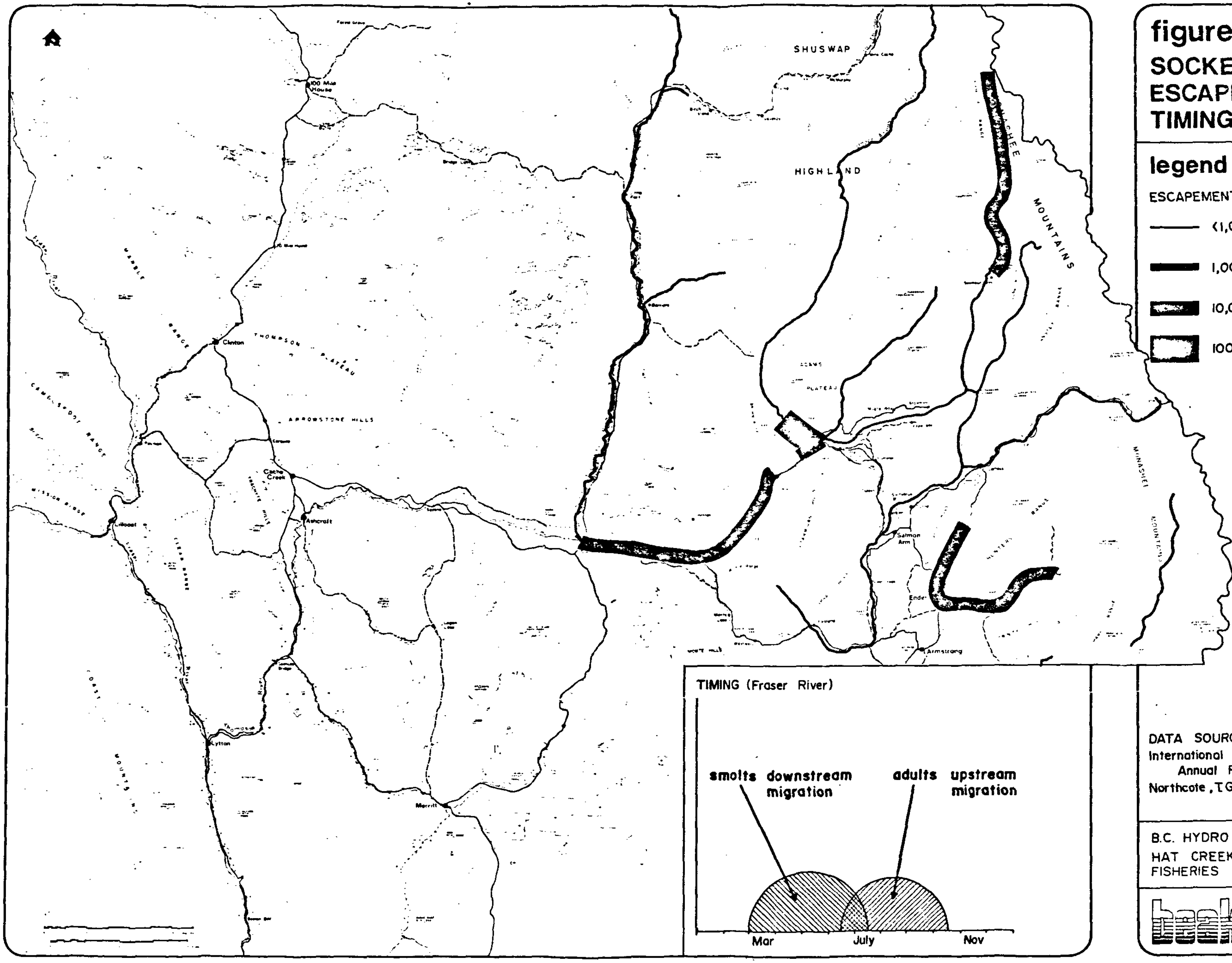

figure 4·8
SOCKEYE SALMON ESCAPEMENT AND TIMING

legend

ESCAPEMENT

- <1,000
- 1,000 - 10,000
- 10,000 - 100,000
- 100,000 - 500,000

DATA SOURCES
International Pacific Salmon Fisheries Commission Annual Reports
Northcote, T.G., 1974

B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
FISHERIES AND BENTHOS STUDY

BEAK CONSULTANTS LIMITED
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TABLE 4-8

AVERAGE CHINOOK SALMON ESCAPEMENT (1957-1976) IN STREAMS LOCATED UPSTREAM, WITHIN AND DOWNSTREAM OF THE REGIONAL STUDY AREA[1,2]

Streams Upstream of the Study Region[3]	Number	Percent of Regional	Percent of F.R. System
Adams River	2,007	8.2	4.3
Bowran River	1,022	4.2	2.2
Cariboo River	Present	-	-
Chilako River	85	<1	<1
Chilcotin River	691	2.8	1.5
Chilko River	3,106	12.8	6.7
Dome Creek[4]	25	<1	<1
Doré Creek[4]	25	<1	<1
Eagle River[5]	845	3.5	1.8
Finn Creek	673	2.8	1.4
Fleet Creek[4]	25	<1	<1
Fraser River N. (main stem)[4]	3,000	12.3	6.4
Fraser River N. (minor tributaries)[6]	90	<1	<1
Goat & Milk River & W. Twin Creek[6]	50	<1	<1
Holmes River, Horsey & Nevin Creek	400	1.6	<1
Horsefly River	198	<1	<1
McGregor River (tributary)[6]	614	2.5	1.3
Morkill River	323	1.3	<1
Portage River	128	<1	<1
Quesnel River	966	4.0	2.1
Raft River	334	1.4	<1
Salmon River[5]	192	<1	<1
Seeback Creek[4]	200	<1	<1
Seton River[5]	26	<1	<1
Slim Creek[4]	946	3.9	2.0
Shuswap River (lower)	5,219	21.4	11.2
Shuswap River (upper)	756	3.1	1.6
Shuswap River (minor tributaries)	91	<1	<1

TABLE 4-8 Cont'd.

AVERAGE CHINOOK SALMON ESCAPEMENT (1957-1976) IN STREAMS

LOCATED UPSTREAM, WITHIN AND DOWNSTREAM OF THE REGIONAL STUDY AREA

	Number	Percent of Regional	Percent of F.R. System
Streams Upstream of the Study Region Cont'd.			
Stellako River	231	<1	<1
Stuart River	295	1.2	<1
Swift Creek[4]	75	<1	<1
Taseko River	481	2.0	1.0
Torpy River & Keg Creek (West Torpy River)	600	2.5	1.3
Walker Creek[4]	300	1.2	0.6
Westroad River[9]	250	1.0	0.5
Willow River	68	<1	0.1
Total Escapement	24,337		53
Streams of the Study Region[7]			
Barriere River	67	<1	<1
Clearwater River & Mahood River[8]	1,629	17.2	3.5
Deadman River	256	2.7	<1
Lemieux Creek	18	<1	<1
Louis Creek	227	2.4	<1
Thompson River	2,122	22.4	4.5
North Thompson River	1,090	11.5	2.3
South Thompson River	3,975	42.0	8.5
Yalakom River	84	<1	<1
Total Escapement	9,468		20

TABLE 4-8 Cont'd.

AVERAGE CHINOOK SALMON ESCAPEMENT (1957-1976) IN STREAMS

LOCATED UPSTREAM, WITHIN AND DOWNSTREAM OF THE REGIONAL STUDY AREA

Streams Downstream of the Study Region[3]	Number	Percent of Regional	Percent of F.R. System
Birkenhead River	825	5.0	1.8
Chilliwack River	341	2.1	<1
Fraser River lower (minor tributaries)	268	1.6	<1
Mission & Harrison River	9,706	58.9	20.8
Nahatlatch River	56	<1	<1
Nicola River	3,671		3.4
Pitt River	1,581	9.6	3.4
Total Escapement	16,488		26
GRAND TOTAL	46,582		

[1] From Environment Canada, Fisheries & Marine Service (1974) and Fisheries & Marine Service, spawning files, unpublished ms., Vancouver

[2] Escapement is a measure of the number of spawning fish and does not include adults migrating to spawning areas in other streams

[3] Average for 1957-1972

[4] Estimate only

[5] Average for 1957-1976

[6] Average for 1955-1972

[7] Escapement refers to entire stream; where a stream is only partly within the boundaries of the the regional base map area, escapement may apply to areas outside of the zone. Data encompass 1957-1976

[8] Average for 1957-1964, 1973-1976 only

[9] Average for 1960 and 1964-1972 only

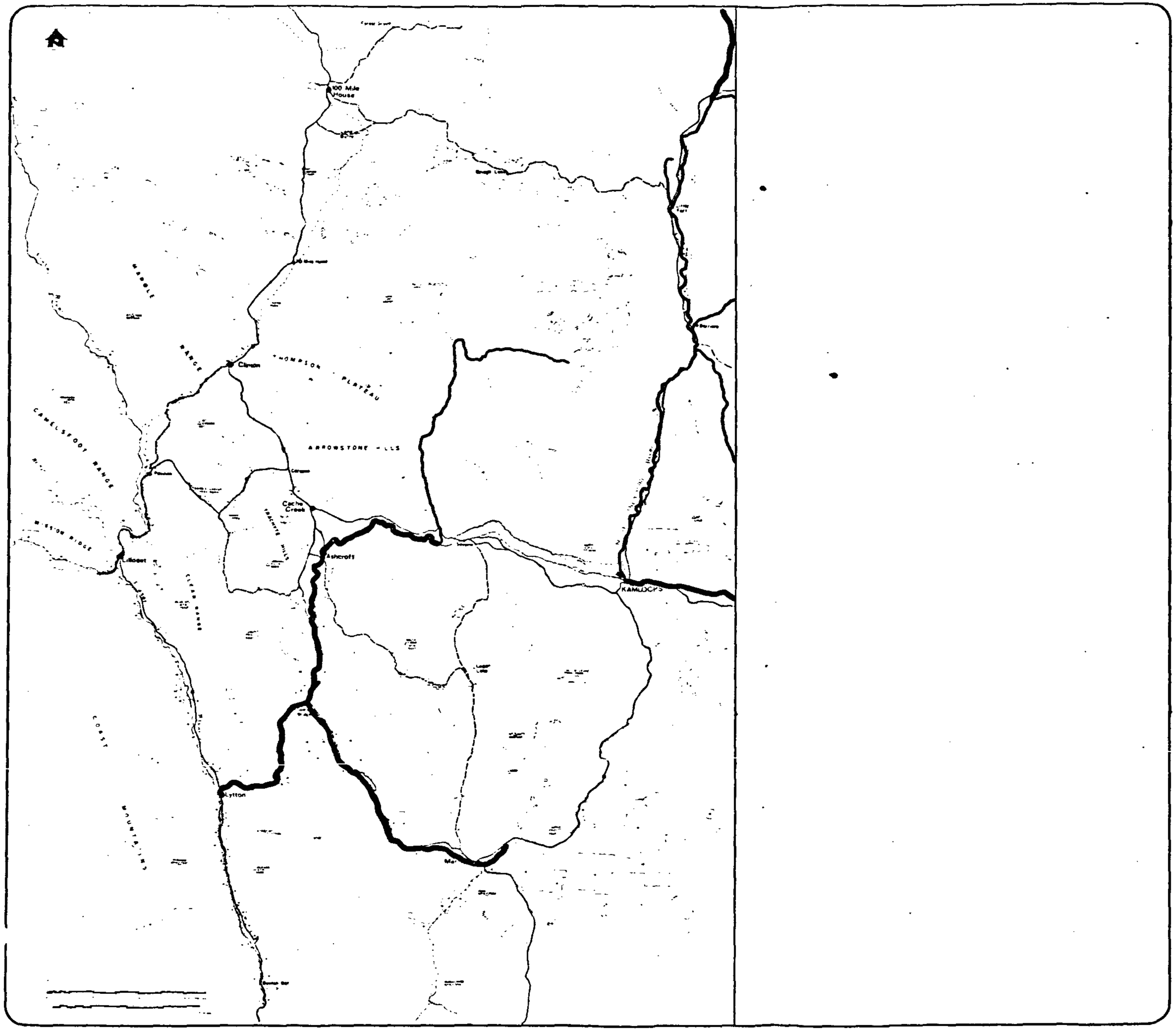


figure 4·9

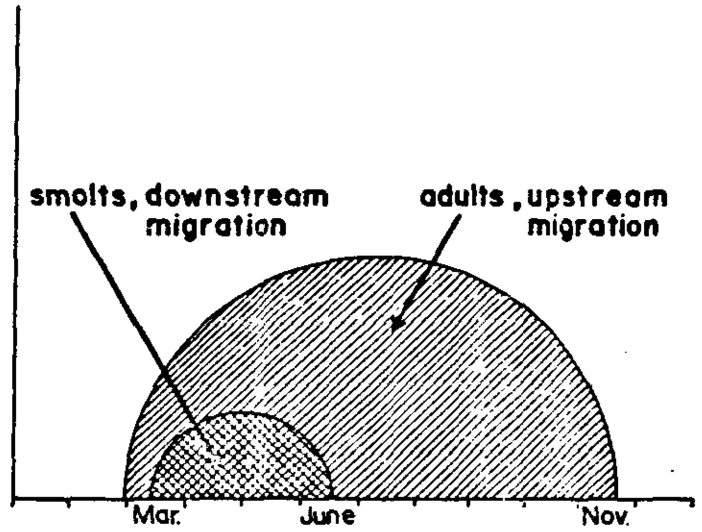
CHINOOK SALMON ESCAPEMENT AND TIMING

legend

ESCAPEMENT

- <1,000
- 1,000 - 10,000
- 100,000 - 500,000

TIMING (Fraser River)



DATA SOURCES:
Environment Canada, Fisheries and Marine Service, 1974
Northcote, T.G., 1974

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HAT CREEK PROJECT
FISHERIES AND BENTHOS STUDY

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of 1,558 and 904 spawners, respectively. Other streams of lesser importance include Deadman Creek (390), Barriere River (503), Mann Creek (80), and Brookfield Creek (75) (Table 4-9, Figure 4-10).

In the Fraser River, spawning commences between March and June with major smolt outmigrations occurring from March to June (Northcote, 1974). In the Thompson River, coho spawn from late September to early November (Fisheries and Environment Canada, Fisheries and Marine Service, 1977a).

(E) Steelhead

Steelhead are found in the Thompson River between Spences Bridge and Kamloops Lake. Other streams which support populations of steelhead include Nahatlatch River, Anderson River, ~~Stein River~~, Nicola River and tributaries, Bonaparte River (lower two miles), Deadman River and Tranquille Creek (B.C. Ministry of Recreation and Conservation, Fish and Wildlife Branch, 1977c). In the Thompson River spawning occurs from March to June and upstream migration takes place from September to April (Pers. comm. John Cartwright, Fish & Wildlife Branch, Oct. 1977).

(iv) Fisheries Resource Utilization

(A) Sport Fishery

The study region contains a large number of lakes and streams which support good to excellent sport fisheries. Steelhead and resident rainbow trout are the principal species sought by sport fishermen. However, eastern brook trout, lake trout, Dolly Varden, kokanee, chinook salmon, mountain whitefish and burbot are also taken.

Best known for its quality steelhead fishing, the region attracts fishermen from across Canada and the United States to the Thompson River. The Thompson River is one of the finest steelhead "trophy" producing streams in British Columbia. Steelhead reach an excess of 9 kg and average 810 mm in length.

TABLE 4-9

AVERAGE COHO SALMON ESCAPEMENT (1957-1976) IN STREAMS

LOCATED UPSTREAM, WITHIN AND DOWNSTREAM OF THE REGIONAL STUDY AREA[1,2]

	Number	Percent of Regional	Percent of F.R. System
Streams Upstream of the Study Region[3]			
Adams River	485	4.7	<1
Anstey River	98	<1	<1
Bessette Creek	831	8.1	1.3
Eagle River[4]	1,867	18.1	3.0
Fennel Creek	241	2.3	<1
Finn Creek	249	2.4	<1
Gates Creek[5]	364	3.5	<1
Lion Creek	2,094	20.3	3.4
Portage Creek	66	<1	<1
Raft Creek	634	6.1	1.0
Reg Christie Creek	37	<1	<1
Salmon River[4]	1,299	12.6	2.1
Seton River & Cayoosh Creek[4]	17	<1	<1
Shuswap River (lower)	980	9.5	
Shuswap River (upper)	1,047	10.1	
Total Escapement	10,309		16
Streams of the Study Region[4]			
Barriere River	503	8.1	1
Brookfield Creek[6]	75	1.2	1
Clearwater River & Mahood River[6]	527	8.5	1
Deadman River	390	6.3	1
Lemieux Creek	904	14.5	1.4
Louis Creek	1,376	22.1	2.2
Mann Creek	80	1.2	1
Nicola River (incl. Spius & Coldwater Creek)	1,558	25.1	2.5
Thompson River	120	1.9	1
North Thompson River[6]	682	11.0	1.1
Total Escapement	6,215		10

TABLE 4-9 Cont'd.

AVERAGE COHO SALMON ESCAPEMENT (1957-1976) IN STREAMS

LOCATED UPSTREAM, WITHIN AND DOWNSTREAM OF THE REGIONAL STUDY AREA

Streams Downstream of the Study Region[3]	Number	Percent of Regional	Percent of F.R. System
Birkenhead River	2,747	6.0	4.4
Chilliwack River & Vedder River	21,047	46.2	33.9
Chilliwack - Vedder (tributary)	1,941	4.3	3.1
Fraser River (lower - minor tributary)	6,395	14.0	10.3
Harrison River	11,707	25.7	18.9
Lillooet River	545	1.2	1
Lillooet River (tributaries)	1,108	2.4	1.8
Total Escapement	45,490		74
GRAND TOTAL	62,014		

---

[1] From Environment Canada, Fisheries & Marine Service (1974) and Fisheries & Marine Service, spawning files, unpublished ms., Vancouver

[2] Escapement is a measure of the number of spawning fish and does not include adults migrating to spawning areas in other streams

[3] Average for 1957-1972

[4] Average for 1957-1976. Escapement refers to entire stream; where a stream is only partly within the boundaries of the regional base map area, escapement may apply to areas outside of the zone

[5] Average for 1957, 1958 and 1961-1972 only

[6] Estimate only

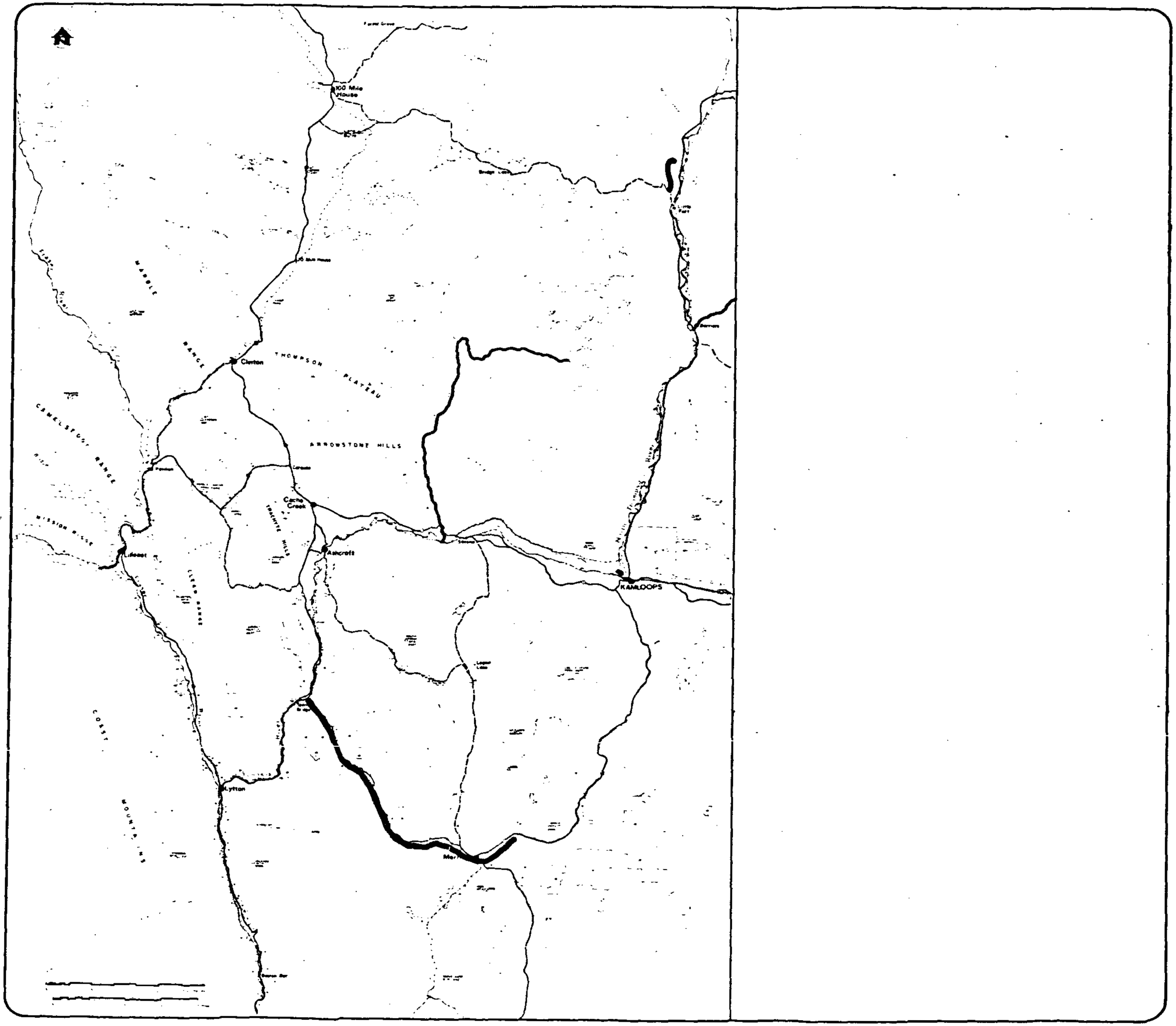


figure 4·10

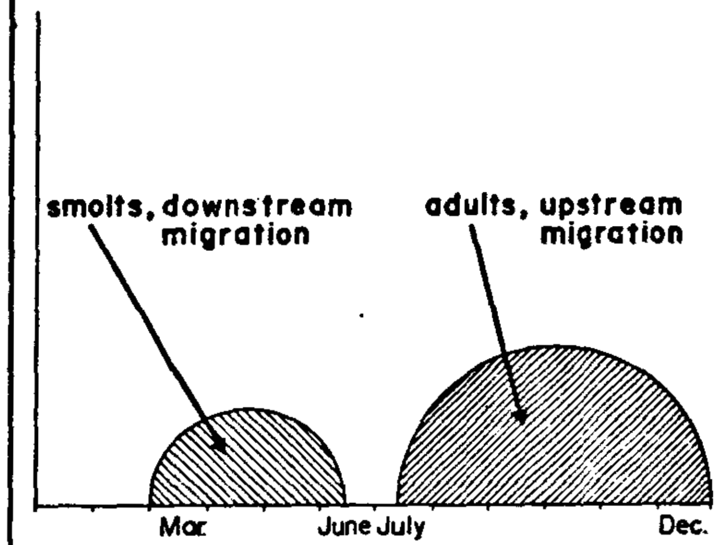
COHO SALMON ESCAPEMENT AND TIMING

legend

ESCAPEMENT

- <1,000
- 1,000 - 10,000
- 100,000 - 500,000

TIMING (Fraser River)



DATA SOURCES

Environment Canada, Fisheries and Marine Service, 1974

Northcote, T.G., 1974

B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
FISHERIES AND BENTHOS STUDY

BEAK CONSULTANTS LIMITED
VANCOUVER, CANADA

Their large size and strong, aggressive behavioural characteristics make them highly valued as a sport fish. The steelhead sport fishery is primarily exploited during the fall and winter runs from October to January. An estimated 732 steelhead were taken during the 1976/77 season in the Thompson River at an average angler success rate of 0.122 fish/angler/day (B.C. Ministry Recreation & Conservation, Fish & Wildlife Branch, 1977d).

Steelhead fishing in the Thompson River accounted for 84% of the average total number of angler days (14,330) expended for steelhead in the region (Table 4-10). Numerous other streams in the region support steelhead; however, in terms of overall angler use they receive minor pressure. Province-wide, fishermen spent 206,944 angler days on streams fishing steelhead, 6.9 % was expended in the study region.

In the remainder of the regional area rainbow trout are the most important sport fish taken. In a survey conducted by Pearse Bowden (1971) during 1969 - 1970 in the Kamloops area results indicated rainbow trout accounted for 84% of the total sport fishing catch (653,000 fish). Char (both eastern brook trout and lake trout), kokanee, steelhead and other species accountec for 57,000, 19,000, 2,000, and 24,000 fish,respectively. By comparison,the total provincial sport fishing catch was 8,642,000 fish. The Kamloops area sport fish catch accounted for 7.6% of the total provincial catch.

Pearse Bowden (1971) indicated that 79 % of the anglers interviewed preferred to fish lakes in the Kamloops area as opposed to streams. In the regional area,an estimated 726,378 days of angler effort were expended on 228 lakes (Table 4-11 and Figure 4-11) Loon Lake, Tunkwa Lake, Lac Le Jeune, Pennask Lake and Roche Lake are the major lake systems which attract sport anglers. All received greater than 25,000 angler days of pressure per year (B.C. Ministry of Recreation & Conservation, Fish & Wildlife Branch, 1977a). The importance of the numerous, accessable smaller lakes in the region cannot be underrated. Nearly 60 percent of the total angler effort is expended on lakes which receive <5,000 angler days of effort per year (Appendix B, Table B-1).

TABLE 4-10

DISTRIBUTION OF STEELHEAD ANGLER EFFORT (ANGLER DAYS)

EXPENDED ON STREAMS IN THE STUDY REGION[1,2]

Water Body	Angler Days[3]	Percent of Regional Effort
Thompson River[4]	12,013	84
Salmon River	916	6
Bridge River	551	4
South Thompson River[4]	393	3
Seton River	165	1
Nicola River	117	<1
North Thompson River	80	<1
Stein River	47	<1
Barriere River	21	<1
Bonaparte River	8	<1
Cold Creek	7	<1
Deadman's Creek	6	<1
Yalakom River	5	<1
Tranquille River	1	<1
MacKay Creek	<1	<1
Total	14,330	100

From: B.C. Ministry Recreation & Conservation, Fish & Wildlife Branch, 1968-1976

[1] Harvest Summary: Total Angler Effort on all streams in Region 14,330
Total Angler Effort on all streams in Province 206,944

[2] Harvest date exists for 1966-67 but does not include numbers of angler days

[3] Angler days - number of anglers x number of days fished per angler

[4] During 1967-72 Thompson River and South Thompson River data were included under the heading "Thompson River"

TABLE 4-11

SUMMARY OF LAKE SPORT FISHING

EFFORT EXPENDED IN MANAGEMENT UNITS

OF THE STUDY REGION

Management Unit	Number of Lakes Fished	Angler Days[2]	Percent of Total Effort
3-12	20	123,828	16.9
3-13	9	33,000	4.5
3-14	1	10,000	1.4
3-15	5	4,800	0.6
3-16	3	6,000	0.8
3-17	12	38,500	5.3
3-18	21	74,150	10.1
3-19	22	125,500	17.1
3-20	18	76,100	10.4
3-27	12	51,500	7.0
3-28	13	18,500	2.5
3-29	19	33,150	4.5
3-30	36	55,000	7.5
3-31	5	10,750	1.5
3-33	1	1,000	0.1
3-38	5	9,500	1.3
3-39	26	60,100	8.2
TOTAL	228	731,378	99.7

[1] Source: B.C. Ministry Recreation & Conservation, Fish & Wildlife Branch, 1977a

[2] Angler days - number of anglers x number of days fished per angler

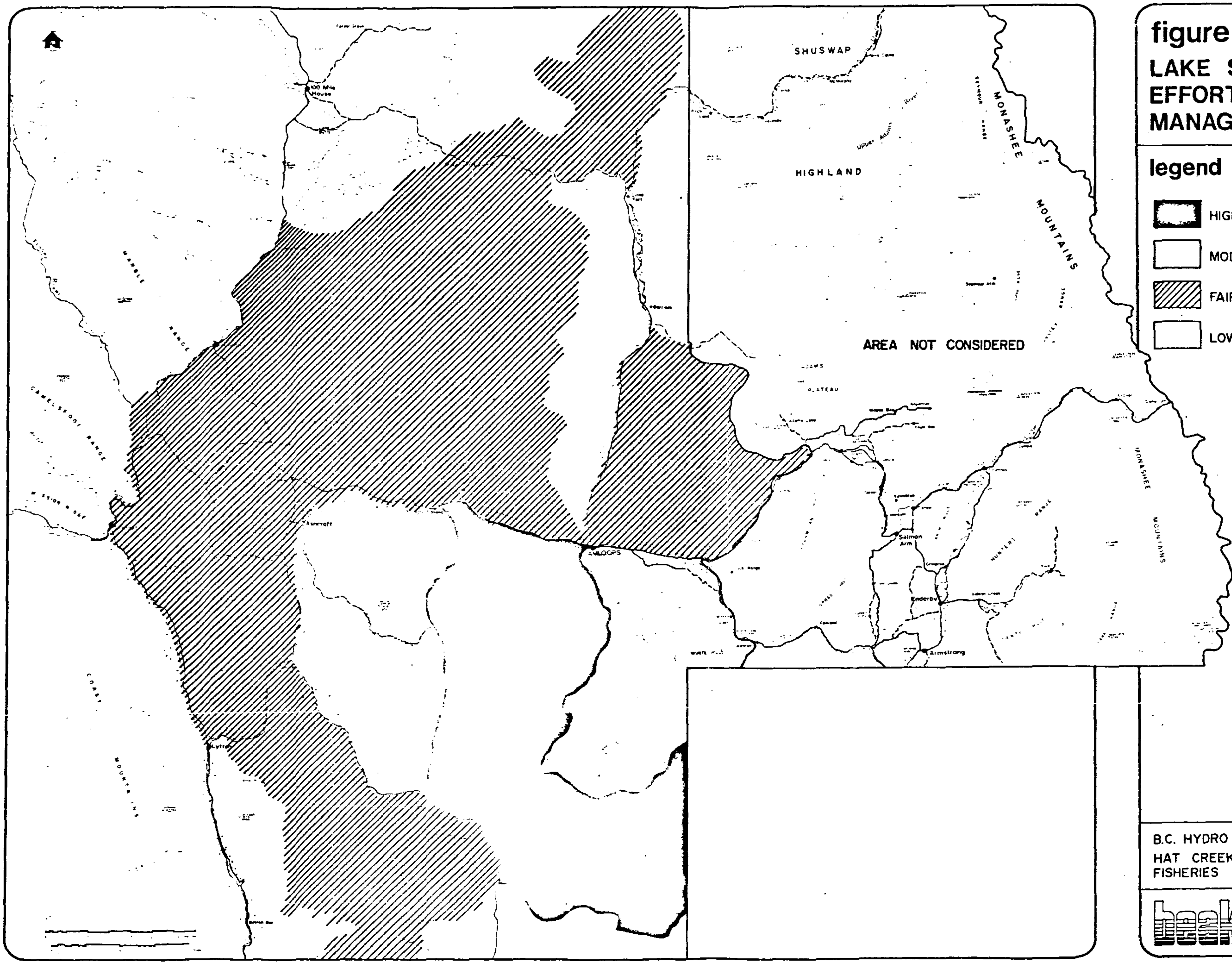


figure 4·11

LAKE SPORT FISHING EFFORT BY MANAGEMENT UNIT

legend

- HIGH
- MODERATE
- FAIR
- LOW

B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
FISHERIES AND BENTHOS STUDY

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VANCOUVER, CANADA

Within the immediate vicinity of Hat Creek (40 km) 41 lakes and streams in portions of eight management units (numbers 13,16,17,18,29,30,31 and 32) provide recreational sport fishing and receive an estimated total angler effort of 116,600 days (B.C. Ministry of Recreation & Conservation, Fish and Wildlife Branch, 1968-76 and 1977a). Over 50% of the fishing pressure is expended on Tunkwa, Kwutlenemo, Pavilion, Leighton and Loon Lakes. The most popular local area management unit is number 17 (Hat Creek vicinity). Unit 17 contains the greatest number of lakes angled and also receives the greatest fishing pressure (51,500 angler days).

In an attempt to determine the capability of local lakes to support increased fishing pressure, opinions of local Fish & Wildlife officials were solicited and their comments summarized on Table 4-12. Most lakes in the vicinity of Hat Creek were considered capable of supporting an increase in fishing pressure; however, Green Lake, Kelly Lake, Kelly Creek and Tunkwa Lake were thought to be at maximum production. Any increase in fishing pressure would likely result in depletion of present fish stocks (S.J. McDonald and J. Cartwright, Pers. comm.). The Thompson River was considered very close to its maximum yield at the present time, however, other sport fish (resident rainbow trout and whitefish) populations were capable of withstanding increased fishing pressure.

Fish stocking in the study region has been used as a management tool to supplement natural populations and, in early years, to introduce exotic fish species. First begun in 1909 with experimental releases of rainbow trout, Atlantic salmon, lake trout and brook trout in Paul Lake, fish stocking has continued as one of the key management tools in maintaining the quality of regional sport fisheries. A stocking history of lakes in the regional area is presented with respect to Management Units in Appendix B, Table B-2. A summary presentation of this data is given in Figure 4-12.

In the past, the province has released rainbow trout, brook trout, kokanee, steelhead, cutthroat trout, atlantic salmon and lake trout in its waters. However, rainbow trout has been the most commonly stocked fish in the last ten years. Paul Lake, Carpenter Lake, Minnie Lake, Pavilion Lake, Peter Hope

TABLE 4-12

CAPABILITY OF LAKES AND STREAMS WITHIN THE LOCAL HAT CREEK AREA TO SUSTAIN INCREASED ANGLING PRESSURE

Water Body	Capable of Supporting an Increase	Principal Sport Fish
Barnes Lake	Yes	rainbow trout
Cornwall Lake	Yes	rainbow trout
Five Mile Lake	Yes	brook trout
Four Mile Lake	Yes	brook trout
Green Lake	No	rainbow trout, kokanee
Hat Creek	Yes	rainbow trout
Kelly Creek	No	rainbow trout
Kelly Lake	No	rainbow trout
Kwutlenemo Lake	Yes, but near maximum	rainbow trout
Leighton Lake	Yes	rainbow trout
Loon Lake	Yes, but near maximum	rainbow trout
Quiltanton Lake	Yes	rainbow trout
Pavilion Lake	Yes, substantial increase	rainbow trout, kokanee
Seton Lake	Yes, substantial increase	rainbow trout, salmon, Dolly Varden, whitefish, kokanee
Six Mile Lake	Yes	brook trout
Thompson River	Yes, but near maximum	steelhead
Tunkwa Lake	No	rainbow trout

From: S.J. MacDonald & J. Cartwright, Fish & Wildlife Branch, Kamloops, 1977 (personal communication)

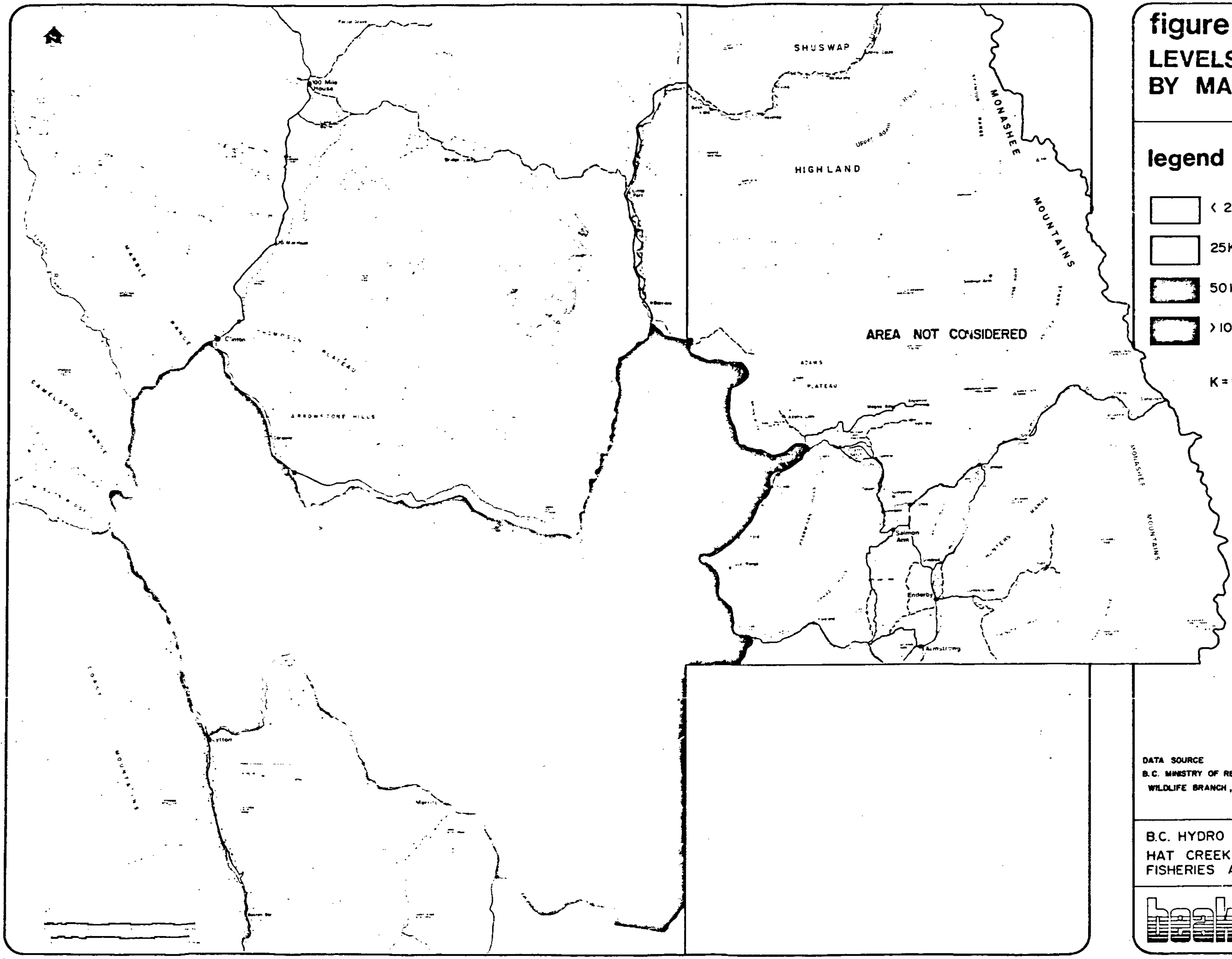


figure 4·12
LEVELS OF STOCKING BY MANAGEMENT UNIT

legend

< 25 K

25K - 50K

50K - 100 K

> 100 K

K = 1000

DATA SOURCE
B.C. MINISTRY OF RECREATION AND CONSERVATION, FISH AND WILDLIFE BRANCH, 1976 b.

B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
FISHERIES AND BENTHOS STUDY

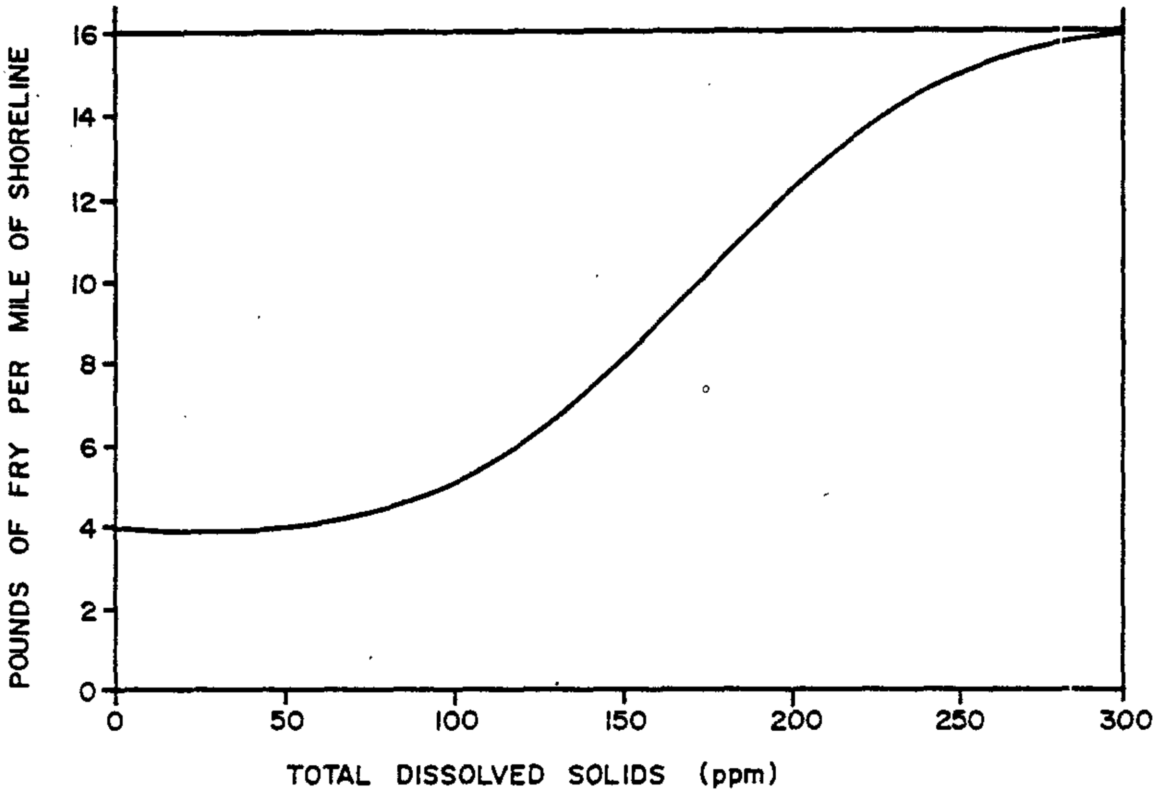
BEAK CONSULTANTS LIMITED
VANCOUVER, CANADA

Lake, Roche Lake, Stump Lake, Heffley Lake, Jacko Lake, Knouff Lake and Tunkwa Lake are all important sport fish lakes which have been stocked in excess of 20,000 fish per year over the last ten years.

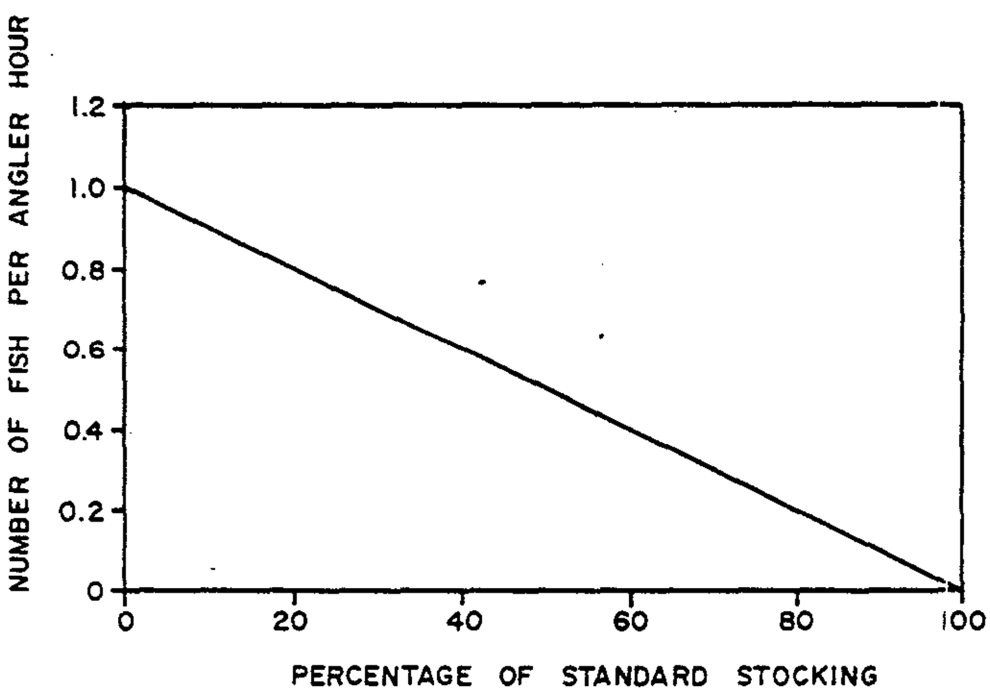
Stocking formulas employed by the Fish and Wildlife Branch to determine the numbers of fish stocked are based on several factors which take into consideration lake productivity, catch success, natural recruitment and public access (Smith *et al.*, 1969). Two graphical aids used in estimating stocking rates are shown in Figure 4-13. Where natural recruitment is marginal or intermittent and catch success is less than 1 fish/hour/angler, fish stocking rates can be obtained from the linear function presented in Figure 4-13. The numbers of fish stocked are also evaluated in terms of lake productivity as measured by total dissolved solids. More productive lakes (higher dissolved solids) are stocked at a greater rate than those which contain less total dissolved solids. In areas where public access is available, stocking rates are related to access and the quality of available spawning area as shown in Table 4-13.

The size of fish stocked in the region varies depending upon hatchery availability and predictability of survival. In general, fall stockings of rainbow trout consist of fry less than 50 mm in length, while in spring, releases consist of fingerlings which range from 50 to 100 mm in length (S.J. McDonald, pers. comm.).

Sport fishery regulations in the regional study area prohibit the use of any fish product other than crustacea or roe. Many rivers in the area are closed to sport fishing between May 1 and June 30 and other regulations such as closures and gear restrictions vary with specific lakes and streams in the study area. Daily catch limits are as follows: aggregate rainbow trout, kamloops trout, steelhead, cutthroat trout, brown trout, Dolly Varden, lake trout, brook trout and kokanee (2, >50cm) aggregate trout, char and grayling (8, >50 cm), kokanee (125, > 50 cm) and burbot (10) (B.C. Ministry Recreation & Conservation, Fish & Wildlife Branch, 1977b). Trout are defined as: rainbow, kamloops, steelhead, cutthroat, brown, and char as Dolly Varden, lake trout & brook trout.



Curve used to estimate Rainbow Trout fry stocking rate from total dissolved solids (from Smith *et al.*, 1969)



Relationship between percentage of standard stocking and number of fish per angler hour (from Smith *et al.*, 1969)

figure 4·13

GRAPHICAL TECHNIQUES USED BY FISH AND WILDLIFE BRANCH TO ESTIMATE FISH STOCKING RATES

TABLE 4-13

RELATIONSHIP OF STOCKING RATE* TO PUBLIC ACCESS

AND QUALITY OF AVAILABLE SPAWNING AREA

	Spawning Rate (%)			
Public Access	Good	Medium	Poor	Nil
Good	0-30	60	80	100
Medium	15	30	45	60
Poor	0-15	15	20	30

Source: Smith *et al.*, 1969.

*Stocking Rate: percent of theoretical stocking rate as determined by graphical methods shown in Figure 4-13.

Ice fishing is a popular sport in the Kamloops area (Stewart, 1977). The first lake in British Columbia designated as an ice fishing only area is Trapp Lake (brook trout). Trapp Lake is situated 24 km south of Kamloops and has attracted hundreds of ice fishermen. The introduction of brook trout into this system in 1975 has enhanced the winter sport fishery.

Jocko, Stake, Walloper and Tunkwa Lakes support substantial rainbow trout populations. Lac La Hache is also well known as a good winter fishery, primarily for kokanee. Red Lake, Heffley Lake, Paul Lake and Kanouff Lake are all popular winter ice fishing areas (S. McDonald, Fish and Wildlife Branch, pers. comm.).

B. Commercial Fishery

The Fraser River system supports a major international pacific salmon fishery that is exploited by Canada and the United States (International Pacific Salmon Fisheries Commission, 1977a). The estimated average annual commercial catch of Fraser River salmon (1957-72; Table 4-14) was 7,094,000 (Environment Canada, Fisheries and Marine Service, 1974).

The Fraser River accounts for approximately one-third of the total salmon taken in the provincial commercial fishery (Aro & Shepard, 1967). Ten percent of the provincial catch originates from the Thompson River system. The commercial salmon fishery in B.C. had a wholesale market value of $219,758,000 in 1974 (B.C. Department of Finance, 1975).

Historical catch and escapement information for pink salmon in the Thompson River are included in Table 4-15.

C. Subsistence Fishery

The Indian food fishery (salmon and steelhead) is based on a permit per household system and unless stocks are threatened, the catch is not limited (Environment Canada, Fisheries & Marine Service, 1974). The average annual indian food catch of salmon and steelhead in the Fraser River is 186,018 (Environment

TABLE 4-14

AVERAGE ANNUAL COMMERCIAL CATCH AND CATCH/ESCAPEMENT RATIOS

OF SALMON ORIGINATING FROM VARIOUS REGIONS OF THE FRASER RIVER SYSTEM (1957-1972)

Area	Chinook (4.0:1)	Sockeye (3.1:1)	Coho (3.0:1)	Pink (2.9:1)	Chum (1.5:1)	Total
Upper Fraser Basin						
Grand Canyon Basin	20,725	-	-	-	-	
McGregor River Basin	2,930	-	-	-	-	
North Fraser Area	8,183	721,680	-	-	-	
Total	31,838	721,680	-	-	-	753,518
Central Fraser System						
Cariboo River Basin	357	-	-	-	-	
Quesnel River System	4,181	235,228	-	-	-	
Middle Fraser Area	17,044	888,212	1,024	210,656	-	
Total	21,582	1,123,440	1,024	210,656	-	1,356,702
Thompson River Basin						
Clearwater River Basin	6,039	775	740	-	-	
North Thompson System	9,290	22,971	15,405	-	-	
Thompson/S. Thompson	68,534	1,668,048	22,050	344,520	-	
Total	83,863	1,691,794	38,195	344,520	-	2,158,372

TABLE 4-14 Cont'd.

AVERAGE ANNUAL COMMERCIAL CATCH AND CATCH/ESCAPEMENT RATIOS

OF SALMON ORIGINATING FROM VARIOUS REGIONS OF THE FRASER RIVER SYSTEM (1957-1972)

Area	Chinook (4.0:1)	Sockeye (3.1:1)	Coho (3.0:1)	Pink (2.9:1)	Chum (1.5:1)	Total
Lower Fraser Area	45,665	383,625	103,512	1,782,978	509,505	7,093,877
GRAND TOTAL	182,948	3,920,539	142,731	2,338,154	509,505	7,093,877

From: Environment Canada, Fisheries & Marine Service, 1974

TABLE 4-15

PINK SALMON COMMERCIAL CATCH/ESCAPEMENT DATA

FOR PERIOD OF RECORD IN THE THOMPSON RIVER

Year	Escapement Thompson River & Tributaries[1]	Catch Thompson River & Tributaries
1957[2]	269,106	780,407.4
1959	87,224	252,950
1961	69,411	201,292
1963	285,243	827,205
1965	233,100	675,990.0
1967	450,487	1,306,412.3
1969	247,896	718,898
1971	258,203	748,789
1973	283,385	821,816
1975	480,350	1,393,015.0

From: International Pacific Salmon Fisheries Commission, Annual Reports 1957-1976

[1] Includes Nicola River, Bonaparte River and minor tributaries
[2] Records of pink salmon were not kept by International Pacific Salmon Fisheries Commission until 1957

Canada, Fisheries & Marine Service, 1974). In 1976, 68,675 sockeye salmon were caught in the Thompson River system, and the Fraser River between Hope and Churn Creek (36 km north of Clinton) by indian fishermen (International Pacific Salmon Fisheries Commission, 1976.).

D. Enhancement

The Fraser River is included in the Federal Government's salmonid enhancement program which is designed to increase commercial catches. Enhancement techniques such as hatcheries and rearing facilities are being investigated. Enhancement of salmon and steelhead is proposed in the regional study area and escapement are expected to increase by 500,000 sockeye, 70,000 coho, 20,000 chinook and 4,000 steelhead (Table 4-16). The streams proposed for enhancement are tributaries of the Thompson River (Deadman River and Nicola River) and North Thompson (Barriere River). Presently, existing facilities are outside of the regional study area and commenced operation as early as 1961 (Table 4-16). Efforts are underway by the In ternational Pacific Salmon Fisheries Commission to introduce pink salmon into the Fraser River which spawn in even numbered years and to increase the present population which spawns in odd years.

(v) Existing Stresses on Fish Populations

Almost every salmon population in the Fraser River contains IHN disease (infectious hematopoictic necrosis). It has also been found in sockeye stock a
migrating through the Thompson River. Its effect on survival of n~~o~~tural salmon X
populations is not known; however, it can cause high mortality on hatchery fish. Parasites such as the proto~~x~~zoan *Trichophrya* sp. and the copepod *Salmincola* are occasionally found in salmon, but their effect on survival is ~~nto~~ NOT known (I. Williams, pers. comm.). Prespawning mortality has been observed in various races of sockeye salmon in the Fraser River system (Williams and Stelter, 1971). Hoskins & Hulstein (1977) reported myxobacterial gill disease in the Fraser River system.

TABLE 4-16

EXISTING AND PROPOSED SALMON AND STEELHEAD ENHANCEMENT FACILITIES

Existing Stream	Species	Description	Comments Start	Comments Area (sq. yd.)
Gates River	Sockeye	spawning channel	1968	13,489
Lower Seton River	Pink	spawning channel	1967	20,886
Nadina River	Sockeye	spawning channel	1973	21,639
Upper Pitt River	Sockeye	incubation channel	1963	711
Upper Seton River	Pink	spawning channel	1961	6,019
Weaver Creek	Sockeye	spawning channel	1965	20,846

Proposed	Species	Description	Number of Fish Added
Barriere River	sockeye		500,000
Deadman River	coho	rearing facility	40,000
	chinook		5,000
	steelhead	hatchery	2,000
Nicola River	coho	rearing facility	30,000
	chinook		15,000
	steelhead		2,000

From: Cooper, 1977 & Fisheries & Environment Canada, Fisheries & Marine Service, 1977

Lampreys (*Entosphenus tridentatus*) are parasitic fishes which attach to fresh-water and anadromous fishes, particularly salmon and steelhead (Hart, 1973). Their effect on the commercial Fraser River catch is not known (Hart, 1973). Lamprey parasitism has been observed in Adams River sockeye and in 1967 over half of the spawning adults bore detectable lamprey wounds resulting in an estimated mortality of 2% (Williams & Gilhousen, 1968). A small sample of pink salmon at the mouth of the Fraser River indicated approximately 20% had been subject to lamprey attack.

A summary of human activities in the study region is presented in Figure 4-14. Current water resource utilization in terms of water intakes and effluent discharges are presented in Tables 4-17 and 4-18, respectively. Mines in the regional study area include Afton (construction near completion), Bethlehem, Lornex and Craigmont. All have water intakes located on the Thompson River system. A pulp mill is located at Kamloops. Municipalities on the Thompson River which remove and discharge water include Ashcroft, Cache Creek, Clinton and Kamloops.

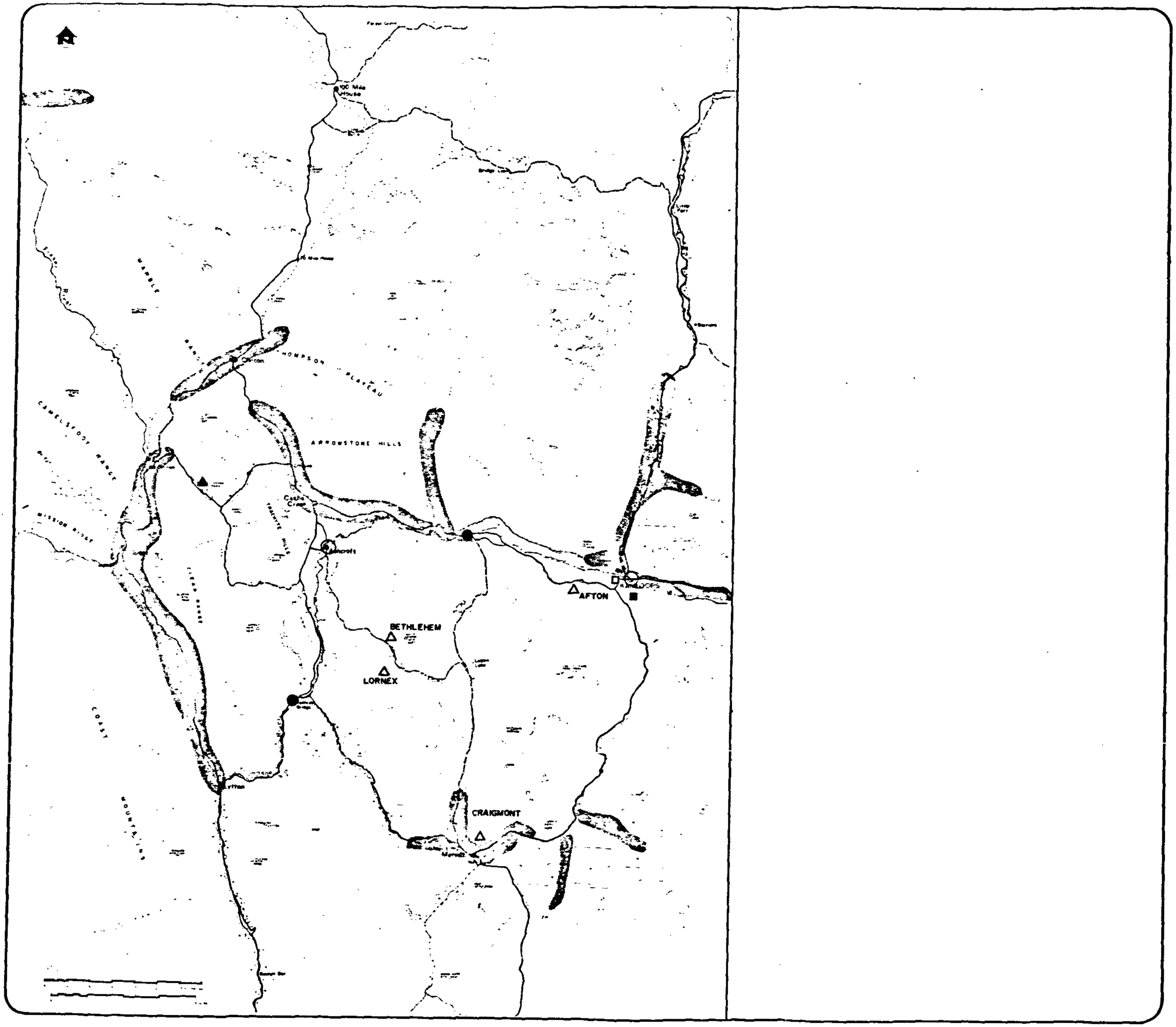


figure 4·14

AGRICULTURE AND INDUSTRY IN THE REGIONAL STUDY AREA

legend

- △ MINE WITH WATER INTAKE
- □ PULP AND PAPER MILL WITH WATER INTAKE AND DISCHARGE
- ○ MUNICIPALITY OR TOWN WITH WATER INTAKE AND DISCHARGE
- ● MUNICIPALITY OR TOWN WITH WATER INTAKE
- ▲ LIME QUARRY
- ■ CEMENT PLANT
- AGRICULTURE
- LOGGING (scattered patches throughout)

DATA SOURCES
Strong, Hall & Associates
Reid Collins & Associates
C.B.R.C.
British Columbia Water Rights Branch
British Columbia Pollution Control Branch

B.C. HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
FISHERIES AND BENTHOS STUDY

BEAK CONSULTANTS LIMITED
VANCOUVER, CANADA

TABLE 4-17

LOCATION AND VOLUME OF MAJOR WATER INTAKES

IN THE REGIONAL STUDY AREA

User	Volume (m^3/day)	Location
Mines		
Afton	construction near completion	No Loon Lake & One Loon L.
Bethlehem Copper	5679.7	Bethsaida Creek
	13.6	Peavine Creek
	16652.1	Jane Spring
	entire flow	Witches Brook
	2446.6	North Lodge
	2446.6	Mann Cr.
	2446.6	Nicholson Creek
	2446.6	Ford Creek
	2446.6	Michel Creek
	2446.6	Orm Creek
	210926.5	Bonaparte River
	299737.7	Scottie Creek
Lornex	1817.5	Thompson River
	13649.8	Pukaist Creek
	79560.0	Pukaist Creek
	113.6	Shuhost Creek
	113.6	Bethsaida Creek
	22202.8	Woods Creek
	5906.9	Nicola River
	169604.7	Stumbles Creek
	6.4	Stumbles Creek
Pulp & Paper		
Kamloops Mill	189649.4	Thompson River
Municipalities		
Ashcroft	4543.8	Thompson River
	1817.5	Thompson River
Cache Creek	4893.2	Bonaparte River
	3180.6	Bonaparte River
	2446.6	Lopez Creek

TABLE 4-17 Cont'd.

LOCATION AND VOLUME OF MAJOR WATER INTAKES

IN THE REGIONAL STUDY AREA

User	Volume (m^3/day)	Location
Clinton	90.9	Clinton Creek
	86.3	Clinton Creek
	10.9	Clinton Creek
	11101.4	Clinton Creek
Kamloops	90.9	South Thompson River
	2271.9	South Thompson River
	436654.9	South Thompson River
	396040.7	South Thompson River
	13631.2	South Thompson River
	44405.6	South Thompson River
	2271.9	South Thompson River
	2271.9	South Thompson River
	4543.8	North Thompson River
	1135.9	North Thompson River
	1850232.8	North Thompson River
	4543.8	North Thompson River
	2405302.6	North Thompson River
	22718.73	North Thompson River
	17268839.3	Jamieson Creek
	6167442.6	Jamieson Creek
	123348.9	Dairy Creek
	123348.9	Dairy Creek
	2466977.0	Noble Creek
	19735816.3	McQueen River
	13631.2	Thompson River
	111013.9	Thompson River
	2271.9	Thompson River
	3885488.8	Thompson River
	2.3	Scotney Brock
	2446.6	Peterson Creek
Savona	4543.8	Kamloops Lake
Spences Bridge	1817.5	Murray Creek
	4543.8	Thompson River

Source: B.C. Ministry of Environment, Water Rights Branch, 1977; and Council of Forest Industries of British Columbia, 1976.

TABLE 4-18

LOCATION AND VOLUME OF MAJOR DISCHARGES

IN THE REGIONAL STUDY AREA

Mines		
Afton	construction near completion	
Lornex	recirculating	
Craigmont	recirculating	
Bethlehem Copper	recirculating	
Municipalities - Thompson River System		
Ashcroft	636.1	Thompson River
Cache Creek	681.6	Cache Creek
Clinton	363.5	Bonaparte River
Kamloops	9087.5	Thompson River
Savona	no discharge (septic tanks)	
Spences Bridge	no discharge (septic tanks)	
Pulp & Paper		
Kamloops Mill	189649.4	Thompson River

Source: B.C. Ministry Environment, Pollution Control Branch, 1977.
Council of Forest Industries of British Columbia, 1976

4.2 OFFSITE ENVIRONMENT

The all weather access road proposed by B.C. Hydro to serve the plant site and station reservoir begins at the intersection of Highway 1 and the Ashcroft road and crosses the Trachyte Hills to the plant site following Cornwall Creek, MacLaren Creek, and Upper Medicine Creek. On the west side of the Trachyte Hills the road passes the plant site and parallels Hat Creek Valley at an elevation of approximately 914 m (3,000 Ft.) then drops abruptly to the valley floor and intersects the Hat Creek road just south of Highway 12.

Through its length the proposed routing will cross Cornwall Creek three times, make a single crossing at MacLaren Creek above McLean Lake and parallel both streams and Upper Medicine Creek for variable distances.

The road also crosses numerous other small intermittent tributaries which drain into these water courses. At the time of the survey none of these small intermittent tributaries contained measurable flow. Cornwall Creek, MacLaren Creek, and Upper Medicine Creek all contained flow but none were considered suitable for supporting fish populations.

Cornwall Creek, the largest of the two major streams crossed by the access road, originates above McLean Lake and follows a narrow, precipitous course through a steep valley to Boston Flats. Stream widths range from 0.3 to 0.5 m and depths 2 to 8 cm. Prevailing bottom substrata are small rocks and boulders. Prior to entering Boston Flats the stream is dammed to provide domestic water to local users. Any potential fish movement above Boston Flats in the small stream would be precluded by a perched irrigation flume located below the dam. After entering Boston Flats, Cornwall Creek broadens slightly (0.3 to 0.7 m) but remains shallow (2 to 10 cm deep) throughout most of its length. Unstable banks consisting of sand and gravel are characteristic and little cover occurs along the stream course to reduce high summer water temperatures. Overall, Cornwall Creek does not appear suitable to maintain fishes, however, the stream may be inhabited in its lower reaches by small numbers of warmwater fish including bridgelip suckers and longnose dace.

The only remaining stream which contained a flow at the time of the field survey and is crossed by the access road is MacLaren Creek. One of the few streams which drain into McLean Lake, this small (1.0 m wide), shallow (4.0 cm deep) stream did not appear to be suitable for maintaining even seasonal fisheries. Both MacLaren Creek and Cornwall Creek undoubtedly freeze solid during winter throughout much, if not all, of their length. Water survey records of Canada (Water Resoures Branch, 1974) for Cornwall Creek near Ashcroft (station No. 08LF006) for the period 1921 - 1931 indicate flow ceases from October to March.

Along the upper, intermittent reaches of Medicine Creek the access road parallels but does not come within close proximity to the channel. None of the stream courses crossed by the access road in the vicinity of the plant site contained flow at the time of the field survey. The outlet of Harry Lake was dry and appreciable evaporation appeared to have reduced lake size substantially.

4.3 HAT CREEK ENVIRONMENT

The emphasis within this section of the study is towards the fish and benthic invertebrate populations of Hat Creek and the physical environment in which they reside. Notwithstanding a local Hat Creek orientation, downstream sections of the Bonaparte River are also included insofar as identifiable interrelationships between the two systems may exist.

(a) Physical Environment

Station locations are shown in Figure 3-2 with biological studies conducted at each noted. The following observations were made to describe general characteristics for each station: substrate, bank vegetation and stability, depth, width, pool-riffle ratio, current and water temperature. Criteria used to determine these parameters are described in Section 3.3 (a). Actual field observations are presented in Appendix C (Basic Physiognonmy of Benthos and Fisheries Sampling Stations). These observations form one basis for the compilation of the habitat profile of Hat Creek.

(i) Habitat Profile

A variety of habitats was discernible within the Hat Creek system. Substrate, flow and character of the channel and associated terrestrial systems varied along the horizontal section of the creek. Hat Creek's general physiognomy displayed 17 habitat complexes designated as A, B, ..., and Q (Figure 4-15); a descriptive account of each is presented in Table 4-19. A helicopter survey on 23 September 1976 enabled the procurement of these data. Supplementary information was obtained during the succeeding two surveys.

(A) Canyon

The downstream-most 8 km of Hat Creek consisted of nine habitat complexes. This section encompassed a fan area, varied flows from slow meandering to fast and a chute which exhibited rapid flows with an abundance of large boulders.

In six of the nine complexes, riffles were most abundant. In one area, pools predominated and in two areas, pools and riffles were equally abundant. In this reach of Hat Creek there appeared to be suitable spawning gravel for rainbow trout in most complexes.

Sections F and H were the only areas that exhibited some degree of erosion. The abundance of deciduous trees, shrubs and grasses served to enhance bank stability at the majority of sites.

The only natural barrier to fish within the Canyon area was the chute (Section 1), where steep gradients and rapid currents may have impeded movement to

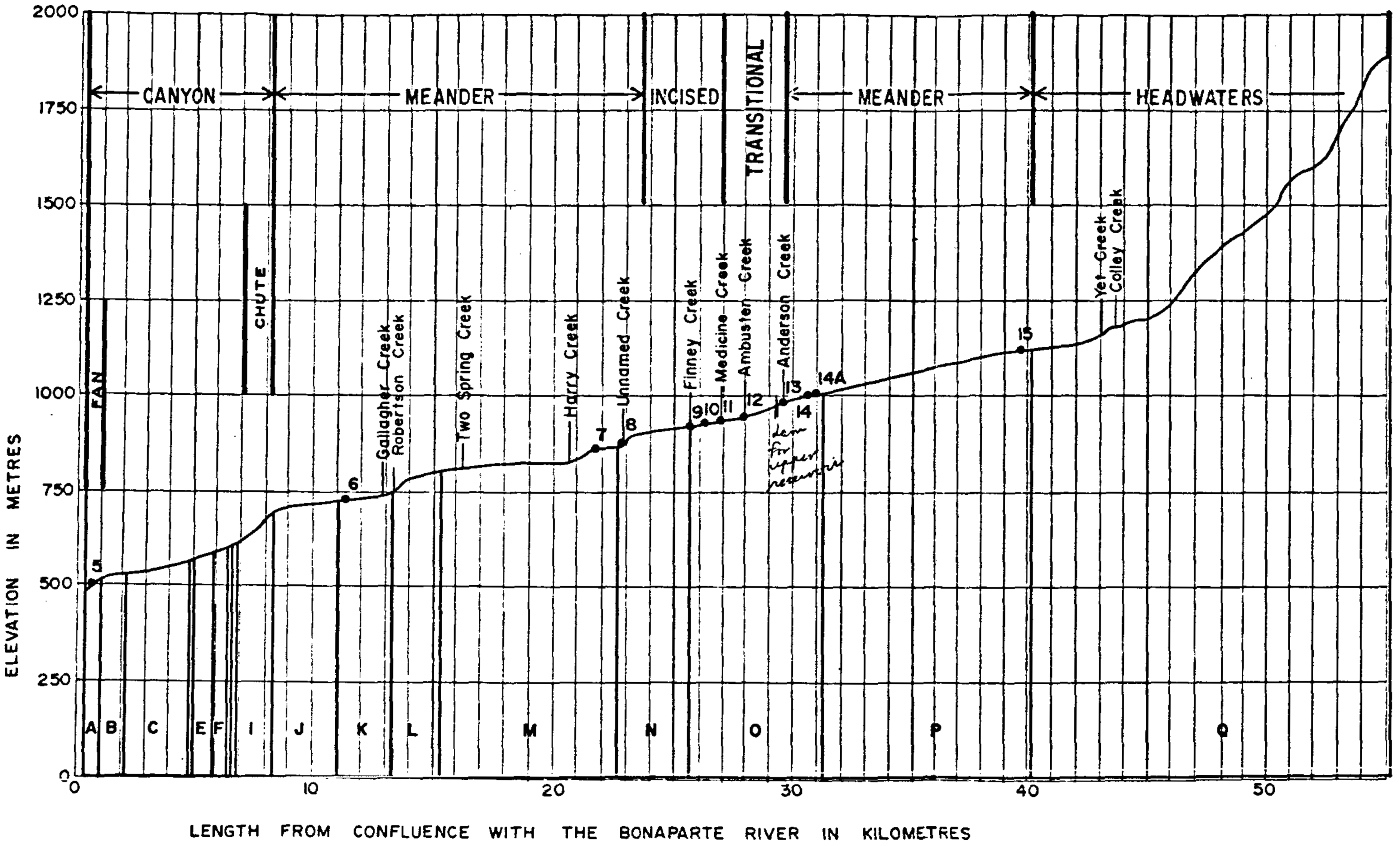


figure 4·15
LONGITUDINAL PROFILE OF HAT CREEK

legend

•4 SAMPLING STATION

A,B,···· PROFILE SECTION

TABLE 4-19

GENERAL CHARACTERISTICS OF PROFILE SECTIONS WITHIN HAT CREEK

Parameter	PROFILE SECTION A	B	C	D	E
Kilometers	0.0 - 0.8	0.8 - 1.8	1.8 - 4.5	4.5 - 4.7	4.7 - 5.8
Substrates	Cobbles, pebbles	Cobbles, pebbles	Boulders, cobbles pebbles	Silt, sand, pebbles	sand, silt, pebbles
Pool:Riffle (%)[1]	30:70	20:80	20:80	90:10	50:50
Banks	Stable	Stable	Rocky, stable	Stable	Stable
Riparian Vegetation	Deciduous trees	Deciduous trees, shrubs	Deciduous trees	Grasses, shrubs	Grasses, shrubs
Barriers	-	-	-	Man made dams, beaver dams	Beaver dams
Note	Station 5	Most pools on undercuts and under trees	Canyon-like, 2-5% covered by fallen trees	current slow	Many dams, large pools

[1] Incorporated in pool percentages are areas of deep and shallow slow flows.

TABLE 4-19 Cont'd.

GENERAL CHARACTERISTICS OF PROFILE SECTIONS WITHIN HAT CREEK

Parameter	PROFILE SECTION F	G	H	I	J
Kilometers	5.8 - 6.2	6.2 - 6.3	6.3 - 6.5	6.5 - 8.0	8.0 - 10.7
Substrates	Silt, pebbles, cobbles	Boulders	Sand, cobbles	Boulders	Sand, silt, pebbles
Pool:Riffles (%)[1]	20:80	10:90	50:50	5:95	80:20
Banks	Stable with some erosion on corner banks	Stable	Some erosion	Rocky, stable	Stable with some high unstable dirt cliffs.
Riparian Vegetation	Shrubs, deciduous trees, sedges	Deciduous trees, shrubs	Grasses, shrubs	Deciduous trees shrubs	Deciduous trees, shrubs, grass
Barriers	Many beaver dams	Possibly steep gradient	Beaver dams	Possibly steep gradient	Beaver dams
Note	Unstable mud bank at refuse pile	current fast	Large pools with dams	current fast	Meadow areas, pools and dams

[1] Incorporated in pool percentages are areas of deep and shallow slow flows.

TABLE 4-19 Cont'd.

GENERAL CHARACTERISTICS OF PROFILE SECTIONS WITHIN HAT CREEK

Parameter	PROFILE SECTION K	L	M	N	O	P	Q
Kilometer	10.7 - 13.0	13.0 - 15.0	15.0 - 22.4	22.4 - 25.5	25.5 - 31.0	31.0 - 40.0	>40.0
Substrates	Cobbles, sand, silt, boulders	Sand, cobbles	Sand, cobbles, pebbles	Cobbles, pebbles	Silt, sand, pebbles, some cobbles	Silt, sand, cobbles	Sand, silt, cobbles
Pool:Riffle (%)[1]	30:70	10:90	5:95	5:95	10:90	40:60	80:20
Banks	Unstable dirt and rock	Stable	Unstable dirt banks at upper end	Unstable sliding banks	Relatively stable	Relatively stable	Relatively stable
Riparian Vegetation	Deciduous trees, grasses	Grasses, shrubs	Deciduous trees, grass,	Small deciduous bushes	Heavy deciduous bushes	Grass, small trees	Coniferous trees, deciduous shrubs and trees
Barriers	Beaver dams	-	Beaver dams	Beaver dam	Beaver dams	Beaver dams	beaver ponds
Note	Many dams, pools, riffles, much downfall and slash; Station 6	some slash, current slow braided and marshy	meadowlike, some fast current, fish rising in pools, much variety from meadow to fast current; Station 7	Occasionally braiding over gravel fans; Station 8	Much slash, fish rising in pools; Station 10, 11, 12, 13, 14, 14A	Marshy, fish rising, passes through farms, algae, diversion canals; Station 15	Large pools, marshy, fish rising

[1] Incorporated in pool percentages are areas of deep and shallow slow flows.

areas above this point. Numerous beaver dams and man-made dams were also present which may prevent fish movement. Many of the larger beaver dams created large pools which retarded flows and created extensive meanders in these sections of Hat Creek.

(B) Meander

From Km 8 to approximately Km 22.5, a primarily meandering profile existed in Hat Creek. Pools were abundant only in Section J, with riffle areas dominant in the remaining four sections. The sections encompassed by the first meander consisted of soil banks that were primarily unstable and loosely bound. Although deciduous vegetation was present, areas of steep gradient precluded the growth of stabilizing flora. Beaver dams were also abundant in this area and could possibly limit fish movement. There appeared to be good spawning gravel in this reach of Hat Creek. One fish, approximately 150 - 200 mm in length, was seen in a beaver pond approximately 4 km downstream of Station 7 during the June helicopter survey. Other fish with lengths estimated at 100 - 250 mm were observed about two to three km downstream of Station 7 during the June flight.

(C) Incised and Transitional

The incised - transitional sections of Hat Creek extended from approximately Km 22.5 to Km 29. Areas within this span were primarily riffles with some small pools. The incised sections consisted principly of small deciduous bushes with the transitional section supporting dense growth of deciduous bushes. An abundance of deadfall was also present. There appeared to be good spawning gravel in this reach of stream. Beaver dams located just downstream of Station 10 could possibly limit fish movement. Some turbidity was noted in upper reaches of this section of Hat Creek and appeared due to discharges from Anderson Creek.

(D) Meander and Headwaters

From Km 29 to approximately Km 55 (Section P) Hat Creek passes through farmland. Often high concentrations of algae were evident below stock corrals and pasture, suggesting some localized nutrient enrichment. Sand and silt was particularly abundant further upstream (Section Q) where approximately 80 % of the system consisted of pools. Banks were stable with deciduous vegetation gradually giving way to predominantly coniferous trees. Large pools, resulting from extensive beaver damming, were noted in upper areas of Hat Creek. Many were observed to support fish during both the September and June helicopter flights. Good spawning gravels occurred intermittently in this reach of Hat Creek. Rainbow Trout spawning areas have been described as consisting of gravel or small rubble in a riffle, often located upstream of a pool (Scott and Crossman, 1973; Baxter and Simon, 1970).

From its confluence with the Bonaparte River to its headwaters, Hat Creek exemplified both rapid and subtle changes in character. Riffle areas were dominant comprising approximately 68 % of the system, with pools 33 %. Beaver dams were very abundant.

Evidence of man's intervention in the Hat Creek system was limited to dams in the Canyon area, flumes for irrigation and the effects of nutrient addition into freshwater systems in the upper sections of Hat Creek.

Information on the Bonaparte River was also gathered during helicopter flights. Fish habitat appeared very good from Station 1 upriver to the mouth of Hat Creek and consisted of riffles, runs and pools. Fish were observed intermittently and spawning gravel regularly in this reach of river. Below Station 1, the gradient of the river increased and fish habitat appeared to be of lower quality.

(ii) Water Quality

Table 4-20 summarizes select chemical parameters for five stations in Hat Creek extending from Station 14 in Upper Hat Creek to Station 5 in Lower Hat

TABLE 4-20

WATER QUALITY FOR SELECT PARAMETERS WITHIN HAT CREEK

Parameter[1]	STATION 14 Sept. 76	14 May 77	10 Sept. 76	10 May 77	7 Sept. 76	7 May 77	6 Sept. 76	6 May 77	5 Sept. 76	5 May 77
Total Kjeldahl Nitrogen	0.23	0.25	0.22	0.31	0.24	0.28	0.12	-	0.12	0.40
Total Orthophosphate Phosphorus	0.09	0.04	0.08	0.05	0.04	0.04	0.06	-	0.05	0.02
Total Alkalinity (as $CaCO_3$)	220	215	232	224	237	211	247	-	254	248
pH	8.3	8.2	8.4	8.4	8.4	8.4	8.5	-	8.6	8.5
Conductivity[2]	470	500	480	510	480	480	470	-	490	540
Suspended Solids	20	2	6	4	17	8	4	-	1	3
Dissolved Solids	340	341	354	347	346	327	333	-	345	359
Dissolved Oxygen	9.5	10.5	9.8	10.2	9.2	9.6	9.5	-	10.3	10.2
	(96)[3]	(102)	(95)	(101)	(88)	(77)	(97)	-	(100)	(101)

[1] Values in mg/l unles otherwise stated

[2] µmhos/cm @ 25°C

[3] % saturation

Creek. Two sampling periods, September 1976 and May 1977, are presented. A comprehensive analysis of the water quality characteristics of Hat Creek is presented in a separate report - Hat Creek Project: Hydrology Study.

Nutrients in the form of organic nitrogen and orthophosphate phosphorus appeared to be relatively consistent between sampling periods as well as along the longitudinal axis of Hat Creek. The exception to this generality is Kjeldahl nitrogen which was 0.40 mg/l at Station 5 in May 1977 (Table 4-20). Organic nitrogen compounds include a variety of decomposition products ranging from proteins to the methylamines. The presence of livestock may have influenced an accumulative effect whereby concentrations of organic nitrogen during run off periods in spring were highest at the farthest downstream station. Throughout much of the creek valley, cattle and other livestock were permitted to graze. The creek periodically flows through fenced corrals in the Upper Hat Creek area. With the spring run off, elevated nutrient levels in the system may be expected. The relatively dense concentrations of periphytic algae in the vicinity of Stations 5 and 6 may be a direct result of this periodic elevation in nitrogen. In certain areas of Lower Hat Creek, dense growths of algae were noted. The two most abundant algae were *Rhizoclonium* sp. (a green algae) and *Nostoc* sp. (a blue-green algae). *Rhizoclonium* formed long, stringy, sometimes rope-like strands. *Nostoc* which is another relatively cosmopolitan algae, is noted for forming shelving or bracket-like growths on the downstream side of stones. This phenomenon was observed in Lower Hat Creek. Diatoms were also recorded near Stations 5 and 6, however, *Rhizoclonium* and *Nostoc* were the most dominant genera.

In Upper Hat Creek (Station 15), *Tribonema* sp. (a golden algae) appeared in greatest abundance. Diatoms were also present. Golden algae are common in cool springs and pools. There appeared to be no direct relationship between chemical composition of the Upper Hat creek system and algal composition.

(b) Biological Environment

The approach to presenting the biological conditions of the Hat Creek system is oriented towards the fish populations therein. Benthic invertebrates are therefore discussed insofar as their importance to fish as food organisms. In addition however, benthic organisms, as a result of their sessile nature, tend to form communities in response to ambient conditions, both in a spatial and temporal sense. Thus, benthic community associations are discussed in terms of system diversity, complexity and overall stability.

(i) Fish Populations

(A) Species Composition and Relative Abundance

*A list of fish species and their numbers collected in Hat Creek and the Bon-*aparte River stations during September 1976, June 1977 and August 1977 surveys is presented in Table 4-21

Bonaparte River

A total of 273 specimens representing seven species were collectec in the Bonaparte River. Longnose dace were the dominant species (150 individuals) followed by bridgelip sucker (66), leopard dace (26) and rainbow trout (19). Species present in smaller numbers were redside shiner (6) mourtain white-fish (6), and brook trout (1).

Total catch and species by month were 104 individuals and seven species in September 1976, 63 individuals and six species in June 1977, and 106 individuals and four species in August 1977. The three most abundant species during each survey were longnose dace (57), bridgelip sucker (26) and leopard dace (8) in September 1976, longnose dace (23), leopard dace (17) and bridgelip sucker (9) in June 1977, and longnose dace (70), bridgelip sucker (31) and rainbow trout (3) in August 1977.

TABLE 4-21

HAT CREEK - SPECIES COMPOSITION AND RELATIVE ABUNDANCE

Species	Month	STATION: Bonaparte River 1	2	3	4	Lower Hat Creek 5	6	7	Upper Hat Creek 10	14	14A	15	Total
Salvelinus fontinalis Brook trout	September	0	0	1	0	0	0	0	0	0	0	0	1
	June	0	0	0	0	0	0	0	0	0	0	0	0
	August	0	0	0	0	0	0	0	0	0	0	0	0
Salmo gairdneri Rainbow trout	September	5	2	0	0	29	19	19	38	62	30	28	232
	June	4	1	3	0	13	28	30	33	32	13	40	197
	August	1	0	2	0	8	25	26	60	33	17	9	181
Prosopium williamsoni Mountain whitefish	September	0	2	2	0	0	0	0	0	1	1	0	6
	June	0	0	1	0	0	0	3	1	0	1	0	6
	August	1	0	0	0	3	0	0	0	0	0	0	4
Catostomus columbianus Bridgelip sucker	September	7	12	2	5	18	0	0	0	0	0	0	44
	June	0	0	9	0	0	0	0	0	0	0	0	9
	August	0	21	9	1	4	0	0	0	0	0	0	35
Richardsonius balteatus Redside shiner	September	0	1	0	0	0	0	0	0	0	0	0	1
	June	0	0	1	4	0	0	0	0	0	0	0	5
	August	0	0	0	0	0	0	0	0	0	0	0	0
Rhinichthys falcatus Leopard dace	September	2	3	1	2	0	0	0	0	0	0	0	8
	June	0	13	0	4	2	0	0	0	0	0	0	19
	August	0	1	0	0	0	0	0	0	0	0	0	1
Rhinichthys cataractae Longnose dace	September	19	12	3	23	0	0	0	0	0	0	0	57
	June	4	9	1	9	6	0	0	0	0	0	0	29
	August	4	40	23	3	0	0	0	0	0	0	0	70
TOTAL	September	33	32	9	30	47	19	19	38	63	31	28	349
	June	8	23	15	17	21	28	33	34	32	14	40	265
	August	6	62	34	4	15	25	26	60	33	17	9	291

Because of difficulty in sampling swift deep areas of the Bonaparte, numbers of fish collected may not be indicative of actual numbers present. For example, large fish which appeared to be rainbow trout were observed in the river during helicopter surveys, but were not collected in the field. However, species composition is probably representative of that actually occurring in the Bonaparte.

Hat Creek

Hat Creek exhibited fewer species and a different order of abundance compared to the Bonaparte River. A total of 632 specimens representing five species was collected in Hat Creek. Rainbow trout were clearly the dominant species (592 individuals), particularly upstream of Station 5. They were followed by bridgelip sucker (22), mountain whitefish (10), longnose dace (6) and leopard dace (2).

Rainbow trout were taken at each station during each survey. A total of 225 was captured in September 1976, 189 in June 1977, and 178 in August 1977. Mountain whitefish were captured at all Hat Creek stations, except 5 and 15, during the course of the study. They appeared to be distributed throughout most of Hat Creek although in much smaller numbers than rainbow trout.

Bridgelip sucker, longnose dace and leopard dace, which were dominant in the Bonaparte, were taken only at the downstream most station (Station 5) in Hat Creek. Their apparent restriction to lower reaches of the creek may be due to factors such as unsuitable habitat further upstream or barriers (beaver dams) which prevented migration of these species further upstream.

Hat Creek Tributaries

Within the study area tributaries to Hat Creek appeared to provide little suitable fish habitat. Electroshocking in the lower 10 m of Medicine Creek yielded four rainbow trout in September 1976, ten rainbow trout in June 1977, and two rainbow trout in August 1977. Upstream movement of fish beyond this point appeared restricted by a barrier about 2 m high. A local rancher stated fish (presumably rainbow trout) occur further upstream in Medicine Creek. Anderson and Ambusten Creeks exhibited no signs of fish life. During the June 1977 and August 1977 surveys, all water had been diverted from Ambusten Creek for irrigation. Finney and Unnamed Creeks exhibited little or no flow during each survey and no sign of fish life. Overall, potential fish habitat in the above tributaries appeared negligible compared to that existing in Hat Creek.

Lakes

No fish were collected in Finney Lake. None were observed during visual examination of shore and deeper waters in September 1976. A local rancher stated that the lake was stocked in the past but froze solid several years later resulting in winterkill. B.C. Fish and Wildlife Branch personnel at Kamloops stated Finney Lake, as well as Aleece Lake located about 3.2 Km (2.0 miles) west, have supported fish in the past and would probably again in the future (S.J. McDonald, pers. comm.).

Visual examination of Goose/Fish Hook Lake in September 1976, for signs of fish life such as young in or near aquatic vegetation and rises or wakes, indicated no fish present. Alkaline deposits were noted along the shoreline. Subsequent measurement revealed a pH of 9.9

(B) Density Estimates and Topographical Variation

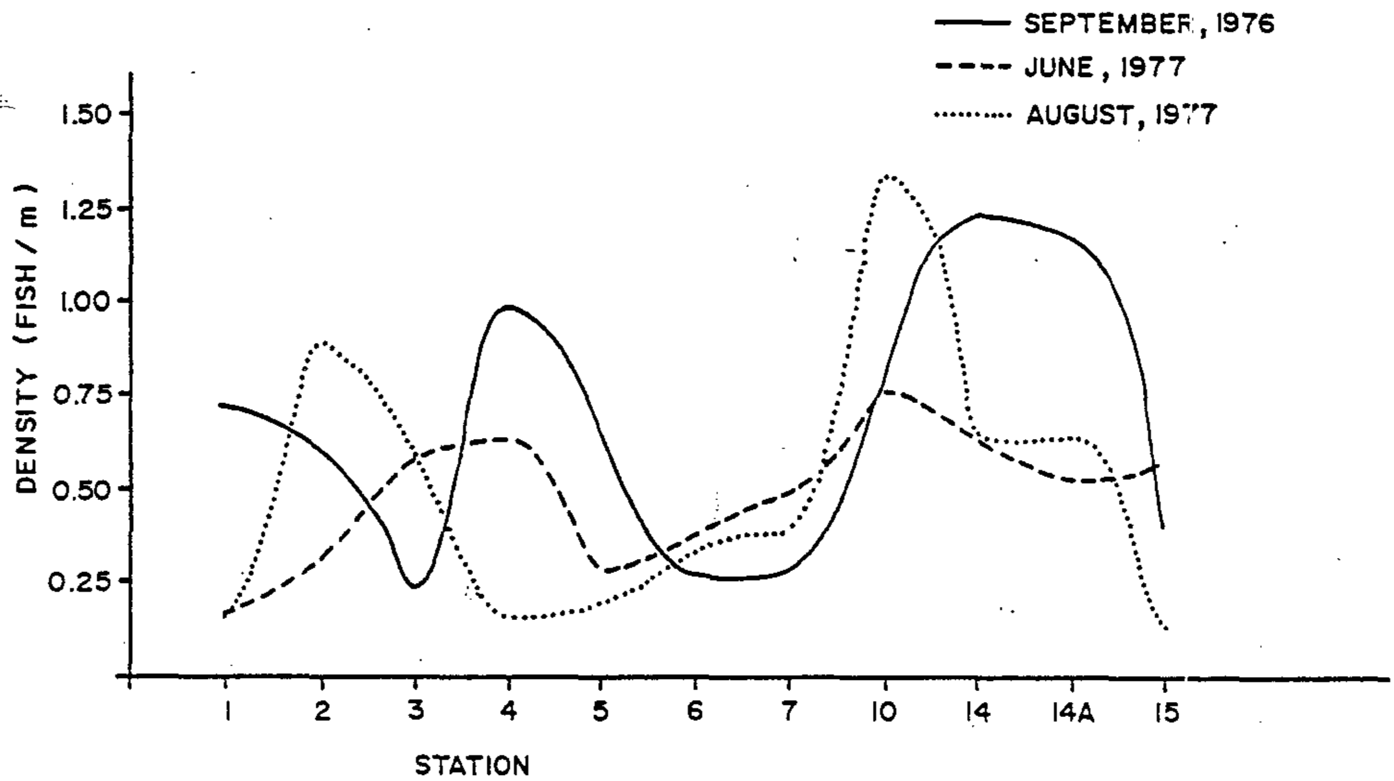
Density estimates for total numbers of fish at each station are presented in Appendix D, Table D-1. Densities were determined for length of stream shocked (fish/m), surface area of stream shocked (fish/m^2) and length of time shocked (fish/min.). Actual length, surface area and time shocked during each survey are shown in Appendix D, Table D-2. Trends among stations for each type of estimate are generally similar within a sampling period. However, to avoid bias resulting from variation in the amount of time necessary to shock different stations (depending on their relative ease or difficulty) and the same station (increased familiarity with station), density estimates discussed below include only those for fish/m and fish/m^2. These data are depicted graphically in Figure 4-16.

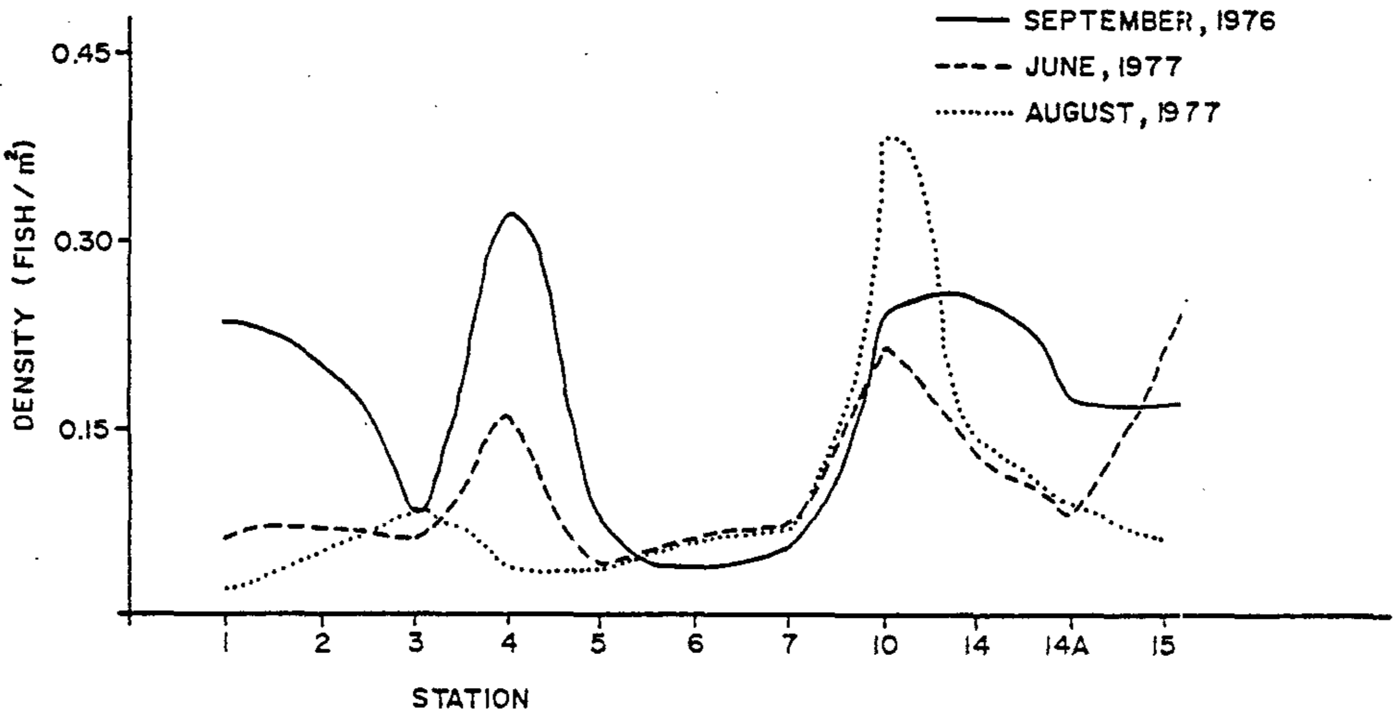
Hat Creek

Densities for both fish/m and fish/m^2 were generally higher at Upper (Stations 7, 10, 14, 14A) than Lower (Stations 5, 6, 7) Hat Creek sites. During each sampling period, densities generally increased from Station 5 upstream to Stations 10 or 14, then declined or remained about the same further upstream through Station 15. The low densities at Station 15 in September 1976, and August 1977, occurred during periods when water had been diverted for irrigation. Fish present were concentrated in remaining pools. Densities at Station 15 during June 1977, when flows appeared normal, are probably most representative of densities in this reach of stream.

There was no pattern of consistently high or low densities at any station during a given month. In September 1976, maximum densities for fish/m (1.22) and fish/m^2 (0.26) occurred at Station 14 while minimum values were noted at Station 6 (0.26 fish/m, 0.04 fish/m^2). In June 1977, maximum densities for fish/m (0.75) and fish/m^2 (0.25) occurred at Stations 10 and 15, respectively; minimum densities during June occurred at Station 5 (0.28 fish/m, 0.04 fish/m^2). In August 1977, maximum densities were observed at Station 10 (1.32 fish/m, 0.38 fish/m^2); minimum values during this month for fish/m (0.13) and fish/m^2 (0.04) occurred at Stations 15 and 5, respectively.

Density estimates for rainbow trout in Hat Creek are nearly identical to values for total fish density. An exception occurred at Station 5 where trout comprised only 62% of the catch in both September 1976 and June 1977 and 53% of the catch in August 1977. At stations further upstream, rainbow trout comprised 91 - 100% of the catch each month.





location: Hat Creek and Bonaparte River stations

periods: September 28-30, 1976; June 14-16, 1977; August 3-5, 1977

figure 4·16
TOTAL FISH DENSITY FOR LENGTH AND SURFACE AREA OF STREAMS ELECTROSHOCKED

Higher densities of rainbow trout in Upper than Lower Hat Creek may be related to the variety and quality of habitat. Stations 10, 14, 14A and 15 appeared to provide an abundance of fish cover. Stations 10 and 14 consisted of intermittent pool and riffle areas, as did Station 15 during normal flow conditions (June 1977). Station 14A was a beaver pond. Stations 6 and 7 in Lower Hat Creek consisted primarily of riffles and a few pools with limited fish cover. Station 5 exhibited primarily shallow riffles.

Bonaparte River

Densities in the Bonaparte River generally varied between months and stations with no clear patterns evident. The least variation in density occurred at Station 3 where values ranged from 0.24 - 0.63 fish/m and 0.06 - 0.08 fish/m^2 during the three surveys. Maximum densities for fish/m (0.98) and fish/m^2 (0.32) occurred in September 1976 at Station 4. Minimum densities for fish/m (0.15) and fish/m^2 (0.02) occurred in August 1977 at Stations 4 and 1, respectively.

Longnose dace, bridgelip sucker and leopard dace were generally the most dominant species. Rainbow trout never comprised more than 20% of the catch at Stations 2 and 3, and were not collected at Station 4. At Station 1, rainbow trout constituted 15% of the catch in September 1976, 50% in June 1977 and 17% in August 1977.

(ii) Age & Growth Characteristics

(A) Length-Frequency Distribution

Rainbow trout

Length-frequency histograms of rainbow trout are presented by station and sampling period in Figure 4-17. Data are presented in tabular form in Appendix D Tables D-3 to D-5. Individual total lengths during each sampling period

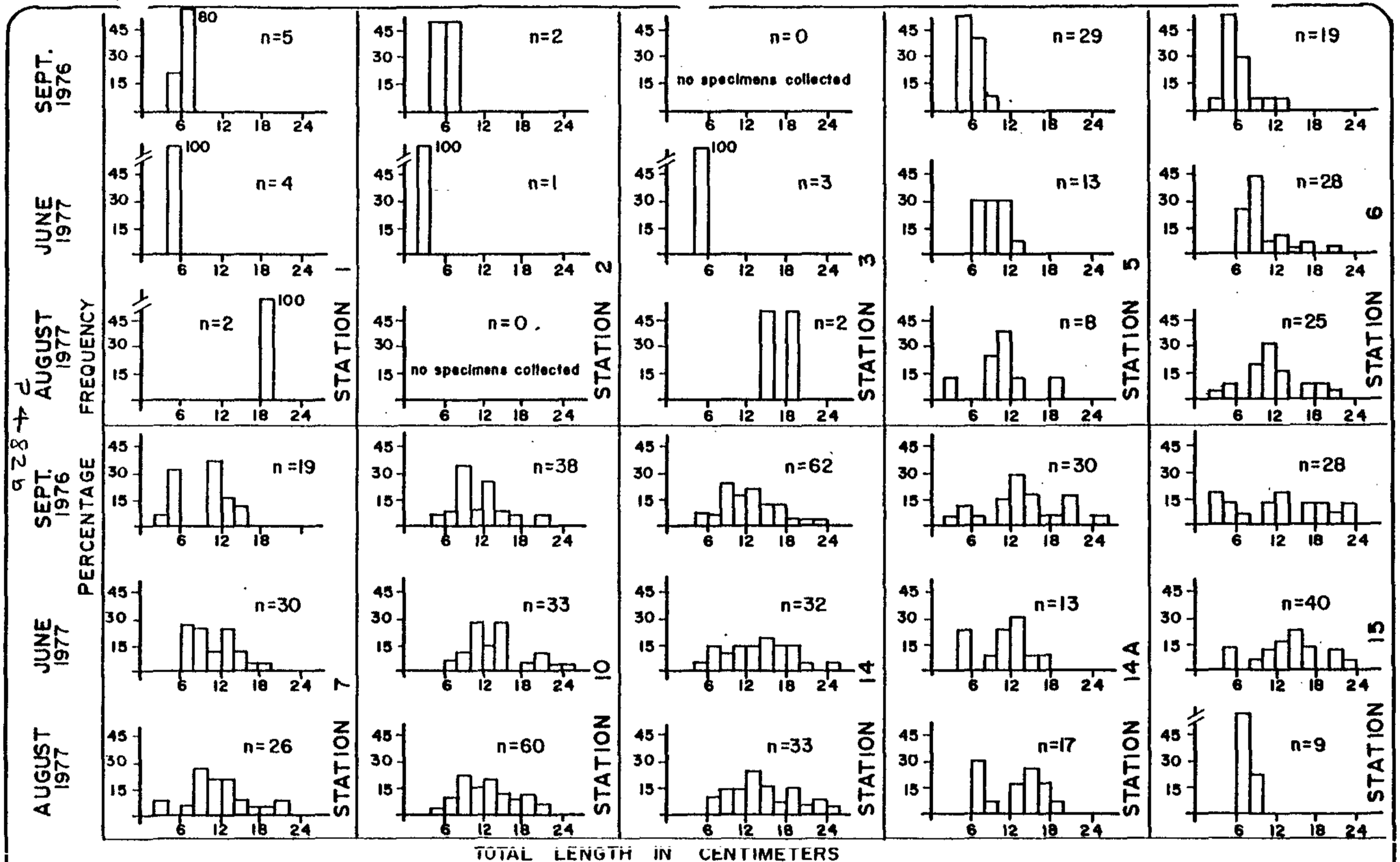


figure 4·17

LENGTH - FREQUENCY HISTOGRAM FOR RAINBOW TROUT

location: Hat Creek and Bonaparte River stations

periods: September 28-30, 1976; June 14-16, 1977; August 3-5, 1977 (each length interval represents 2 cm) ranged from 31 mm at Station 15 to 253 mm at Station 14A in September 1976, 35 mm at Station 2 to 255 mm at Station 10 in June 1977, and 32 mm at Station 7 to 241 mm at Station 14 in August 1977.

The presence of small sized rainbow trout at each Hat Creek station in September 1976, suggests spawning occurs throughout the study area. Scale analysis showed most fish less than about 95 mm collected during this month were young-of-the-year (1976 year-class). Increased lengths of this age group from September 1976 through June 1977 (lengths to approximately 105 mm) and August 1977 (lengths to approximately 125 mm) represent growth of the 1976 year class over a 10 - 11 month period. Growth during this period appears similar to that reported by Larkin *et al.*, (1957) for Rainbow Trout in British Columbia lakes. The histograms do not clearly illustrate growth of older age groups of fish in Hat Creek, except possibly for the 1975 year class (age 1+ fish in 1976 and age 2+ fish in 1977).

The occurrence of fish less than 60 mm total length at Stations 5, 5, 7 and 10 in August 1977, represents recruitment of the 1977 year-class to the fishery. Scale analyses showed these fish were young-of-the-year. The absence of young from Stations 14, 14A and 15 in August 1977, suggests that in 1977 spawning occurred later or growth of young was less rapid at these stations than further downstream in Hat Creek. Collection of small-sized young at Stations 14, 14A and 15 in September, 1976, suggests spawning occurs in this reach of Hat Creek.

At Bonaparte River Stations 1, 2 and 3, young from the 1977 year class were first collected in June 1977, approximately one month earlier than in Hat Creek. These individuals are represented in the histograms by specimens less than 60 mm total length. Their presence indicates that in 1977 rainbow trout spawned earlier or young grew more quickly in the river than in the creek.

Examiniation of the histograms reveals that, in general, larger fish were better represented and comprised a greater proportion of the catch in Upper (Stations 10, 14, 14A and 15) than Lower (Stations 5, 6 and 7) Hat Creek. This was especially noticeable during the September 1976 and June 1977 surveys. The near absence of larger trout from Bonaparte River collections probably resulted from sampling difficulties described above. The absence of fish larger than 100 mm at Station 15 in August 1977 was probably related to the diversion of water from this station for irrigation. Therefore, length-frequency distributions for this reach of stream are probably best represented by those for September 1976 or June 1977 rather than August 1977.

General differences in stream habitat may account for variation in length-frequency distributions of rainbow trout. Upper Hat Creek appears to provide adequate riffle areas which serve as spawning grounds for adults and nursery areas for young. This section also contains pools with deeper, slower moving water which provide cover for adults. Lower Hat Creek has a relatively greater proportion of riffles and a lesser proportion of pools which may account for the predominance of small rainbow trout and paucity of larger specimens. This area appears to be an important nursery area for young, many of which were captured near the stream-edge in shallow water. This section may also be an important spawning ground for adults migrating upstream from the Bonaparte as well as those resident to Lower Hat Creek.

With respect to previous Hat Creek investigations, B.C. Research and Dolmage Campbell (1975) reported that many pools and slow moving flats in Hat Creek provide good fish habitat. They also noted Hat Creek as exhibiting good rainbow trout spawning potential. Potential spawning grounds (riffle areas) were observed in Upper Hat Creek, but were more numerous in areas further downstream. Studies by the B.C. Fish and Wildlife Branch, Kamloops (Holman, 1974) on July 4 and 5, 1974, showed a good spawning area was located in the general vicinity or just upstream of Station 7 of this study. Two pairs of spawning rainbow trout were also observed in Upper Hat Creek. In the

1974 survey, a total of 69 rainbow trout with lengths from 50 - 300 mm were taken in Medicine Creek and a second tributary approximately 4.8 km downstream. Provincial personnel concluded a good population of rainbow trout probably existed in Hat Creek.

Mountain Whitefish

Total lengths of mountain whitefish collected during the three surveys ranged from 79 - 354 mm. Scale analyses revealed ages were from 0+ to 5+ years. Total length of specimens taken in September 1976 were 97 and 113 mm at Station 2, 103 and 109 mm at Station 3, 177mm at Station 14 and 97 mm at Station 14A. The large and small fish captured at Stations 14 and 14A were ages 1+ and 0+, respectively. Although scale samples were not taken from other specimens collected in September 1976, their lengths indicated they were age 0+ fish.

During the June 1977 survey, total lengths and ages of whitefish collected were 133 mm (age 1+) at Station 3, 314 mm (age 4+), 352 mm (age 5+) and 354 mm (age 4+) at Station 7, 290 mm (age 4+) at Station 10, and 116 mm (scales not sampled but probably age 1+) at Station 14A. Lengths of mountain whitefish captured in August were 198 mm (age 1+) at Station 1 and 78, 89 and 98 mm (all age 0+) at Station 5. The three large whitefish captured at Station 7 in June 1977 were all taken from a slow run about 4 m long, 2 m wide and 1 m deep.

Data reflect the general growth of the 1976 year class (age 0+ fish in September 1976, age 1+ fish in June 1977 and August 1977) over an approximate 10 to 11 month period. The age 0+ fish captured in August 1977 (lengths of 79 - 98 mm) represent recruitment of the 1977 year class to the fishery. The age-size relationship for mountain whitefish collected in this study concurs with data presented by Northcote (in Scott and Crossman, 1973). Northcote also reported size overlaps among fish from older year classes similar to that observed for age 4+ and 5+ fish in Hat Creek.

Brook Trout

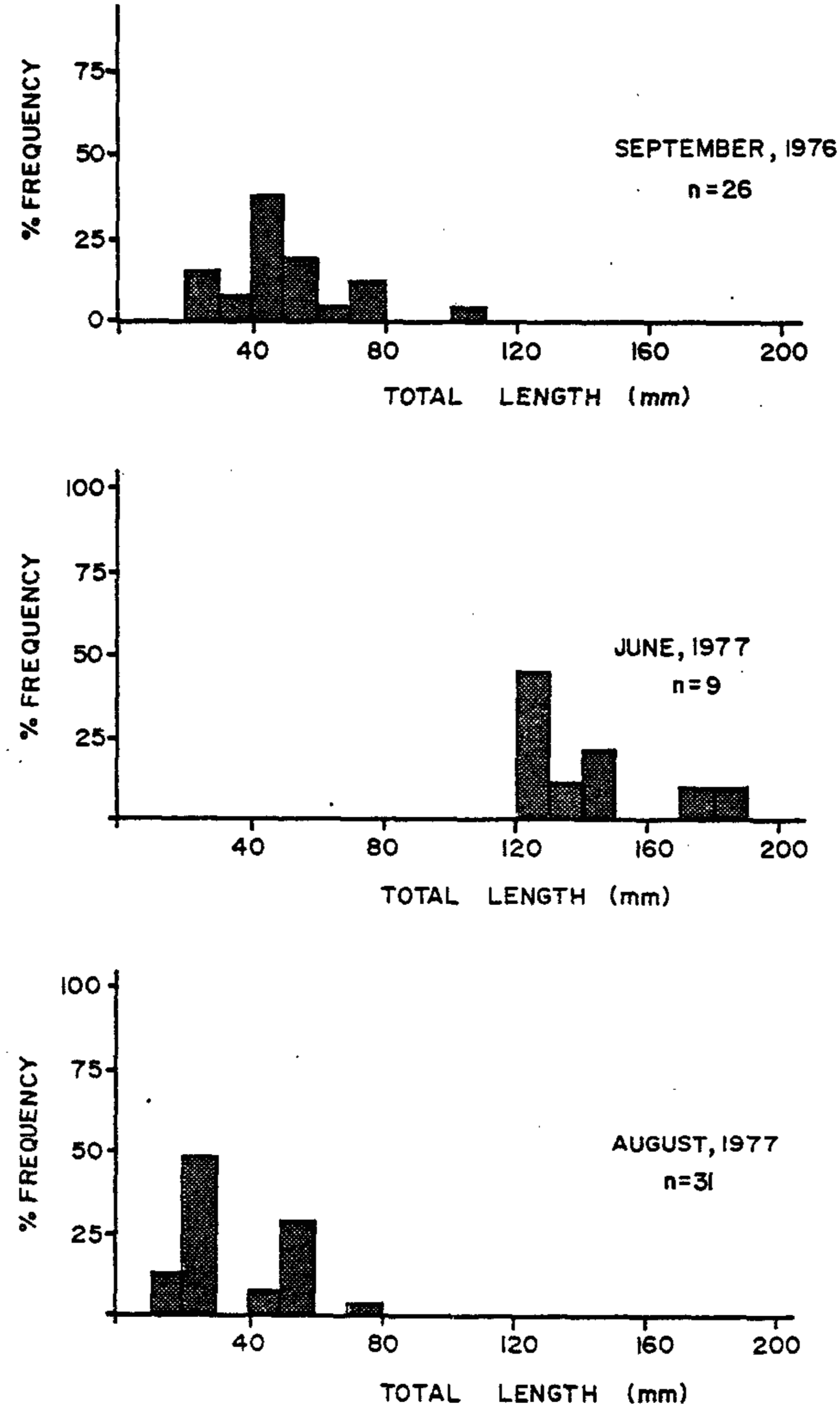
Total length of the single brook trout taken at Station 3 in September 1976 was 114 mm. Comparison of this to length ranges presented by Scott and Crossman (1973) indicate it was an age 1+ fish. Verification was accomplished by scale analysis. Using a direct proportion relationship, total length of this specimen at time of first annulus formation was 73 mm, a value similar to that for rainbow trout collected in this study.

Bridgelip Sucker

Length-frequency histograms for bridgelip sucker captured in the Bonaparte River are shown in Figure 4-18. Data are presented in tabular form in Appendix D Table D-6. Total lengths of bridgelip sucker collected in the Bonaparte varied from 20 - 103 mm in September 1976, 121 - 184 mm in June 1977, and 14 - 74 mm in August 1977.

Most bridgelip suckers captured in September 1976 were probably young-of-the-year (1976 year-class), assuming growth in the Bonaparte is similar to that in Idaho where young attain lengths of 40 to 80 mm at the end of their first summer (Scott and Crossman, 1973). Specimens taken in June 1977 were all spawning adults and included one female (184 mm) and eight males (121 - 180 mm). Most fish captured in August 1977, approximately 1.5 months after spawning adults had been collected, were probably young from the 1977 year class. Larger specimens captured during August may have been age 1+ fish.

Total lengths of bridgelip sucker captured in Hat Creek were 28 - 171 mm in September 1976 and 57 - 63 mm in August 1977. None were collected in June 1977. Sixteen of the 18 individuals taken in September 1976 had lengths of 28 - 34 mm. The two remaining specimens were a male (171 mm) and female (160 mm), and may have spawned the young collected at this station. Lengths of individuals captured in August 1977 suggest they were age 1+ fish since specimesn collected in September of the previous year were 23 - 35 mm smaller.



location: Bonaparte River (each length interval represents 10 mm)
period: September 28-30, 1976; June 14-16, 1977; August 3-5, 1977

figure 4·18
LENGTH - FREQUENCY HISTOGRAMS FOR BRIDGELIP SUCKER

Longnose Dace

Length-frequency histograms for longnose dace collected in the Bonaparte River are shown in Figure 4-19. Data are presented in tabular form in Appendix D Table D-7. Total lengths varied from 21 - 96 mm in September 1976, 23 - 99 mm in June 1977, and 15 - 98mm in August 1977. The 98 mm specimen taken in August 1977 was a spent female.

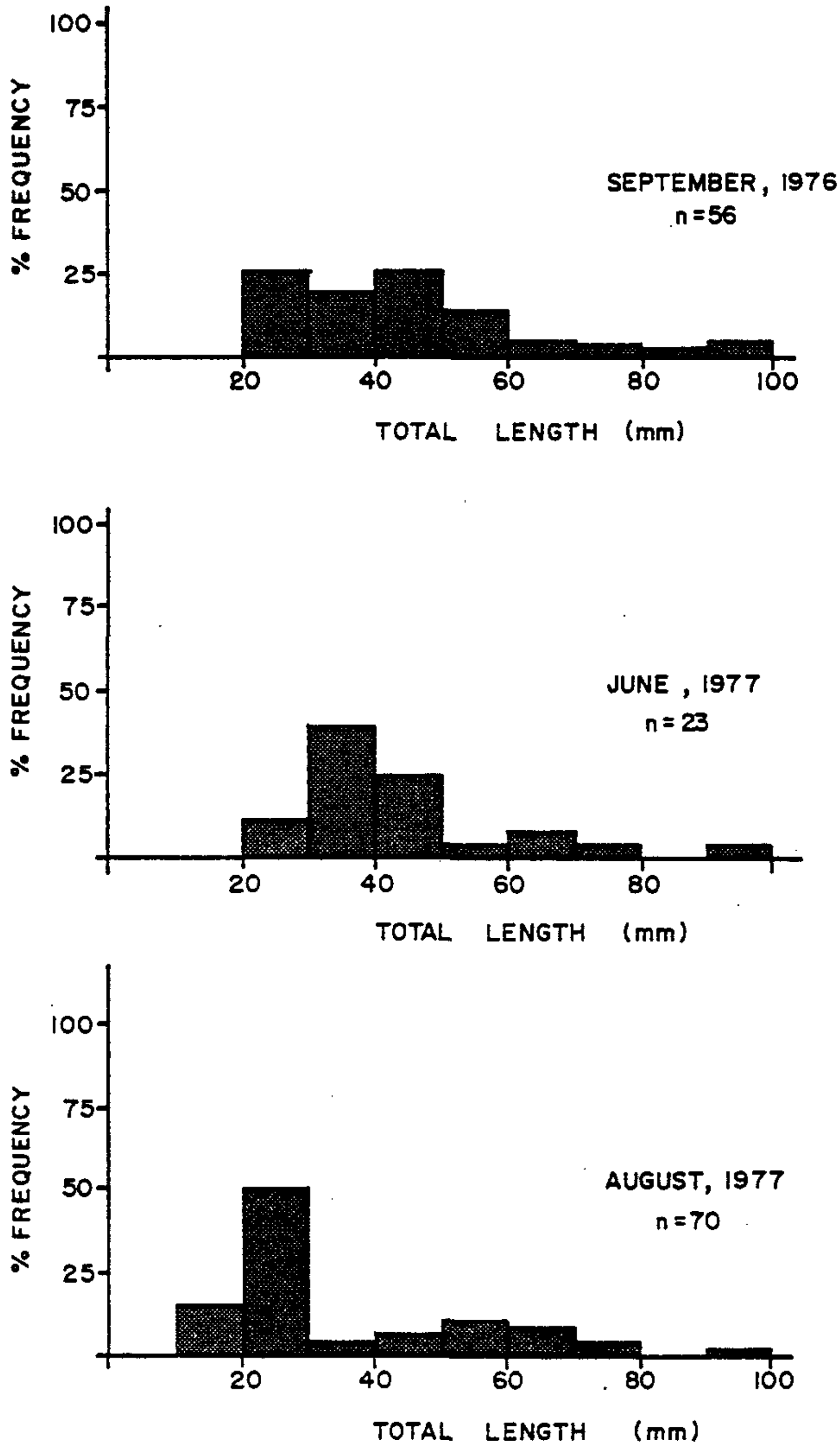
Data indicated at least several year classes of longnose dace were captured in the Bonaparte each sampling period. Kuehn (in Scott and Crossman, 1973) reported total lengths of longnose dace in Minnesota waters increased from 48 mm at age 1 to 99 mm at age 5. Fish with lengths less than 30 mm captured in August were probably young from the 1977 year class. Most specimens with lengths less than approximately 50 mm, taken in June, probably represented the 1976 year class.

Total lengths of longnose dace collected at Station 5 (Hat Creek) in June 1977 were 81 - 110 mm. Four of the six specimens were ripe adult males, indicating longnose dace spawn in this reach of the creek. Approximately 75 longnose dace with lengths of about 30 - 40 mm were captured in a seine haul immediately upstream from Station 5 in August 1977. These were probably young-of-the-year.

Leopard Dace

Total lengths of leopard dace captured in the Bonaparte River were 39 - 70 mm in September 1976 (8 specimens) and 30 - 69 mm in June (17 specimens). The single specimen taken in August 1977 was 64 mm. Based on studies by Gee and Northcote (in Scott and Crossman, 1973), smallest fish captured in September 1976 and June were probably age 2+ or 3+.

Lengths of two leopard dace collected at Hat Creek Station 5 in June 1977 were 30 and 33 mm. These were probably age 1+ fish.



location: Bonaparte River (each length interval represents 10 mm)

periods: September 28-30, 1976; June 14-16, 1977; August 3-5, 1977

figure 4·19
LENGTH-FREQUENCY HISTOGRAMS FOR LONGNOSE DACE

Redside Shiner

The single redside shiner captured in the Bonaparte River in September had a total length of 81 mm. Lengths of five specimens taken in the Bonaparte in August ranged from 78 - 104 mm; all were ripe adult males. Based on length data presented by Scott and Crossman (1973) for British Columbia, ages of these fish were probably from 2+ to 4+.

(B) Back-Calculated Lengths

Lengths of various ages of rainbow trout at scale annulus formation were determined by back-calculation and used to compare growth of different year classes in Hat Creek.

Rainbow trout collected at Stations 5, 6, 7, 10 and 14 for scale analyses were used in calculations since they represented a wide range in fish sizes. Linear regression was used to compare fish length-scale radius relationships for September 1976, June 1977, and August 1977 (Rounsefell and Everhart, 1966; Steel and Torrie, 1960). Regression lines for the three months were:

September: total length (mm) = 4.803 + 5.855 scale radius;
June: total length (mm) = 0.382 + 6.297 scale radius; and
August total length (mm) = 16.738 + 5.560 scale radius.

Values for scale radii were given in mm after magnification at 45x. Correlations between total length and scale radius were 0.921, 0.896 and 0.903, respectively. Sample sizes for the three months were 77, 97 and 81 fish, respectively.

Analysis of variance was used to test whether a linear regression adequately described the relationship for each month (Steel and Torrie, 1960). The simple regression model was found to describe the dependence of length on scale radius sufficiently well for all data sets. Analyses of variance indicated that the relationship between scale radius and total length did not deviate significantly from linearity (September 1976: $F = 3.29$, df = 1,74; June 1977: $F = 0.85$, df = 1,94; August 1977: $F = 4.61$, df = 1,78; all $p \geq 0.01$). In each case accounted for at least 80% of the length variability.

Analysis of variance was then used to test whether the three regression lines were derived from samples estimating populations which had equal slopes. The regression coefficients were found to be homogeneous ($F = 1.53$; df = 2,249; $p < .05$).

The three population regressions were found to be identical (equal intercepts as well as slopes) and thus coincide ($F = 1.56$, df = 2,249; $p \leq .05$). Data sets were thus pooled and one best estimate of the relationship between length and scale radius obtained was:

total length (mm) = 5.571 + 5.979 scale radius.

The correlation coefficient was 0.908.

Individual total lengths at each annulus were determined from measurements along the anterior scale radius and calculated by the formula:

$$l_n - c = \frac{S_n}{S} (l - c)$$

where:
- l_n = length of fish when annulus "n" was formed;
- c = correction factor for length of fish at scale formation (5.571 mm);
- S_n = length of scale from focus to annulus "n";
- S = length of scale from focus to margin; and
- l = length of fish at time of capture (Ricker, 1971).

Mean back-calculated total lengths and ranges of all rainbow trout collected in Hat Creek for scale analyses are shown in Table 4-22. Mean total lengths at age 1 indicated good agreement between year classes. Values ranged from 61 mm for the 1973 year class to 69 mm for the 1975 year class. Considerable variation was noted among individual lengths within the 1973-1976 year classes (from 40 to 68 mm) as compared to the two previous year classes (variation of 15 and 25 mm). Mean lengths at age 2 were similar among year classes, ranging from 103 mm for the 1973 year class to 110 mm for the 1971 year class. Variation among individual lengths within a year class was from 39 to 63 mm. Relatively large fluctuations (from 58 to 62 mm) were again noted among individual lengths within a year class. Mean lengths at age 4 ranged from 169 mm for the 1973 year class to 179 mm for the 1971 year class. Variation among individual lengths within a year class was from 50 to 63 mm. Mean lengths at age 5 were 193 mm for the 1972 year class and 203 mm for the 1971 year class. Individual lengths varied 35 mm for the 1972 year class and 44 mm for the 1971 year class. Mean length of age 5 fish, the oldest age group collected, was 225 mm. Individual lengths varied 49 mm.

In summary, weighted mean back-calculated total lengths were 64 mm at age 1, 108 mm at age 2, 143 mm at age 3, 172 mm at age 4, 197 mm at age 5 and 225 mm at age 6. The general similarity of mean lengths at a given age for the various year classes suggests factors governing growth of rainbow trout in Hat Creek have remained relatively constant the past four or five years. Factors affecting variation in individual growth also appeared to have remained relatively constant. The wide range in individual lengths of age 1 fish suggests that length differences observed in these and older fish may be largely due to their being spawned over an extended period of time as well as variation in individual growth rates during the first year of life.

TABLE 4-22

MEAN BACK CALCULATED TOTAL LENGTHS AND RANGES FOR RAINBOW TROUT IN HAT CREEK

Age (Year Class)		Annulus 1	2	3	4	5	6
I (1976)	X̄	63					
	r	40-98					
	n	92					
II (1975)	X̄	69	109				
	r	45-106	82-126				
	n	46	29				
III (1974)	X̄	64	109	144			
	r	43-111	81-144	108-170			
	n	39	39	27			
IV (1973)	X̄	61	103	140	169		
	r	39-79	88-131	115-173	139-198		
	n	20	20	20	15		
V (1972)	X̄	63	108	144	172	193	
	r	54-79	88-127	114-172	143-206	177-212	
	n	14	14	14	14	9	
VI (1971)	X̄	65	110	141	179	203	225
	r	59-74	83-130	106-164	148-198	177-221	195-244
	n	5	5	5	5	5	4
Weighted mean calculated length (mm)		64	108	143	172	197	225
Weighted mean increment (mm)		64	44	35	29	25	28

Comparison of the above age-length data to values for British Columbia lakes (Larkin et al.,1957) indicates that Hat Creek fish age 2 and older are relatively slow-growing. However, there is no indication that they may be stunted. Growth rates of rainbow trout in Hat Creek may well be typical of similar-sized streams in interior British Columbia.

Back-calculated lengths of male and female rainbow trout collectec in Hat Creek were also determined and compared for growth differences. Mean total lengths and ranges are presented in Tables 4-23 (males) and 4-24 (females). The correction factor 5.571 mm, which was used to back-calculate lengths of total fish (Table 4-22), was used to determine lengths for each sex. This value was felt to best estimate the correction factor for males and females since it was derived from fish representing a wide length-range.

Weighted mean lengths of male rainbow trout were slightly greater than those for females of the same age. The oldest female was age 5 and the oldest male age 6.

Weighted mean back-calculated lengths and ranges for various age groups of rainbow trout collected in Hat Creek are presented by station in Table 4-25. The correction factor 5.571 was used to determine fish length at annulus formation. For purposes of comparison, weighted mean back-calculated lengths of male, female and all rainbow trout (including juveniles) are also shown in Table 4-25.

Mean lengths at age 1 were similar among stations, ranging from 60 mm at Station 6 to 68 mm at Station 14. Lengths at age 2 were also similar and varied from 105 mm at Station 10 to 113 mm at Station 5. Lengths of age 3 and 4 fish varied more among stations than for younger fish, and were slightly greater in Lower than Upper Hat Creek. For age 3 fish, mean lengths were from 149 - 162 mm at Stations 5 - 7 and 132 and 147 mm at Stations 10

TABLE 4-23

MEAN BACK CALCULATED TOTAL LENGTHS AND RANGES FOR MALE RAINBOW TROUT IN HAT CREEK

Age (Year Class)		Annulus 1	2	3	4	5	6
I (1976)	$\bar{X}$	72					
	r	54-98					
	n	3					
II (1975)	$\bar{X}$	71	114				
	r	49-96	108-121				
	n	11	7				
III (1974)	$\bar{X}$	67	112	146			
	r	43-111	91-138	127-165			
	n	15	15	12			
IV (1973)	$\bar{X}$	62	104	138	169		
	r	45-72	90-117	117-154	140-185		
	n	6	6	6	6		
V (1972)	$\bar{X}$	66	111	148	174	195	
	r	55-79	92-127	114-172	143-202	186-212	
	n	6	6	6	6	6	
VI (1971)	$\bar{X}$	63	108	141	178	205	225
	r	59-74	83-130	106-164	148-198	177-221	195-244
	n	4	4	4	4	4	4
Weighted mean calculated length (mm)		67	111	144	173	200	225
Weighted mean increment (mm)		67	44	33	29	27	25

TABLE 4-24

MEAN BACK CALCULATED TOTAL LENGTHS AND RANGES FOR FEMALE RAINBOW TROUT IN HAT CREEK

Age (Year Class)		Annulus 1	2	3	4	5
I (1976)	X̄	74				
	r	60-91				
	n	7				
II (1975)	X̄	68	113			
	r	48-97	102-126			
	n	14	14			
III (1974)	X̄	65	110	141		
	r	45-100	82-144	108-163		
	n	13	13	11		
IV (1973)	X̄	59	106	146	171	
	r	39-79	91-131	125-173	139-198	
	n	11	11	11		
V (1972)	X̄	59	107	143	168	195
	r	54-69	88-127	114-162	145-183	191-203
	n	6	6	6	6	4
Weighted mean calculated length (mm)		65	109	143	170	195
Weighted mean increment (mm)		65	44	34	27	25

TABLE 4-25

WEIGHTED MEAN BACK CALCULATED TOTAL LENGTHS OF MALE, FEMALE AND ALL RAINBOW TROUT IN HAT CREEK

	Category		Annulus 1	2	3	4	5	6
LOWER HAT CREEK	Station 5	$\bar{X}$	65	113	162			
		r	(50-79)	(102-124)	-			
		n	19	3	1			
	Station 6	$\bar{X}$	60	108	149	183		
		r	(39-82)	(94-120)	(127-170)	-		
		n	37	13	7	1		
	Station 7	$\bar{X}$	62	112	152	194		
		r	(41-91)	(81-136)	(135-165)	(190-198)		
		n	50	22	7	2		
UPPER HAT CREEK	Station 10	$\bar{X}$	66	105	132	164	193	221
		r	(43-111)	(82-138)	(106-107)	(139-202)	(177-221)	(195-244)
		n	54	35	22	14	7	3
	Station 14	$\bar{X}$	68	110	147	175	200	237
		r	(41-100)	(82-144)	(115-173)	(145-206)	(191-217)	-
		n	56	34	29	17	7	1
	Males	$\bar{X}$	67	111	144	172	200	225
	Females	$\bar{X}$	65	109	143	170	195	-
	All Fish (including juveniles)	$\bar{X}$	64	108	143	172	197	225

and 14. For age 4 fish, mean lengths were 183 and 194 mm at Stations 6 and 7, and 164 and 175 mm at Stations 10 and 14. Age 5 and 6 fish were collected only in Upper Hat Creek. Mean lengths for both age groups were greater at Station 14 than 10, as they were for younger fish.

The generally smaller mean lengths of older-age fish in Upper than Lower Hat Creek and at Station 10 compared to Station 14 appears inversely related to fish densities. Densities were almost always higher in Upper than Lower Hat Creek, and Station 10 exhibited some of the highest densities measured during the study. This suggests some factor such as food, space or cover may slightly limit the growth of rainbow trout in Upper Hat Creek, particularly at Station 10. Other factors, possibly the overall quality and quantity of fish habitat could favor the abundance of older age fish in Upper Hat Creek and limits it in Lower Hat Creek. Angling pressure could possibly account for the relatively low numbers of larger - sized fish in Lower Hat Creek. However, no fishermen were observed during the surveys. It is suspected that angling does not exert control over population structure in Lower Hat Creek.

(C) Observed Lengths

Mean observed total lengths of rainbow trout collected for scale analyses in Hat Creek are presented by station and sampling period in Table 4-26. Detailed data including means, ranges and sample sizes are listed in Appendix D Tables D-8 to D-10.

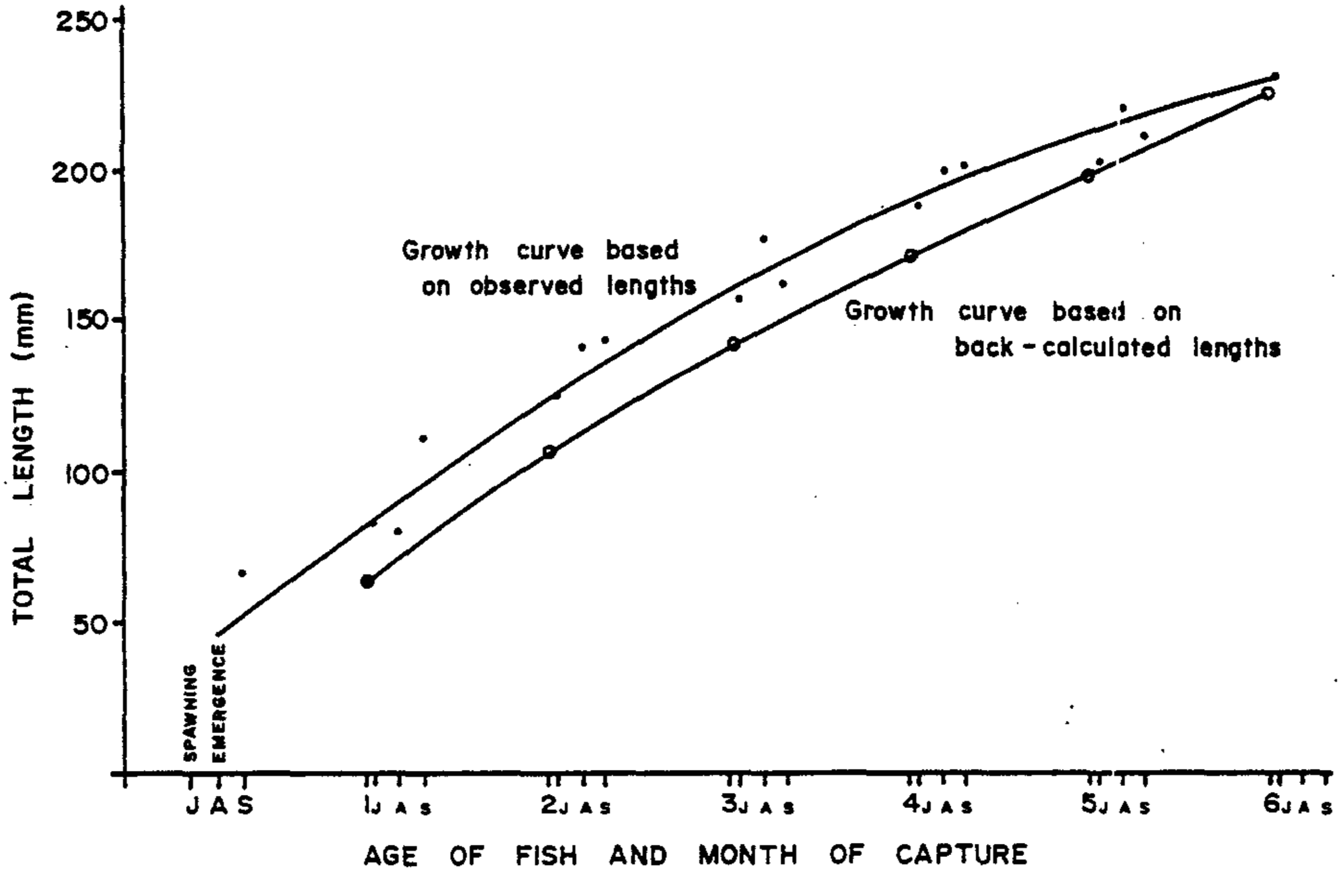
Data on observed total lengths show the same trends, such as length variation among stations and among fish from the same year class, as did back-calculated lengths. They do, however, provide additional information on fish growth within a year. Mean observed lengths among stations are plotted by month in Figure 4-20. Year classes have been plotted successively to illustrate a general growth curve for rainbow trout in Hat Creek. This assumes growth

TABLE 4-26

MEAN OBSERVED TOTAL LENGTHS OF RAINBOW TROUT IN HAT CREEK

Age (Year Class)[1]	Month	Lower Hat Creek			Upper Hat Creek		Mean
		Station 5	Station 6	Station 7	Station 10	Station 14	
0+	S[2]	[2]	[2]	[2]	[2]	[2]	[2]
(1977)	J	-	-	-	-	-	-
	A	36(1)[3]	42(3)	34(2)	42(1)	-	38(7)
1+	S	58(10)	59(9)	55(3)	81(9)	82(6)	67(37)
(1976)	J	88(12)	85(12)	77(10)	82(5)	86(8)	84(47)
	A	104(14)	105(10)	104(13)	90(10)	79(8)	80(45)
2+	S	-	114(2)	110(5)	111(4)	113(6)	112(17)
(1975)	J	134(1)	133(3)	126(7)	117(3)	117(1)	125(15)
	A	133(1)	152(3)	149(3)	132(4)	136(3)	140(14)
3+	S	-	-	138(5)	134(6)	161(1)	144(12)
(1974)	J	-	174(4)	167(3)	138(3)	150(5)	157(15)
	A	187(1)	187(2)	177(1)	156(2)	180(4)	177(11)
4+	S	-	-	-	156(2)	169(3)	162(5)
(1973)	J	-	-	-	151(3)	177(4)	187(7)
	A	-	207(1)	214 (2)	198(2)	197(3)	198(8)
5+	S	-	-	-	206(2)	195(3)	200(5)
(1972)	J	-	-	-	201(3)	202(3)	201(6)
	A	-	-	-	208(1)	232(2)	220(3)
6+	S	-	-	-	-	210(1)	210(1)
(1971)	J	-	-	-	229(3)	244(1)	232(4)
	A	-	-	-	-	-	-

[1] Fish spawned in 1977 denoted as age 0+, in 1976 as age 1+, etc.
[2] 1977 year class not yet in existence in September 1976
[3] n - sample size



location: Hat Creek

periods: September 28-30, 1976; June 14-16, 1977; August 3-5, 1977

Age at annulus formation (1-6) corresponds to back-calculated lengths.

Month of capture (J=June; A=August; S=September) corresponds to observed lengths.

figure 4·20
GROWTH CURVES FOR RAINBOW TROUT IN HAT CREEK

among fish from different year classes, but of the same age, is constant. Data on back-calculated lengths indicate this is the case.

Weighted mean back-calculated lengths are also plotted in Figure 4-20. Scale analyses indicated annuli formed about May or early June. Lengths at annulus formation were therefore plotted against the month of June for each age group. Estimated time of spawning (about mid-June to late July) and emergence of young (approximately August) are noted in Figure 4-20.

The two growth curves follow the same pattern. The small correction factor (5.571 mm), which is theoretical fish length at scale formation, may account for back-calculated lengths being less than observed lengths. A correction factor of 15 or 20 mm is probably more representative of actual fish length at scale formation and would result in nearly identical curves.

(D) Population Estimates

Population estimates for rainbow trout in Hat Creek were determined from density (number of fish/m of stream electroshocked) at Stations 5, 6, 7, 10, 14, 14A and 15, and the length of stream each station appeared to represent. Estimates were made for each survey. Sections of stream characterized by each station are listed in Table 4-27. Estimates were not made for the Bonaparte River because of sampling difficulties described above.

In order to estimate population size for various fish lengths, length frequency distributions at each station sampled during each survey were determined for class intervals 0 - 100, 101 - 150, 151 - 200, 201 - 250, and 250 mm (Table 4-28). Because habitat at Stations 14 (free-flowing stream) and 14A (beaver pond) represented conditions found in one section of Upper Hat Creek, data for these sites were combined and treated as single rather than separate samples.

TABLE 4-27

SECTIONS OF HAT CREEK

CHARACTERIZED BY VARIOUS STATIONS

Station	Stream Section[1]
5	0 - 8.0
6	8.0 - 22.4
7	22.4 - 25.5
10	25.5 - 30.0
14, 14A	30.0 - 39.0
15	39.0 - 41.0

[1] Kilometers from Hat Creek - Bonaparte River confluence

TABLE 4-28

LENGTH-FREQUENCY DISTRIBUTIONS (%) FOR RAINBOW TROUT

Month and Length Interval (mm)	Lower Hat Creek			Upper Hat Creek		
	Station 5	Station 6	Station 7	Station 10	Stations 14 & 14A	Station 15
September 1976						
0-100	100.0	89.5	36.8	47.3	28.3	32.2
101-150	-	10.5	57.9	36.8	47.8	28.6
151-200	-	-	5.3	10.5	15.2	21.4
201-250	-	-	-	5.3	7 6	17.8
>250	-	-	-	-	1.1	-
June 1977						
0-100	61.5	67.9	50.0	15.2	26.7	20.0
101-150	38.5	17.9	36.7	57.6	42.2	25.0
151-200	-	10.7	13.3	12.1	26.7	42.5
201-250	-	3.5	-	12.1	4.4	12.5
>250	-	-	-	3.0	-	-
August 1977						
0-100	37.5	32.0	38.5	31.7	26.0	100.0
101-150	50.0	48.0	38.5	41.7	38.0	-
151-200	12.5	16.0	15.3	21.6	30.0	-
201-250	-	4.0	7.7	5.0	6.0	-
>250	-	-	-	-	-	-

Population estimates were made according to the equation:

$$N = D \times L \times S$$

where: D = density at a particular station;
L = length of stream that station typifies; and
S = proportion of fish in a given length category at that station.

This equation was derived for the present study and makes the following assumptions:

1) densities and size class structures are constant within that portion of stream typified by a given station;
2) stream habitat is comparable within that portion of stream typified by a given station; and
3) all fish present in the area samples were captured.

The above assumptions are not entirely valid for all size classes of fish. Field observations indicated approximately 10-20% of fish less than 100 mm in length were not captured, and therefore resulted in under-estimates of population sizes for this length category. Population estimates for larger fish may also be low, although field observations indicated very few fish larger than 100 mm escaped capture.

Population estimates in those reaches of Hat Creek typified by Stations 5 and 6 may be less accurate than for areas further upstream. Station 5, and in particular Station 6 were located in reaches of Hat Creek which contained a variety of habitats. Therefore, densities at these stations may not be entirely representative of their respective reaches of stream.

Population estimates by station and size class during each survey are presented in Table 4-29. Total population size for rainbow trout in Hat Creek during the three surveys was estimated at 22,851 in September 1976, 17,782

TABLE 4-29

POPULATION ESTIMATES BY LENGTH INTERVAL (mm) FOR RAINBOW TROUT

Month and Length Interval (mm)	Lower Hat Creek*			Upper Hat Creek[1]			TOTAL
	0 - 8.0	8.0 - 22.4	22.4 - 25.5	25.5 - 30.0	30.0 - 39.0	39.0 - 41.0	
September 1976							
0-100	3,120	3,351	319	1,788	2,983	258	11,819
101-150	-	393	502	1,391	5,038	228	7,552
151-200	-	-	46	401	1,602	171	2,220
201-250	-	-	-	201	801	142	1,144
>250	-	-	-	-	116	-	116
TOTAL	3,120	3,744	867	3,781	10,540	799	22,851
June 1977							
0-100	836	3,715	698	499	1,370	228	7,346
101-150	524	979	512	1,893	2,165	285	6,358
151-200	-	589	185	398	1,370	404	3,023
201-250	-	192	-	298	225	142	957
>250	-	-	-	98	-	-	98
TOTAL	1,360	5,472	1,395	3,286	5,130	1,139	17,782
August 1977							
0-100	330	1,567	465	1,883	1,498	260	6,003
101-150	440	2,350	465	2,477	2,189	-	7,921
151-200	110	783	185	1,283	1,728	-	4,089
201-250	-	196	94	297	345	-	932
>250	-	-	-	-	-	-	-
TOTAL	800	4,896	1,209	5,940	5,760	260	18,945

[1] Kilometers from Hat Creek - Bonaparte River confluence

in June 1977 and 18,945 in August 1977. About 35 - 45% of the total number during each survey occurred in Lower Hat Creek, an area which comprised about 60% of the length of Hat Creek.

Population estimates for rainbow trout greater than 150 mm were 3,480 in September 1976, 4,078 in June 1977, and 5,021 in August 1977. Only approximately 1% of fish greater than 150 mm occurred in Lower Hat Creek in September 1976. This figure increased to about 25% in both June 1977 and August 1977.

Overall, size classes were better represented and population estimates higher per unit length of stream in Upper than Lower Hat Creek. However, a viable fishery appears to exist in both areas of the creek.

(iii) Condition & Body Statistics

(A) Condition Factor

The body condition of rainbow trout were computed using the function:

$$K = \frac{10^5 W}{L^3}$$

where: K = Condition factor;
W = weight in g; and
L = length in mm.

The condition factor provides a measure of the relative plumpness of fish. Comparison of condition factors for rainbow trout between stations and between sampling periods provides one indication of the robustness or well-being of individuals in a temporal and spatial framework.

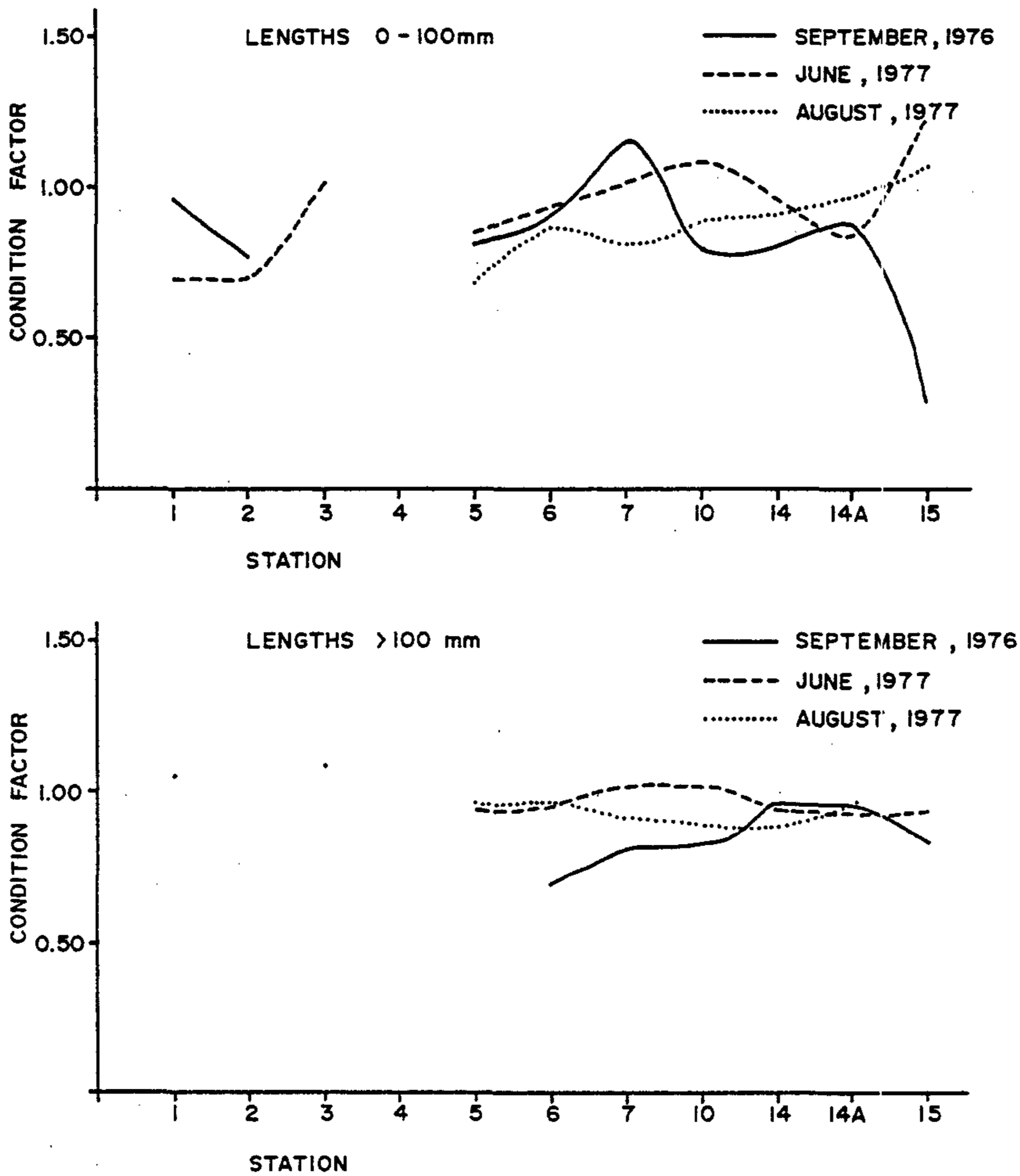
Means and ranges for condition factors of rainbow trout at each station during each sampling period are shown in Appendix D Table D-11. To minimize any fish-size effects, values were determined for length size classes of less than 100 mm and greater than 100 mm. Mean values for both size groups of fish are shown in Figure 4-21.

Mean condition factors of rainbow trout were usually less than 1.00. Examination of specimens at time of collection showed most were in good condition with few appearing emaciated.

For fish less than 100 mm, mean condition factors ranged from 0.29 at Station 15 in September 1976 to 1.23 at Station 15 in June 1977; individual condition factors for fish of this size varied from 0.13 at Station 15 in September 1976 to 1.81 at Station 15 in June 1977. For fish greater than 100 mm, mean condition factors ranged from 0.70 at Station 6 in September 1976 to 1.09 at Station 3 in August 1977; individual values for fish greater than 100 mm varied from 0.66 at Station 6 in September 1976 and Station 14 in June 1977 to 1.45 at Station 7 in June 1977.

In Upper Hat Creek (Stations 10, 14, 14A and 15) mean condition factors for rainbow trout less than 100 mm were generally highest in June 1977, intermediate in August 1977, and lowest in September 1976. In Lower Hat Creek (Stations 5, 6 and 7), values were highest in June 1977 or September 1976 and lowest in August 1977. The only month in which a trend was apparent occurred in August 1977 when values generally increased from Station 5 upstream to Station 15. In the Bonaparte River, mean condition factors for trout less than 100 mm were within the range of values reported for Hat Creek.

The extremely low condition factors for rainbow trout less than 100 mm at Station 15 in September 1976 may have been related to the diversion of water for irrigation. Fish were concentrated in remaining pools and may have suffered a limited food supply, especially since larger fish (greater than 100 mm) were also present. In addition, the presence of larger fish may have caused small fish to spend less time searching for food and more time avoiding possible predation, thus contributing to the low condition factor. September 1976 conditions were in contrast to those in June 1977, when flows appeared



location: Hat Creek and Bonaparte River stations

periods: September 28-30, 1976; June 14-16, 1977; August 3-5, 1977

for rainbow trout 0-100 mm and > 100mm total length.

Absence of point from graph indicates no specimens collected.

figure 4·21

MEAN CONDITION FACTORS FOR RAINBOW TROUT

normal, and August 1977, when water had been diverted but only small fish were present.

Mean condition factors for trout greater than 100 mm were similar among Hat Creek stations in June 1977 and August 1977. Values were slightly higher at Stations 14, 14A and 15 than Stations 6, 7 and 10 in September 1976 and suggests slightly better growth conditions at upstream stations during this month. The higher condition factors at Stations 6, 7 and 10 in June 1977 and August 1977 than September 1976 may reflect the increased weight of gonads during months nearest spawning (approximately June - July). This relationship was not apparent at stations further upstream. Mean condition factors for trout greater than 100 mm in the Bonaparte River were slightly higher than those in Hat Creek.

Mean condition factors for rainbow trout less than 100 mm varied more than for larger fish. This may reflect an inherent variation in the length-weight relationship of fish until they attain some larger size. It suggests that the growth or condition of smaller fish may be more sensitive to variation in the diversity and quantity of available food than larger fish.

(B) Length-Weight Relationship

The length-weight relationship of rainbow trout in Hat Creek was determined for fish less than and greater than 100 mm total length collected during each sampling period. All trout captured at Hat Creek stations were used in the analysis. Differentiation was made according to fish size to allow for the possibility of any inherent differences in length-weight relationships between small and large fish. Differentiation was made among sampling periods to determine if seasonal changes resulting from factors such as increased weight of ovaries and testes near time of spawning or increased fish weight during maximum growth periods occurred.

The length-weight relationship has been described by the formula:

$$\log \text{weight (g)} = \log a + b \log \cdot \text{length (mm)}$$

where: Log a = Y-intercept; and
b = regression coefficient (Ricker, 1971).

After logarithmic transformation of length-weight data, a linear regression was performed to evaluate this relationship for Hat Creek fish. Regression lines, correlation coefficients and sample sizes for each size category of fish during each sampling period are presented in Table 4-30.

Analysis of variance (Steel and Torrie, 1960) showed the simple linear regression model described the dependence of weight on length sufficiently well for four of the six data sets. The values for each were as follows (significant *F* values indicates that the relationship between weight and length deviates from linearity):

Date	Fish Length (mm)	*F*	Degrees of Freedom
September 1976	≤ 100	18.826**	1, 103
September 1976	> 100	0.250	1, 116
June 1977	≤ 100	1.000	1, 64
June 1977	> 100	0.000	1, 119
August 1977	≤ 100	18.700**	1, 59
August 1977	> 100	0.500	1, 113

**$p \leq 0.01$

TABLE 4-30

LENGTH-WEIGHT RELATIONSHIPS FOR RAINBOW TROUT:

REGRESSION LINES, CORRELATION COEFFICIENTS AND SAMPLE SIZES[1]

Month and Fish Length (mm)	Regression Line	Correlation Coefficient	Sample Size
September 1976			
≤ 100	Log weight = -5.906 + 3.437 log length	0.93	106
> 100	Log weight = -5.907 + 3.022 log length	0.98	119
June 1977			
≤ 100	Log weight = -4.883 + 2.930 log length	0.95	67
> 100	Log weight = -4.872 + 2.933 log length	0.99	122
August 1977			
≤ 100	Log weight = -5.941 + 3.468 log length	0.97	62
> 100	Log weight = 5.020 + 2.990 log length	0.99	116

[1] Lengths measured on total length

Examination of the September 1976 $\leq$ 100 mm data revealed that the weight of fish less than approximately 50 mm in length tended to vary greatly and was not adequately described by a straight line. The linear regression, however, accounted for at least 86% of the weight variability in both cases.

Analysis of the three regression lines for fish less than 100 mm showed significant differences in the slopes of the regression lines (F = 3.2; df = 2,229; $p \leq 0.05$). Consequently data sets were not pooled.

Analyses of variance was then used to test whether the regression lines for fish greater than 100 mm were derived from samples estimating populations among which the slopes were equal. The regression coefficients were found to be homogeneous (F = 1.18, df = 2,351; $p > 0.05$). While the slopes of the regression lines were found to be identical, the intercept of the lines with the Y axis were found to be unequal (the linear regressions have different evaluations) and therefore do not coincide (F = 13.20; df = 2,351; $p \leq 0.05$). The data sets were not pooled.

The nearness of all slopes to 3.0 indicates growth of rainbow trout in Hat Creek is generally symmetrical. Regression lines with slopes greater than 3.0 indicate fish become heavier per unit length as they grow larger. Greatest increase in weight per unit length increase was exhibited by those fish which comprised regression lines with the greatest (steepest) slopes.

(C) Spawning Time and Sex Ratios

Rainbow Trout

Examination of gonads indicated that in 1977 rainbow trout in Hat Creek spawned primarily between mid-June and late July. Collection of sexually mature fish at all stations indicated spawning occurred the length of Hat Creek.

During the June 1977 survey, ovaries and testes appeared to be developing. During the August 1977 survey, most sexually mature fish were spent. Water temperatures at most Hat Creek stations were about 10-12°C in June and 11-14°C in August 1977. These ranges correspond roughly to preferred spawning temperature of 10-15.5°C (Scott and Crossman, 1973). Examination of fish during the September 1976 survey showed sex of most was indistinguishable and indicates spawning occurred considerably earlier.

During June 1977, ovaries of most females did not appear fully developed and ova were consistently small (approximately 1 mm diameter). Three females with lengths of 198 - 211 mm which were captured at Station 14 appeared closest to spawning. Each contained about 300 - 400 eggs. Although the eggs were still connected by interstitial tissue, their size (about 2 - 3 mm diameter) indicated these fish would soon spawn. Scott and Crossman (1973) reported mature ova are 3 - 5 mm diameter. About half the males collected during June 1977 exuded milt when slight pressure was applied to the abdomen. Testes of the rest did not appear fully developed.

Most sexually mature rainbow trout captured in August 1977 were spent. Ovaries of many females were flaccid and contained granular particles < 1 mm diameter. Several females contained eggs about 3 - 4 mm diameter which had not been discharged during spawning. Testes of most males had diminished in size, although several specimens exuded milt when pressure was applied to the abdomen.

Some large sized rainbow trout (> 150 mm) captured in August 1977 which would have been expected to spawn appeared not to have spawned. Ovaries were small and thread-like, and contained no granular material usually present after spawning. Testes were similarly of small size. It is also possible these fish spawned considerably earlier than most with enough time passing between spawning and actual collection that their gonads would not indicate this. The possibility of extended spawning in Hat Creek could account for length differences observed among young-of-the-year rainbow trout.

Numbers and length ranges of sexually mature male and female rainbow trout captured at Hat Creek stations during June 1977 and August 1977 are presented in Table 4-31. The smallest male was 110 mm and the smallest female 121 mm Youngest fish for both sexes were age 1+, although sexually mature fish of this age were uncommon. Sex ratios (males:females) at each station appeared relatively even.

Mountain Whitefish

Three sexually mature female mountain whitefish were captured at Station 7 in June 1977. Lengths and ages were 314 mm (age 4+), 352 mm (age 5+) and 354 mm (age 4+). One sexually mature male (290 mm, age 4+) was captured at Station 10 in June 1977. Examination of gonads indicated all would spawn during Fall. One male whitefish (133 mm, age 1+) captured at Station 3 in June 1977 did not appear sexually mature. In the Okanagan system, mountain whitefish spawn near mid-November (Carl *et al.*, 1973).

Brook Trout

The brook trout taken at Station 3 in September 1977 was immature. Its length was 114 mm and age 1+.

Bridgelip Sucker

Sexually mature bridgelip suckers were collected at Station 3 in June 1977, and included one female (184 mm) and eight males (121 - 180 mm). They were taken over a gravel substrate in swift water approximately 0.5 m deep. Milt was exuded from males and roe from the female when slight pressure was applied to the abdomen. Carl *et al.*, (1973) reported collecting ripe bridgelip sucker north of Prince George in June 1977.

TABLE 4-31

NUMBERS AND LENGTH RANGES (mm)

OF SEXUALLY MATURE RAINBOW TROUT

		Station 5	Station 6	Station 7	Station 10	Station 14
June						
Males	n	0	4	4	6	3
	r	-	140-170	140-187	145-255	177-244
Females	n	1	1	4	7	5
	r	134	127	123-162	121-208	141-211
August						
Males	n	1	2	5	7	5
	r	187	110-161	119-192	115-231	167-241
Females	n	0	4	5	4	4
	r	-	171-207	130-216	134-183	181-210

Longnose Dace

Four sexually mature males with lengths of 81 - 110 mm were collected at Station 5 in June 1977. Milt was observed flowing from all specimens. One spent female (98 mm) was taken at Station 3 in August 1977. Carl *et al.*, (1973) reported collecting ripe longnose dace in the Nicola River drainage area in June 1977.

Leopard Dace

No spawning male or female leopard dace were observed during the study. Gee and Northcote (in Scott and Crossman, 1973) reported this species probably spawns in early July.

Redside Shiner

One sexually mature male (104 mm) was captured at Station 3 in June 1977. Four mature males (78 - 99 mm) were also collected at Station 4 in June 1977. All exuded milt when handled. Scott and Crossman (1973) reported redside shiner may spawn as early as May or as late as August.

(D) Ectoparasites

Parasitic copepods were observed on rainbow trout in Hat Creek during each sampling period. None were observed on Bonaparte River fish, although this was probably due to the small sample size compared to that in Hat Creek rather than the absence of parasites from the river. Most parasitized fish were larger specimens (usually greater than 180 mm total length) and collected primarily at Stations 10 and 14 in Upper Hat Creek. Only two parasitized trout (201 mm at Station 6, 140 mm at Station 7) were captured in Lower Hat Creek.

Parasites were usually attached at the base of the pelvic or pectoral fins, occasionally on the inner surface of the operculum, and on one fish at the base of the dorsal fin. Parasites were observed on both males and females and occasionally on smaller, sexually immature fish. Numbers and length ranges of parasitized rainbow trout collected during each survey were four in September 1976 (183 - 234 mm), 14 in June 1977 (140 - 255 mm), and 12 in August 1977 (84 - 241 mm). Two large trout (234 and 244 mm) which appeared thin may have been stressed by the infestation; condition factors of these two specimens were were 0.99 and 0.69, respectively.

(iv) Availability & Utilization of Food Organisms

Invertebrates living in or on bottom sediments can be used as indicators of adverse changes in aquatic environments because they display varying degrees of sensitivity to degradation in water quality (Hynes, 1958; Wilhm & Dorris, 1966 and 1968; Cairns & Dickson, 1971). Natural benthic communities are relatively stable or exhibit predictable oscillations in structure and composition. This phenomenon, coupled with their respective sensitivities to water quality, enables the use of benthic fauna as a biological measure of environmental conditions.

Coupled with their inherent potential as ecological indicators, benthic invertebrates are a major food item of fish (Lagler, 1966). These aquatic insects are critical to the food chain of any freshwater system culminating in fish. The importance of invertebrates is embodied in their ability to convert energy entrapped by primary producers to a form capable of being utilized by fish.

Composition, relative abundance and distribution of food organisms determine, in part, population levels, growth rates and overall condition of fish. With seasonal changes, alterations in food being utilized may occur, coinciding with possible shifts in food availability.

The following sub-sections will examine the structure of benthic invertebrate systems studies in relation to inherent community complexity and dynamics. Subsequent to these data, consideration will be given to an analysis of the relationship of benthic invertebrates to fish populations with respect to food habits and utilization of major food items.

(A) Benthic Invertebrate Communities

Perspective

Results of the first order identifications (to taxonomic order) for the September 1976, June 1977 and August 1977 sampling periods are presented in Appendix E. Detailed identifications (to genus and/or species) for each sampling period follow the first order data in each respective section of Appendix E. Tables 4-32, 4-33, 4-34 and 4-35 summarize benthic invertebrate data for each sampling station during each of the three sampling periods.

Dominance indices indicated that at the majority of stations examined, one group of benthic invertebrate dominated inhabitable substrates regardless of sample period. Percentage data showed that during September 1976, 75% of the stations samples supported Group 3 fauna in greatest abundance; in June 1977, 69% of the stations were dominated by Group 3 and in August 1977, 92%.

Lake habitats (Stations 16 and 17; Table 4-35) were sampled with a Ponar dredge which is most effective in soft, fine sediments. Consequently, use of this sampling method selects for organisms that are common to substrates of this consistency, the Group 2 forms (Diptera, Amphipods and Leeches). Following the September 1976 survey, lake stations were discontinued.

The preponderance of Group 3 invertebrates at the majority of stations suggests that, in general, water quality was good in Hat Creek and the Bonaparte

TABLE 4-32

BONAPARTE RIVER - SUMMARY OF BENTHIC INVERTEBRATE DATA

	Bonaparte River - Stations											
	1			2			3			4		
Parameter	Sept. 76	June 77	Aug. 77	Sept. 76	June 77	Aug. 77	Sept. 76	June 77	Aug. 77	Sept. 76	June 77	Aug. 77
% Group 3	40.1	95.3	75.7	75.4	76.0	84.7	62.3	78.7	67.2	86.8	77.7	87.1
% Group 2	59.5	4.7	20.5	23.0	24.0	15.3	36.7	21.3	30.9	13.2	21.8	12.9
% Group 1	0.4	0.0	3.8	1.6	0.0	0.0	1.0	0.0	1.9	0.0	0.5	0.0
Mean No./m²												
Group 3	229	366	646	91	38	283	229	393	876	24	299	620
Group 2	340	18	175	27	12	51	135	106	403	3	84	92
Group 1	2	0	32	2	0	0	3	0	24	0	2	0
Total	571	384	853	120	50	334	367	499	1303	27	385	712
Dominance (C)[1]	0.52	0.91	0.62	0.63	0.64	0.74	0.53	0.67	0.55	0.80	0.65	0.78
Diversity ($\bar{d}$)[2]	3.19	1.92	3.99	3.17	1.83	2.91	3.68	2.83	3.25	1.56	2.89	3.00
Total No. (N)	102	101	120	65	27	102	105	107	110	15	104	104
Total No. Genera (S)	15	11	18	16	7	15	19	13	16	5	17	16
Richness (R)[2]	3.03	2.17	3.55	3.59	1.82	3.03	3.87	2.57	3.19	1.48	3.45	3.23
Equitability (J)[2]	0.82	0.56	0.72	0.79	0.65	0.74	0.87	0.76	0.81	0.67	0.71	0.75

[1] Calculated from biotic index data
[2] Calculated from detailed identification data

TABLE 4-33

LOWER HAT CREEK - SUMMARY OF BENTHIC INVERTEBRATE DATA

	Lower Hat Creek - Stations											
	5			6			7			8		
Parameter	Sept. 76	June 77	Aug. 77	Sept. 76	June 77	Aug. 77	Sept. 76	June 77	Aug. 77	Sept. 76	June 77	Aug. 77
% Group 3	66.9	28.9	65.4	66.7	26.6	74.1	90.1	67.3	80.6	91.5	81.5	95.3
% Group 2	31.0	69.4	32.0	33.3	66.9	25.0	9.9	31.6	17.3	5.7	10.8	2.7
% Group 1	2.1	1.7	2.6	0.0	6.5	0.9	0.0	1.1	2.1	2.8	7.7	2.0
Mean No./m^2												
Group 3	426	898	891	299	555	1051	573	662	1363	297	541	627
Group 2	197	2158	436	149	1394	354	63	311	292	18	72	18
Group 1	13	51	35	0	133	14	0	11	36	8	51	13
Total	636	3107	1362	448	2082	1419	636	984	1691	323	664	658
Dominance (C)[1]	0.55	0.57	0.53	0.56	0.52	0.61	0.82	0.55	0.68	0.85	0.68	0.91
Diversity ($\bar{d}$)[2]	3.42	2.80	3.35	2.83	2.74	2.79	2.52	3.80	3.14	3.62	3.01	3.02
Total No. (N)	109	165	105	107	157	102	107	101	113	109	104	107
Total No. Genera (S)	18	17	17	15	12	14	17	25	20	20	13	14
Richness (R)[2]	3.62	3.13	3.44	3.00	2.18	2.81	3.42	5.20	4.02	4.05	2.58	2.78
Equitability (J)[2]	0.82	0.69	0.82	0.72	0.77	0.72	0.62	0.82	0.73	0.84	0.81	0.79

[1] Calculated from biotic index data
[2] Calculated from detailed identification data

TABLE 4-34

UPPER HAT CREEK - SUMMARY OF BENTHIC INVERTEBRATE DATA

Parameter	Upper Hat Creek - Stations 10 Sept. 76	10 June 77	10 Aug. 77	11 Sept. 76	11 June 77	11 Aug. 77	12 Sept. 76	12 June 77	12 Aug. 77
% Group 3	79.5	73.6	80.9	82.9	17.9	81.8	37.9	-	-
% Group 2	17.7	25.2	18.7	13.6	70.0	15.2	17.5	-	-
% Group 1	2.5	1.2	0.4	3.5	12.1	2.0	44.6	-	-
Mean No./m^2									
Group 3	418	649	997	843	395	2851	92	-	-
Group 2	92	222	230	138	1540	564	42	-	-
Group 1	13	11	5	35	265	72	108	-	-
Total	523	882	1232	1016	2200	3487	242	-	-
Dominance (C)[1]	0.67	0.61	0.69	0.71	0.54	0.70	0.37	-	-
Diversity ($\bar{d}$)[2]	3.75	3.22	3.28	3.00	2.96	2.80	2.40	-	-
Total No. (N)	102	105	104	110	176	181	112	-	-
Total No. Genera (S)	24	18	18	13	15	14	11	-	-
Richness (R)[2]	4.97	3.65	3.66	2.55	2.71	2.50	2.12	-	-
Equitability (J)[2]	0.82	0.77	0.79	0.81	0.76	0.74	0.69	-	-

[1] Calculated from biotic index data
[2] Calculated from detailed identification data

TABLE 4-34 Cont'd.

UPPER HAT CREEK - SUMMARY OF BENTHIC INVERTEBRATE DATA

	Upper Hat Creek - Stations								
	13			14			15		
Parameter	Sept. 76	June 77	Aug. 77	Sept. 76	June 77	Aug. 77	Sept. 76	June 77	Aug. 77
% Group 3	54.3	89.9	93.8	80.8	69.9	67.8	87.9	8.8	29.5
% Group 2	44.0	8.4	4.3	12.2	21.5	27.8	10.4	90.4	68.2
% Group 1	1.7	1.7	1.9	7.0	8.6	4.4	1.7	0.8	2.3
Mean No./m^2									
Group 3	241	1440	1463	318	790	1028	735	338	733
Group 2	196	135	67	47	243	421	86	3476	1694
Group 1	7	27	30	27	97	68	14	32	57
Total	444	1602	1560	392	1130	1517	835	3846	2484
Dominance (C)[1]	0.49	0.82	0.88	0.68	0.54	0.54	0.79	0.83	0.55
Diversity ($\bar{d}$)[2]	1.84	2.71	3.38	2.66	3.07	3.47	2.80	2.18	2.53
Total No. (N)	135	158	109	101	116	138	108	133	186
Total No. Genera ( )	12	15	15	13	18	19	14	9	12
Richness (R)[2]	2.24	2.77	2.98	2.60	3.58	3.65	2.78	1.64	2.10
Equitability (J)[2]	0.51	0.69	0.86	0.72	0.74	0.82	0.74	0.69	0.71

[1] Calculated from biotic index data
[2] Calculated from detailed identification data

TABLE 4-35

GOOSE/FISH HOOK LAKE (STATION 16) AND FINNEY LAKE (STATION 17) -

SUMMARY OF BENTHIC INVERTEBRATE DATA

Parameter	Lakes - Stations 16 September 76	17 September 76
% Group 3	3.3	1.2
% Group 2	96.7	89.0
% Group 1	0.0	9.8
Mean No./m^2		
Group 3	33	11
Group 2	1076	795
Group 1	0	86
Total	1109	892
Dominance (C)[1]	0.94	0.80
Diversity ($\overline{d}$)[2]	0.61	2.44
Total No. (N)	112	113
Total No. Genera (S)	4	11
Richness (R)[2]	0.64	2.12
Equitability (J)[2]	0.31	0.71

[1] Calculated from biotic index data
[2] Calculated from detailed identification data

River during the three sampling periods. Fluctuations in water quality during the course of the study were not of sufficient magnitude to significantly inhibit the development of benthic invertebrate systems dominated by Group 3 fauna.

The mayflies, caddisflies and stoneflies (Group 3) respire by external gill structures that exhibit low tolerance to chemical pollutants and fine suspended sediment that may cause abrasive damage. Consequently, the preponderance of these invertebrate orders would tend to indicate that the water systems studied did not exert severe negative conditions to a level of significantly altering the direction of community development.

Sampling stations in the Bonaparte and Hat Creek systems may be grouped into three units for ease of data interpretation, these include:

1) Bonaparte River - Stations 1, 2, 3 and 4;
2) Lower Hat Creek - Stations 5, 6, 7 and 8; and
3) Upper Hat Creek - Stations 10, 11, 12, 13, 14 and 15.

Table 4-36 summarizes the overall mean figures for select parameters by study area unit and sample period.

In the Bonaparte River (Tables 4-32 and 4-36), Group 3 organisms were most abundant, consisting of 52.8%, 83.1% and 75.7% of the population during September 1976, June 1977 and August 1977, respectively. However, this pattern was not duplicated in either Lower or Upper Hat Creek.

During September 1971 and August 1977 (Tables 4-33, 4-34, 4-36), Group 3 fauna, on the average, predominated in accordance with 78.1% and 76.7%, (Lower Hat Creek) and 76.6% and 68.8% (Upper Hat Creek), respectively. The June 1977 sampling period in Lower and Upper Hat Creek exhibited a preponderance of Group 2 fauna in mean percentages of 57.6 and 58.1, respectively.

TABLE 4-36

SUMMARY OF BENTHIC INVERTEBRATE DATA

FOR THE THREE STUDY UNITS

	Overall Mean								
	Bonaparte River			Lower Hat Creek			Upper Hat Creek		
Parameter	Sept. 76	June 77	Aug. 77	Sept. 76	June 77	Aug. 77	Sept. 76	June 77	Aug. 77
% Group 3	52.8	83.1	75.7	78.1	38.8	76.7	76.6	37.4	68.8
% Group 2	46.5	16.7	22.5	20.9	57.6	24.4	17.5	58.1	28.9
% Group 1	0.7	0.2	1.8	1.0	3.6	1.9	5.9	4.5	2.3
Mean No. Organisms/m^2									
Group 3	143	274	606	399	664	983	441	722	1414
Group 2	126	55	180	107	984	275	101	1123	595
Group 1	2	0.5	14	5	61	24	34	86	46
Total	271	329.5	800	511	1709	1282	576	1931	2055
Dominance	0.61	0.72	0.67	0.69	0.58	0.68	0.61	0.67	0.67
Diversity	2.90	2.37	3.04	3.10	3.09	3.07	2.74	2.83	3.09
Richness	2.99	2.50	3.25	3.52	3.27	3.26	2.88	2.87	2.98
Equitability	0.79	0.67	0.75	0.75	0.77	0.77	0.71	0.73	0.78

These data suggest some temporal oscillation probably related to the life histories of the invertebrate species recorded. An alternative which may account for the slight decline of Group 3 fauna during the June 1977 sampling period is increased flow and higher sediment characteristics of the system.

Over a 10 year period, 1963 - 1973, the months of May and June (freshet period) flows averaged approximately 1.9 and 2.7 m^3/s (Upper Hat Creek Water Survey Station 08LF061), values markedly higher than at any other time of year. During freshet marked increases in solids levels are not uncommon. On the this basis the slight average decline in Group 3 organisms in June 1977 (Table 4-36) may be resultant to a greater input of suspended sediment in Hat Creek during freshet. Increased sediment would similarly serve as an abrasive agent on the sensitive gill structures of Group 3 organisms.

Benthic invertebrates collected in various segments of the study area are common to lotic freshwater systems. Table 4-37 presents a summary of the dominant benthic genera collected during each sample period in each study unit.

The dominant genera recorded during the study were encompassed primarily by the taxomomic order Ephemeroptera (mayflies). The Trichopterans (caddisflies), Plecopterans (stoneflies) and Dipterans (midges) also were recorded as exhibiting varying degrees of dominance.

Table 4-38 summarizes the appearance of dominant orders in the Hat Creek and the Bonaparte River. It is evident that the mayflies, of the genus *Baetis* and *Ephemerella* in particular (Appendix E), were the most abundant organisms. One or the other or both of these invertebrates appeared throughout the lotic systems under examination.

TABLE 4-37

SUMMARY OF DOMINANT INVERTEBRATE GENERA

September 1976

Bonaparte River	Lower Hat Creek	Upper Hat Creek
Rhithrogena sp. (E)[1]	*Baetis* sp. (E)	*Rhithrogena* sp. (E)
Baetis sp. (E)	*Ephemerella* sp. (E)	*Cinygmula* sp. (E)
Hydropsyche sp. (T)	*Hydropsyche* sp. (T)	*Baetis* sp. (E)
Cricotopus sp. (D)	*Diplectroma* sp. (T)	*Ephemerella* sp. (E)
	Claassenia sp. (P)	*Hydropsyche* sp. (T)
	Micropsectra sp. (D)	*Claassenia* sp. (P)
	Antocha sp. (D)	*Pericoma* sp. (D)
		Turbellaria

June 1977

Bonaparte River	Lower Hat Creek	Upper Hat Creek
Rhithrogena sp. (E)	*Ironopsis* sp. (E)	*Ironopsis* sp. (E)
Baetis sp. (E)	*Cinygmula* sp. (E)	*Cinygmula* sp. (E)
Ephemerella sp. (E)	*Baetis* sp. (E)	*Baetis* sp. (E)
Brachycentrus sp. (T)	*Ephemerella* sp. (E)	*Hastaperla* sp. (P)
	Micropsectra sp. (D)	*Cardiocladius* sp. (D)
	Orthocladius sp. (D)	*Simulium* sp. (D)
	Cardiocladius sp. (D)	Turbellaria
	Oligochaeta	Oligochaeta

August 1977

Bonaparte River	Lower Hat Creek	Upper Hat Creek
Rhithrogena sp. (E)	*Baetis* sp. (E)	*Baetis* sp. (E)
Baetis sp. (E)	*Ephemerella* sp. (E)	*Ephemerella* sp. (E)
Ephemerella sp. (E)	*Hydropsyche* sp. (T)	*Paraleptophlebia* sp. (E)
Caenis sp. (E)	*Claassenia* sp. (P)	*Claassenia* sp. (P)
Hydropsyche sp. (T)	*Nemoura* sp. (P)	*Hastaperla* sp. (P)
Micropsectra sp. (D)	*Antocha* sp. (D)	*Nemoura* sp. (P)
		Cardiocladius sp. (D)

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[1] E = Ephemeroptera
T = Trichoptera
P = Plecoptera
D = Diptera

TABLE 4-38

SUMMARY OF DOMINANT INVERTEBRATE ORDERS INHABITING

BONAPARTE RIVER AND HAT CREEK STATIONS

Dominant Orders	% of Stations where Dominant[1] September 1976	June 1977	August 1977
Ephemeroptera	64.3	61.5	84.6
Trichoptera	14.2	7.7	0.0
Plecoptera	7.1	0.0	7.7
Diptera	7.1	30.8	7.7
Oligochaeta	7.1	0.0	0.0

[1] Computed from data in Appendix E

Community Structure

The richness component of a community is the relative wealth of the system in terms of the number of invertebrate genera sampled. Community wealth is directly related to the ability of the area to provide raw materials such as food and space for biological development.

Community richness in Lower Hat Creek (Table 4-36) was the highest of the three study sections during each sampling period. A high richness factor indicates that within the area in quesion a given sample of the habitat yields a high number of genera per unit of organism abundance. A greater number of genera can only be supported by greater habitat complexity. Consequently, it may be inferred that microhabitats within the Lower Hat Creek section were in greater abundance, thereby providing a greater area for potential colonization and community development.

Lower Hat Creek exhibited a greater proportion of riffle areas compared to Upper Hat Creek and the Bonaparte River. This phenomenon would tend to facilitate formation of a more diverse abiotic system into which invertebrates would immigrate and perpetuate. It should also be noted that the richness factor appeared to vary least temporally in Lower Hat Creek compared to the Bonaparte River and Upper Hat Creek. This low amplitude oscillation would suggest some form of high stability of the biological community.

Community equitability is the eveness with which individuals are apportioned in the sampled invertebrate genera. Data on equitability in Table 4-36 indicate that, in general, equitability was relatively comparable between study units and between sampling periods. All the communities were not excessively reliant on one particular genus of invertebrate for overall energy transfer. In effect, the potential loss of a portion of a communities generic complement would not be overly traumatic (up to some threshold level) as an efficient redirection of energy flow to remaining organisms would be possible.

The attributes of richness and equitability when synthesized as a single parameter yield a single quantitative estimate of system complexity and stability, this measure is diversity.

Table 4-36 shows the relative changes in diversity for each study unit by sampling period. It is evident that Lower Hat Creek, as with richness, exemplified minimal shifts in diversity through the three periods compared to the Bonaparte River and Upper Hat Creek. The absolute values of diversity in Lower Hat Creek were consistantly higher than at any of the other sites at a given period. These data indicate that Lower Hat Creek was more stable with respect to being able to compensate for and dampen the effects of environmental perturbations. However, beyond some threshold level the effects of negative environmental stimuli would be detected in the benthic community.

To broaden the data base and minimize possible statistical error due to low sample sizes, computations were made using diversity and richness from September through August combined into one data base. Table 4-39 summarizes select statistical parameters focussing on these two community indicies.

Diversity and richness were the highest in Lower Hat Creek. The projection to a 95% fiducial inference yields a theoretical range of values that would be obtained. Based on present data, the ranges are higher within Lower Hat Creek. Also, the coefficient of variation of the mean for diversity and richness was the lowest in Lower Hat Creek. These data add to the conclusion that Lower Hat Creek was undoubtedly a more complex unit of biological interaction.

It is of interest that although Lower Hat Creek exhibited the most complex system, it did not support the most abundant populations of organisms at any given time (Table 4-36). Therefore, absolute numbers of invertebrates alone do not necessarily control overall community structure and dynamics. The arrangement of these numbers in available genera ultimately dictates system complexity, stability and direction.

TABLE 4-39

SUMMARY OF BENTHIC DIVERSITY AND RICHNESS STATISTICS FOR THE THREE STUDY UNITS

Parameter	Bonaparte River (Stations 1,2,3,4)	Lower Hat Creek (Stations 5,6,7,8)	Upper Hat Creek (Stations 10,11,12,13,14,15)
Diversity			
Mean (N)	2.77 (12)	3.09 (12)	2.89 (16)
Fiducial Inference	±0.411	±0.247	±0.265
Range (with fiducial inference)	2.359-3.181	2.843-3.337	2.625-3.155
Coefficient of Variation (of the mean)	23.3%	12.6%	17.2%
Richness			
Mean (N)	2.91 (12)	3.35 (12)	2.91 (16)
Fiducial Inference	±0.476	±0.514	±0.438
Range (with fiducial inference)	2.434-3.386	2.836-3.864	2.472-3.348
Coefficient of Variation (of the mean)	25.8%	24.1%	28.3%

Upper Hat Creek may not have exhibited a relatively stable community as a result of human activities in the area. Irrigation, flume construction and livestock enrichment may have hindered the development of a system comparable to that of a relatively undisturbed Lower Hat Creek system.

(B) Utilization by Fish

The availability of food,to a large degree,influences the acceptability of a given area as a potential habitat frequented by fish. Regardless of their mobility, fish may select certain food items while others may not play an important role as a useable food resource. An analysis of food utilization in conjunction with food availability facilitates some degree of projection in the description of interactions between these two trophic systems.

Numerical, Volumetric and Frequency of Occurrence

Numerical and frequency of occurrence values for the three most abundant food items in stomachs of rainbow trout collected in Hat Creek and the Bonaparte River during each survey are presented in Tables 4-40 to 4-42 (Computer program output for stomach analyses are presented in Appendix F). In September, food habits of fish 0 - 100 mm in length appeared generally similar among stations (Table 4-40). Ephemeroptera nymphs were usually the dominant food. Exceptions occurred for fish 51 - 100 mm at Station 1 where Trichoptera larvae were the major food, and at Station 7 where Ostracoda and Diptera adults were dominant and Ephemeroptera nymphs were absent from the diet. Other important foods for fish 0 -100 mm were Diptera larvae, pupae and emergents, Ephemeroptera emergents, Plecoptera nymphs and Nematoda.

Numerically important foods for fish greater than 100 mm in September 1976 were often insect life stages normally associated with the water column or surface. These included Diptera pupae and adults and Hemiptera and Coleoptera adults. Unlike smaller fish, no particular food item was regularly dominant among stations or size classes. Other principle foods for fish

TABLE 4-40 Numerical (N) and frequency of occurrence (FO) values for the three most abundant food items in stomach of rainbow trout collected at Hat Creek and Bonaparte River stations, September 28-30, 1976. Number of stomachs examined (n) and number empty (e) are shown for each station and fish length interval[1]

Fish Length Interval (mm)	Station 1 (Bonaparte River) Taxa	N(%)	FO(%)	Station 5 (Lower Hat Creek) Taxa	N(%)	FO(%)	Station 6 (Lower Hat Creek) Taxa	N(%)	FO(%)
0-50	n=0			n=0			n=0		
51-100	Trichoptera (L)	31.9	60.0	Ephemeroptera (N)	31.6	40.0	Ephemeroptera (N)	55.0	44.4
	Ephemeroptera(N)	14.9	60.0	Diptera (E)	13.2	20.0	Insecta	25.0	11.1
	Insecta	12.8	20.0	Nematoda	13.2	20.0	Nematoda	10.0	22.2
	n=5, e=0			n=10, e=0			n=9, e=0		
101-150	n=0			Unid. Animal	**	100.0	Ephemeroptera (N)	50.0	50.0
				Detritus	**	100.0	Trichoptera (L)	50.0	50.0
				n=1, e=0			Unid. Animal	**	100.0
							n=2, e=0		
151-200	n=0			n=0			n=0		
>200	n=0			n=0			n=0		

Fish Length Interval (mm)	Station 7 (Lower Hat Creek) Taxa	N(%)	FO(%)	Station 10 (Upper Hat Creek) Taxa	N(%)	FO(%)	Station 14 (Upper Hat Creek) Taxa	N(%)	FO(%)
0-50	Ephemeroptera(N)	80.0	100.0	Ephemeroptera (N)	100.0	100.0	Ephemeroptera (N)	40.0	50.0
	Diptera (P)	20.0	50.0	n=1, e=0			Trichoptera (L)	20.0	50.0
	Unid. Animal	**	100.0				Diptera (L)	20.0	50.0
	n=2, e=0						Ostracoda	20.0	50.0
							n=2, e=0		
51-100	Ostracoda	28.6	40.0	Ephemeroptera (N)	51.2	54.6	Ephemeroptera (N)	73.7	50.0
	Diptera (A)	28.6	20.0	Diptera (L)	16.3	27.3	Trichoptera (L)	5.3	25.0
	Trichoptera (L)	14.3	20.0	Trichoptera (L)	9.3	27.3	Insecta	5.3	25.0
	Ephemeroptera(E)	14.3	20.0	Plecoptera (N)	9.3	27.3	n=8, e=1		
	Insecta	14.3	20.0	n=11, e=1					
	n=5, e=0								
101-150	Nematoda	28.6	44.4	Hemiptera (A)	27.3	28.6	Ephemeroptera (N)	67.2	60.0
	Insecta	19.0	33.3	Diptera (L)	18.2	57.1	Coleoptera (L)	13.8	60.0
	Ephemeroptera(N)	14.3	22.2	Nematoda	13.6	28.6	Hymenoptera	6.9	40.0
	Hemiptera (A)	14.3	22.2	Insecta	13.6	14.3	n=5, e=0		
	n=9, e=0			n=7, e=0					
151-200	Trichoptera (L)	40.0	100.0	Diptera (A)	47.1	66.7	Coleoptera (L)	22.9	66.7
	Hymenoptera	40.0	100.0	Coleoptera (L)	17.6	33.3	Diptera (P)	22.9	66.7
	Nematoda	20.0	100.0	Coleoptera (A)	11.8	33.3	Diptera (L)	19.5	100.0
	n=1, e=0			Hemiptera (A)	11.8	33.3	n=6, e=0		
				n=3, e=0					
>200	n=0			Diptera (A)	59.7	50.0	Diptera (P)	47.9	50.0
				Trichoptera (L)	19.4	50.0	Hemiptera (A)	14.6	100.0
				Hemiptera (A)	7.5	50.0	Nematoda	10.4	50.0
				n=2, e=0			n=2, e=0		

[1] (A) = Adult
(E) = Emergent
(N) = Nymph
(P) = Pupae
(L) = Larvae
** = Not Applicable

TABLE 4-41

NUMERICAL (N) AND FREQUENCY OF OCCURRANCE (FO) VALUES FOR THE THREE MOST ABUNDANT FOOD ITEMS IN STOMACHS OF RAINBOW TROUT COLLECTED AT HAT CREEK & BONAPARTE RIVER STATIONS, JUNE, 1977

Fish Length Interval (mm)	Station 1 (Bonaparte River) Taxa	N (%)	FO (%)	Station 3 (Bonaparte River) Taxa	N (%)	FO (%)	Station 5 (Lower Hat Creek) Taxa	N (%)	FO (%)
0-50	Ephemeroptera (N)[1]	75.0	100.0	Ephemeroptera (N)	87.5	100.0	n = 0		
	Diptera (L)	16.7	100.0	Trichoptera (L)	6.2	33.3			
	Trichoptera (L)	8.3	50.0	Diptera (L)	6.2	33.3			
	n = 2, e = 0			n = 3, e = 0					
51-100	Ephemeroptera (N)	85.0	100.0	n = 0			Ephemeroptera (N)	44.1	75.0
	Plecoptera (N)	15.0	50.0				Diptera (L)	37.6	37.5
	Uniden. animal	[2]	100.0				Trichoptera (L)	8.6	37.5
	n = 2, 3 = 0						n = 8, e = 0		
101-150	n = 0			n = 0			Ephemeroptera (N)	44.6	60.0
							Diptera (L)	27.7	100.0
							Trichoptera (L)	8.5	80.0
							Nematoda	8.5	60.0
							n = 5, e = 0		
151 - 200	n = 0			n = 0			n = 0		
>200	n = 0			n = 0			n = 0		

[1] A = adult
E = emergent
N = nymph
P = pupae
L = larvae

[2] Not Applicable

TABLE 4-41 Cont'd.

NUMERICAL (N) AND FREQUENCY OF OCCURRANCE (FO) VALUES FOR THE THREE MOST ABUNDANT FOOD ITEMS

IN STOMACHS OF RAINBOW TROUT COLLECTED AT HAT CREEK & BONAPARTE RIVER STATIONS, JUNE, 1977

Fish Length Interval (mm)	Station 6 (Lower Hat Creek) Taxa	N (%)	FO (%)	Station 7 (Lower Hat Creek) Taxa	N (%)	FO (%)	Station 10 (Upper Hat Creek) Taxa	N (%)	FO (%)
0-50	n = 0			n = 0			n = 0		
51-100	Ephemeroptera (N)	56.9	90.0	Ephemeroptera (N)	70.9	100.0	Diptera (L)	75.0	100.0
	Trichoptera (L)	15.5	40.0	Diptera (L)	9.1	30.0	Ephemeroptera (N)	9.1	75.0
	Diptera (L)	13.8	50.0	Nematoda	7.3	30.0	Uniden. insect	9.1	50.0
	n = 10, e = 0			n = 10, e = 0			n = 4, e = 0		
101-150	Diptera (L)	36.8	80.0	Ephemeroptera (N)	33.3	42.9	Diptera (L)	47.6	100.0
	Trichoptera (L)	34.2	100.0	Plecoptera (N)	15.8	57.1	Ephemeroptera (N)	17.1	85.7
	Ephemeroptera (N)	15.8	60.0	Trichoptera (L)	14.1	57.1	Annelida	7.6	38.5
	n = 5, e = 0			n = 5, e = 0			n - 7, e = 0		
151-200	Trichoptera (L)	54.8	66.7	Ephemeroptera (E)	34.5	33.3	Diptera (L)	43.1	100.0
	Ephemeroptera (N)	12.9	33.3	Nematoda	20.7	33.3	Annelida	25.0	33.3
	Plecoptera (N)	9.7	66.7	Trichoptera (L)	17.2	66.7	Trichoptera (L)	8.3	33.3
	n = 3, e = 0			Diptera (L)	17.2	33.3	n = 3, e = 0		
				n = 3, e = 0					
>200	Trichoptera (L)	28.5	100.0	Trichoptera (L)	63.6	100.0	Annelida	49.4	40.0
	Coleoptera (A)	28.6	100.0	Ephemeroptera (N)	36.4	100.0	Nematoda	16.5	60.0
	Ephemeroptera (N)	14.3	100.0	Uniden. animal	**	100.0	Diptera (L)	8.8	40.0
	Plecoptera (N)	14.3	100.0	n = 1, e = 0			n = 5, e = 0		
	Hymenoptera	14.3	100.0						
	n = 1, e = 0								

TABLE 4-41 Cont'd.

NUMERICAL (N) AND FREQUENCY OF OCCURRANCE (FO) VALUES FOR THE THREE MOST ABUNDANT FOOD ITEMS IN STOMACHS OF RAINBOW TROUT COLLECTED AT HAT CREEK & BONAPARTE RIVER STATIONS, JUNE 1977

Fish Length Interval (mm)	Station 14 (Upper Hat Creek) Taxa	N (%)	FO (%)
0-50	Ephemeroptera (N)	100.0	100.0
	Uniden. Animal	**	100.0
	n = 1, e = 0		
51-100	Diptera (L)	76.5	83.3
	Ephemeroptera (N)	11.8	100.0
	Uniden. insect	7.6	50.0
	n = 6, e = 0		
101-150	Diptera (L)	74.8	100.0
	Ephemeroptera (N)	9.7	100.0
	Uniden. insect	6.4	75.0
	n = 4, e = 0		
151-200	Hymenoptera	43.9	66.7
	Diptera (L)	34.1	100.0
	Plecoptera (E)	6.1	66.7
	n = 3, e = 0		
>200	n = 0		

TABLE 4-42

NUMERICAL (N) AND FREQUENCY OF OCCURRANCE (FO) VALUES FOR THE THREE MOST ABUNDANT FOOD ITEMS IN STOMACHS OF RAINBOW TROUT COLLECTED AT HAT CREEK & BONAPARTE RIVER STATIONS, AUGUST, 1977

Fish Length Interval (mm)	Station 1 (Bonaparte River)			Station 3 (Bonaparte River)			Station 5 (Lower Hat Creek)		
	Taxa	N (%)	FO (%)	Taxa	N (%)	FO (%)	Taxa	N (%)	FO (%)
0-50	n = 0			n = 0			n = 1, e = 1		
51-100	n = 0			n = 0			Ephemeroptera (N)[1]	50.0	100.0
							Diptera (L)	40.0	100.0
							Plecoptera (N)	10.0	100.0
							n = 1, e = 0		
101-150	n = 0			n = 0			Nematoda	50.0	100.0
							Diptera (L)	25.0	75.0
							Ephemeroptera (N)	10.0	25.0
							Hymenoptera	10.0	25.0
							n = 4, e = 0		
151-200	Trichoptera (L)	87.7	100.0	Hymenoptera	55.9	100.0	Hymenoptera	33.3	100.0
	Ephemeroptera (N)	4.6	100.0	Coleoptera (A)	27.2	100.0	Uniden. insect	23.8	100.0
	Coleoptera (A)	4.2	50.0	Diptera (L)	6.6	1-0.0	Coleoptera (A)	14.3	100.0
	n = 2, e = 0			n = 2, e = 0			Coleoptera (L)	14.3	100.0
							n = 1, e = 0		
>200	n = 0			n = 0			n = 0		

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[1] A = adult
E = emergent
N = nymph
P = pupae
L = larvae

[2] Not applicable

TABLE 4-42 Cont'd.

NUMERICAL (N) AND FREQUENCY OF OCCURRANCE (FO) VALUES FOR THE THREE MOST ABUNDANT FOOD ITEMS

IN STOMACHS OF RAINBOW TROUT COLLECTED AT HAT CREEK & BONAPARTE RIVER STATIONS, AUGUST, 1977

Fish Length	Station 6 (Lower Hat Creek)			Station 7 (Lower Hat Creek)			Station 10 (Upper Hat Creek)		
Interval (mm)	Taxa	N (%)	FO (%)	Taxa	N (%)	FO (%)	Taxa	N (%)	FO (%)
0-50	Ephemeroptera (N)	71.8	100.0	Ephemeroptera (N)	69.2	100.0	Ephemeroptera (N)	66.7	100.0
	Diptera (L)	28.1	66.7	Diptera (L)	30.8	50.0	Diptera (L)	16.7	100.0
	Uniden. animal	[2]	66.7	Uniden. animal	[2]	100.0	Trichoptera (L)	16.7	100.0
	n = 3, e = 0			n = 2, e = 0			n = 1, e = 0		
51-100	Ephemeroptera (N)	33.3	100.0	Ephemeroptera (N)	44.4	87.5	Diptera (L)	46.6	100.0
	Diptera (L)	33.3	75.0	Trichoptera (L)	36.7	100.0	Ephemeroptera (N)	28.5	100.0
	Trichoptera (L)	13.3	75.0	Diptera (L)	36.7	100.0	Coleoptera (L)	8.8	62.5
	n = 4, e = 0			n = 8, e = 0			n = 8, e = 0		
101-150	Trichoptera (L)	27.0	100.0	Trichoptera (L)	42.9	100.0	Diptera (L)	47.1	100.0
	Ephemeroptera (N)	21.6	66.7	Ephemeroptera (N)	42.5	100.0	Ephemeroptera (N)	15.0	66.7
	Diptera (L)	21.6	16.7	Diptera (L)	9.7	50.0	Diptera (P)	11.8	16.7
	n = 6, e = 0	n = 6, e = 0		n = 6, e = 0					
151-200	Uniden. insect	36.7	100.0	Ostracoda	59.2	25.0	Ephemeroptera (N)	44.7	100.0
	Coleoptera (A)	19.4	75.0	Trichoptera (L)	17.7	100.0	Diptera (L)	17.1	100.0
	Hymenoptera	15.3	75.0	Uniden. insect	7.2	75.0	Trichoptera (L)	10.6	100.0
	n = 4, e = 0			n = 4, e = 0			n = 6, e = 0		
>200	Uniden. insect	56.5	100.0	Uniden. insect	63.0	100.0	Diptera (P)	28.6	100.0
	Hymenoptera	26.1	100.0	Hymenoptera	13.9	100.0	Diptera (L)	28.6	66.7
	Plecoptera (N)	13.0	100.0	Trichoptera (L)	9.8	100.0	Ephemeroptera (N)	14.3	33.3
	n = 1, e = 0			n = 2, e = 0			n = 3, e = 0		

TABLE 4-42 Cont'd.

NUMERICAL (N) AND FREQUENCY OF OCCURRANCE (FO) VALUES FOR THE THREE MOST ABUNDANT FOOD ITEMS IN STOMACHS OF RAINBOW TROUT COLLECTED AT HAT CREEK & BONAPARTE RIVER STATIONS, AUGUST, 1977

Station 14 (Upper Hat Creek)

Fish Length Interval (mm)	Taxa	N (%)	FO (%)
0-50	n = 0		
51-100	Diptera (L)	86.8	57.1
	Ephemeroptera (N)	9.9	42.9
	Trichoptera (L)	1.1	14.3
	Plecoptera (N)	1.1	14.3
	Cladocera	1.1	14.3
	n = 7, e = 1		
101-150	Diptera (L)	78.4	100.0
	Ephemeroptera (N)	11.4	40.0
	Hymenoptera	9.1	20.0
	n = 5, e = 0		
151-200	Diptera (L)	54.0	83.3
	Uniden. insect	14.7	50.0
	Hymenoptera	14.0	83.3
	n = 6, e = 0		
>200	Diptera (L)	41.7	100.0
	Uniden. insect	31.5	100.0
	Hymenoptera	15.7	100.0
	n = 3, e = 0		

Volumetric analysis of June 1977 data showed Ephemeroptera nymphs, Plecoptera nymphs and Trichoptera larvae were usually dominant food items in the Bonaparte River and Lower Hat Creek. Diptera larvae were less important by volume than number in Upper Hat Creek. Instead, larger-sized organisms such as Ephemeroptera nymphs, Hymenoptera and, in particular, Annelida were primary food items at Stations 10 and 14.

Unidentified animal remains (primarily insects) were an important food in both the river and creek. Minerals were present in several stomachs as in September. No fish were observed in stomachs of specimens, and no stomachs were empty.

Food habits of rainbow trout in August 1977 (Table 4-42) were somewhat similar to those in June 1977. Numerically, Ephemeroptera nymphs were a primary food for fish less than 100 mm at Stations 5, 6 and 7. Trichoptera and Diptera larvae were also important foods at these stations. Diptera larvae, followed by Ephemeroptera nymphs, were principal foods for most size classes of fish at Stations 10 and 14. While food items such as Trichoptera larvae, Ephemeroptera nymphs and Diptera larvae were important in the diet of fish greater than 100 mm downstream of Station 10, the presence of such foods as Hymenoptera and Coleoptera adults indicated increased utilization of drift organisms in August. Drift appeared less important in the diet of fish further upstream at Stations 10 and 14.

Food items which were important numerically were also important volumetrically in August 1977. As in June 1977, small-sized foods such as Diptera larvae comprised a lesser proportion of the diet by volume than by number. Minerals were again present in the stomachs of some trout and fish appeared absent from the diet. The stomachs of one specimen 93 mm in length captured at Station 14 and a second 36 mm in length collected at Station 5 were empty.

Stomach contents of two mountain whitefish (103 and 109 mm total length) collected in the Bonaparte River at Station 3 in September 1976 included Trichoptera larvae (dominant food), Coleoptera and Chironomidae larvae, greater than 100 mm were Hymenoptera, Nematoda, Trichoptera and Diptera larvae. Ephemeroptera nymphs appeared less important in the diet of larger than smaller fish. Although they were the dominant food for fish 101 - 150 mm at Stations 6 and 14, Ephemeroptera nymphs were not a major food for fish greater than 150 mm.

Volumetric analysis of September 1976 data showed unidentified animal remains (primarily insects) usually comprised a large percentage of total food volume. In addition, food items which were important numerically were usually also important by volume. The occurrence of minerals in stomachs of both small and large fish may have resulted from accidental ingestion while feeding near the bottom or represent remains of Trichoptera cases. Nearly all rainbow trout with lengths of 83 mm at Station 10 and 78 mm at Station 14. No fish were present in stomachs of trout examined.

In June 1977, Ephemeroptera nymphs were the dominant food (numerically) for rainbow trout less than 150 mm in the Bonaparte River and Lower Hat Creek (Stations 1, 3, 5, 6 and 7; Table 4-41). Other major foods for fish of this size were Diptera and Trichoptera larvae with Plecoptera nymphs and Nematoda also occasionally important. For fish greater than 150 mm captured at Stations 6 and 7, Trichoptera larvae were usually the dominant food. An exception occurred for fish 151 - 200 mm at Station 7 where Emphemeroptera nymphs were the principle food. Other major foods for fish greater than 150 mm at Station 6 and 7 were Plecoptera nymphs, Coleoptera adults, Diptera larvae and Hymenoptera.

Different food habits were observed further upstream at Stations 10 and 14 (Upper Hat Creek) in June 1977. Diptera larvae, rather than Ephemeroptera nymphs, were usually the primary food (numerically) for all fish sizes, Ephemeroptera nymphs were generally the second most important food for fish less than 150 mm. Annelida, Hymenoptera, Trichoptera larvae and Nematoda, in addition to Diptera larvae, were major foods for fish greater than 150 mm.

Nematoda and minerals. Stomach contents of a 177 mm whitefish captured at Station 14 in September1976 were Ephemeroptera nymphs (dominant food), Chironomidae and Trichoptera larvae, Nematoda, unidentified animal remains (primarily insects) and minerals.

Stomachs of two large whitefish (352 and 354 mm) taken at Station 7 in June 1977 contained Trichoptera larvae (primary food), Plecoptera and Ephemeroptera nymphs, unidentified animal remains (primarily insects) and minerals. Diptera larvae were the principle food for a large whitefish (290 mm) collected at Station 10 in June 1977. At Station 3, Coleoptera larvae were the major food in the stomach of a 133 mm specimen.

The dominant food for three mountain whitefish with lengths of 79 - 93 mm captured at Station 5 in August 1977 was Diptera larvae. Ephemeroptera nymphs were also an important food for these fish with Plecoptera nymphs, Trichoptera larvae and Diptera pupae present in smaller numbers.

Stomach contents of a brook trout (114 mm total length) collected at Station 3 in September were Plecoptera nymphs, Hemiptera adults, Trichoptera and Coleoptera larvae, unidentified animal remains (primarily insects), and detrius. No particular food item was dominant.

Forage Ratios

The forage ratio (S/B) was used to determine the degree of proportion of utilization of the benthic food supply by rainbow trout (Rounsefell and Everhart, 1966). The variables "S" and "B" represent the numerical percentage a particular organism comprises of the total number in the stomach (S) and benthos (B). Values greater than 1.0 indicate selection for or easy availability of a food item of fish. Values less than 1.0 indicate the opposite, selection against or difficulty in utilizing a food item. Values were calculated for major benthic food present in stomachs of rainbow trout (listed in Tables 4-40 to 4-42) and are presented in Tables 4-43 to 4-45. Values could not be calculated

TABLE 4-43

FORAGE RATIOS (S/B) FOR MAJOR BENTHIC FOOD ITEMS OF RAINBOW TROUT COLLECTED AT HAT CREEK AND BONAPARTE RIVER STATIONS, SEPTEMBER, 1977

Fish Length Interval (mm)	Station 1 (Bonaparte River) Taxa	S/B	Station 5 (Lower Hat Creek) Taxa	S/B	Station 6 (Lower Hat Creek) Taxa	S/B	Station 7 (Lower Hat Creek) Taxa	S/B	Station 10 (Lower Hat Creek) Taxa	S/B	(Lower Hat Creek) Taxa	S/B
0-50	n=0		n=0		n=0		Ephemeroptera (N) n=2	2.2	Ephemeroptera (N) n=1	2.0	Ephemeroptera (N) Trichoptera (L) Diptera (L) n=2	0.5 10.2 2.0
51-100	Trichoptera (L) Ephemeroptera (N) n=5	3.7 0.6	Ephemeroptera (N) Nematoda n=10	1.8 ∞	Ephemeroptera (N) Nematoda n=9	1.8 13.7	Trichoptera (L) n=5	0.3	Ephemeroptera (N) Diptera (L) Trichoptera (L) Plecoptera (N) n=11	1.0 1.5 0.9 0.6	Ephemeroptera (N) Trichoptera (L) n=8	1.0 2.7
101-150	n=0		n=1		Ephemeroptera (N) Trichoptera (L) n=2	1.7 1.8	Nematoda Ephemeroptera (N) n=9	81.5 0.4	Diptera (L) Nematoda n=7	1.7 41.7	Ephemeroptera (N) Coleoptera (L) n=5	0.9 ∞
151-200	n=0		n=0		n=0		Trichoptera (L) Nematoda n=1	0.9 57.0	Coleoptera (L) n=3	∞	Coleoptera (L) Diptera (L) n=6	∞ 2.0
>200	n=0		n=0		n=0		n=0		Trichoptera (L) n=2	1.8	Nematoda n=2	12.5

[1] (E) = Emergent
(N) = Nymph
(L) = Larvae

TABLE 4-44

FORAGE RATIOS (S/B) FOR MAJOR BENTHIC FOOD ITEMS OF RAINBOW TROUT COLLECTED AT HAT CREEK AND BONAPARTE RIVER STATIONS, JUNE, 1977

Fish Length Interval (mm)	Station 1 (Bonaparte River)		Station 3 (Bonaparte River)		Station 5 (Lower Hat Creek)		Station 6 (Lower Hat Creek)	
	Taxa	S B	Taxa	S B	Taxa	S B	Taxa	S B
0-50	Ephemeroptera (N)[1]	0.9	Ephemeroptera (N)	1.3	n = 0		n = 0	
	Diptera (L)[1]	4.0	Trichoptera (L)	0.5				
	Trichoptera (L)	1.8	Diptera (L)	0.3				
	n = 2		n = 3					
51-100	Ephemeroptera (N)	1.0	n = 0		Ephemeroptera (N)	1.9	Ephemeroptera (N)	3.7
	Plecoptera (N)	5.3			Diptera (L)	0.5	Trichoptera (L)	1.9
	n = 2				Trichoptera (L)	3.1	Diptera (L)	0.2
					n = 8		n = 10	
101-150	n = 0		n = 0		Ephemeroptera (N)	1.9	Diptera (L)	0.5
					Diptera (L)	0.4	Trichoptera (L)	4.2
					Trichoptera (L)	3.0	Ephemeroptera (N)	1.0
					Nematoda	∞	n = 5	
					n = 5			
151-200	n = 0		n = 0		n = 0		Trichoptera (L)	6.8
							Ephemeroptera (N)	0.8
							Plecoptera (N)	3.2
							n = 3	
>200	n = 0		n = 0		n = 0		Trichoptera (L)	3.5
							Ephemeroptera (N)	0.9
							Plecoptera (N)	4.8
							n = 1	

[1] N = nymph
L - larvae

beak

TABLE 4-44 Cont'd.

FORAGE RATIOS (S/B) FOR MAJOR BENTHIC FOOD ITEMS OF RAINBOW TROUT COLLECTED AT HAT CREEK AND BONAPARTE RIVER STATIONS, JUNE, 1977

Fish Length Interval (mm)	Station 7 (Lower Hat Creek) Taxa	S B	Station 10 (Upper Hat Creek) Taxa	S B	Station 14 (Upper Hat Creek) Taxa	S B
0-50	n = 0		n = 0		Ephemeroptera (N)	1.5
					n = 1	
51-100	Ephemeroptera (N)	1.7	Diptera (L)	3.1	Diptera (L)	4.2
	Diptera (L)	0.3	Ephemeroptera (N)	0.2	Ephemeroptera (N)	0.2
	Nematoda	24.3	n - 4		n = 6	
	n = 10					
101-150	Ephemeroptera (N)	0.8	Diptera (L)	1.9	Diptera (L)	4.1
	Plecoptera (N)	2.5	Ephemeroptera (N)	0.3	Ephemeroptera (N)	0.1
	Trichoptera (L)	0.7	Annelida	∞	n = 4	
	n = 7		n = 7			
151-200	Nematoda	69.0	Diptera (L)	1.6	Diptera (L)	1.9
	Trichoptera (L)	0.8	Annelida	∞	n = 3	
	Diptera (L)	0.6	Trichoptera (L)	1.2		
	n = 3		n = 3			
>200	Trichoptera (L)	3.1	Annelida	∞	n = 0	
	Ephemeroptera (N)	0.9	Nematoda	82.5		
	n = 1		Diptera (L)	0.3		
			n = 5			

TABLE 4-45

FORAGE RATIOS (S/B) FOR MAJOR BENTHIC FOOD ITEMS OF RAINBOW TROUT COLLECTED AT HAT CREEK AND BONAPARTE RIVER STATIONS, AUGUST, 1977

Fish Length	Station 1 (Bonaparte River)		Station 3 (Bonaparte River)		Station 5 (Lower Hat Creek)		Station 6 (Lower Hat Creek)	
Interval (mm)	Taxa	S B	Taxa	S B	Taxa	S B	Taxa	S B
0-50	n = 0		n = 0		n = 1		Ephemeroptera (N)[1]	1.3
							Diptera (L)[1]	1.1
							n = 3	
51-100	n = 0		n = 0		Ephemeroptera (N)	1.4	Ephemeroptera (N)	0.6
					Diptera (L)	0.2	Diptera (L)	1.3
					Plecoptera (N)	0.8	Trichoptera (L)	1.1
					n = 1		n = 4	
101-150	n = 0		n = 0		Nematoda	-	Trichoptera (L)	2.2
					Diptera (L)	0.8	Ephemeroptera (N)	0.4
					Ephemeroptera (N)	0.3	Diptera (L)	0.9
					n = 4		n = 6	
151-200	Trichoptera (L)	2.9	Diptera (L)	0.2	Coleoptera (L)	2.0	n = 4	
	Ephemeroptera (N)	0.1	n = 2		n = 1			
>200	n = 0		n = 0		n = 0		Plecoptera (N)	3.0
							n = 1	

[1] N = nymph
L = larvae

TABLE 4-45 Cont'd.

FORAGE RATIOS (S/B) FOR MAJOR BENTHIC FOOD ITEMS OF RAINBOW TROUT COLLECTED AT HAT CREEK AND BONAPARTE RIVER STATIONS, AUGUST, 1977

Fish Length Interval (mm)	Station 7 (Lower Hat Creek) Taxa	S B	Station 10 (Upper Hat Creek) Taxa	S B	Station 14 (Upper Hat Creek) Taxa	S B
0-50	Ephemeroptera (N)	1.2	Ephemeroptera (N)	1.2	n = 0	
	Diptera (L)	1.8	Diptera (L)	0.9		
	n = 2		Trichoptera (L)	1.3		
			n = 1			
51-100	Ephemeroptera (N)	0.8	Diptera (L)	2.6	Diptera (L)	3.1
	Diptera (L)	0.9	Ephemeroptera (N)	0.5	Ephemeroptera (N)	0.2
	Trichoptera (L)	2.1	Coleoptera (L)	6.8	Trichoptera (L)	0.2
	n = 8		n = 8		Plecoptera (N)	0.1
					n = 7	
101-150	Trichoptera (L)	2.5	Diptera (L)	2.6	Diptera (L)	2.5
	Ephemeroptera (N)	0.7	Ephemeroptera (N)	0.3	Ephemeroptera (N)	0.2
	Diptera (L)	0.6	n = 6		n = 5	
	n = 6					
151-200	Trichoptera (L)	1.0	Ephemeroptera (N)	0.8	Diptera (L)	1.9
	n = 4		Diptera (L)	0.9	n = 6	
			Trichoptera (L)	0.8		
			n = 4			
>200	Trichoptera (L)	0.6	Diptera (L)	1.6	Diptera (L)	1.5
	n = 2		Ephemeroptera (N)	0.3	n = 3	
			n = 3			

beak

for pupae, emergents or adults since they are not a part of the benthic community, nor were they calculated for benthic taxa which appeared to be of minor dietary importance.

In September 1976, forage ratios for Ephemeroptera nymphs varied from 0.4 to 2.2 indicating they were fed upon in approximately the same proportion they occurred in benthic samples (Table 4-43). These values may be expected considering the abundance of Ephemeroptera in most benthic samples and stomachs of smaller fish. Forage ratios for Trichoptera larvae ranged from 0.3 to 10.2, but most were slightly greater than 1.0. Except for the minimum and maximum values, rainbow trout appeared to utilize Trichoptera in about the same or in slightly greater proportion than they occurred in the benthic community. Forage ratios for Diptera larvae (1.5 to 2.0) also indicate a slight selectivity by fish. The forage ratio for Plecoptera nymphs (0.6), on the single occasion they were among the three most abundant food items, suggests a slight selection against or difficulty in utilizing this food by fish. Forage ratios for Nematoda and Coleoptera larvae, the other major benthic food groups, were relatively high (in several cases infinity when none occurred in benthic samples). This indicated a high degree of selection for these foods by fish or their occurrence in a particular habitat not sampled during benthic investigations.

In June 1977, forage ratios for Ephemeroptera nymphs at Stations 1, 3, 5, 6 and 7 ranged from 0.8 to 3.7 with most values approximating 1.0 (Table 4-44). At Stations 10 and 14, forage ratios for this food were usually much less than 1.0 indicating a greater selection against or difficulty in utilization than at stations further downstream. The pattern of forage ratios for Diptera larvae was opposite that for Ephemeroptera nymphs. Values in the Bonaparte River and Lower Hat Creek were usually less than 1.0 while those in Upper Hat Creek were usually greater than 1.0. Forage ratios for Trichoptera larvae varied from 0.5 to 6.8 but were usually greater than 1.0. Forage ratios for Plecoptera nymphs (2.5 - 5.3) similarly indicated a selection for or ease in utilization. Values for Nematoda and Anneldia were extremely high (in four cases infinity) and may have resulted from the same effects described for the September 1976 sampling.

In August 1977, forage ratios for Ephemeroptera nymphs ranged from 0.1 to 1.4 in the Bonaparte River and Lower Hat Creek and from 0.2 to 1.2 in Upper Hat Creek (Table 4-40). As in June 1977, values for this food were generally lower at Stations 10 and 14 than at stations further downstream. The patern of forage ratios for Diptera larvae in August 1977 was similar to that in June 1977. Forage ratios for Diptera larvae in the Bonaparte River and Lower Hat Creek were close to 1.0 and ranged from 0.6 to 1.8. Those at Stations 10 and 14 in Upper Hat Creek were usually higher and varied from 0.2 to 0.9 and were usually lower at Stations 10 and 14 than further downstream. Forage ratios for Plecoptera nymphs were 0.1 and 0.8 and lower than in August. Forage ratios of 2.0 and 6.8 for Coleoptera larvae on the two occasions they were a major food indicate selectivity by fish. The forage ratio for Nematoda on the single occasion they were a major food was infinity.

(c) Concluding Discussion

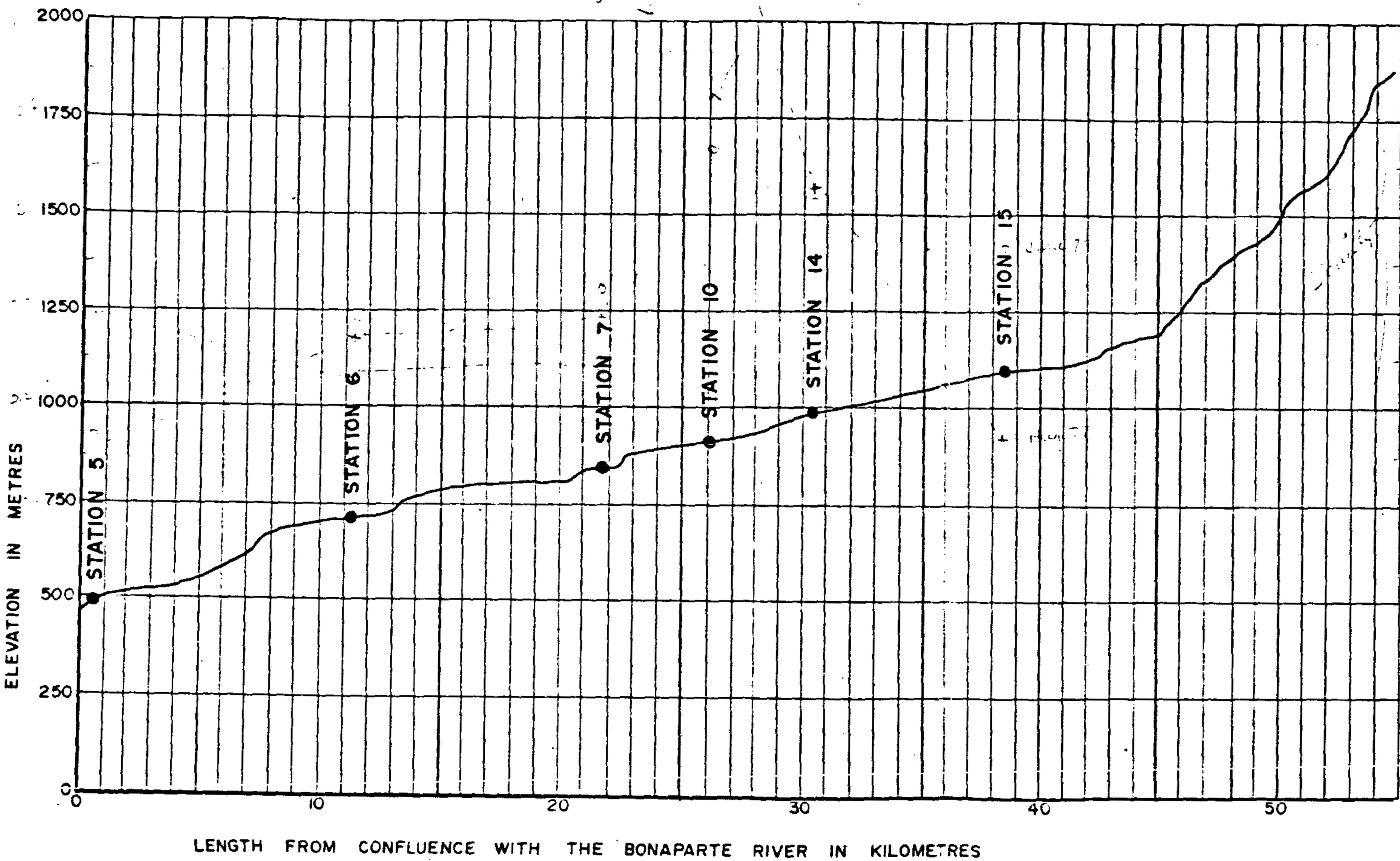
A variety of habitats existed in Hat Creek from its headwaters to mouth, ranging from a series of beaver dams in both upper and lower reaches to fast flowing water in the canyon and chute. General distinctions in terms of fish habitat can be made between Upper Hat Creek, which consists of both pool and riffle areas and slower flowing water and Lower Hat Creek where riffles were more numerous and currents generally swifter. The division between Lower and Upper Hat was designated primarily by habitat characteristics. Kilometers 0 - 22.4 encompassed the Lower Hat Creek section with areas above km 22.4 being considered as Upper Hat Creek. Overall, Hat Creek appeared to provide good habitat for rainbow trout.

Substrate ranged from silt-sand in pools to boulders in areas exhibiting steeper gradient, although gravel and small pebbles appeared to be most common. Stream depth ranged from about 25 mm in shallow riffles to approximately 1.5 m in deeper pools. Stream width varied from about 1.5 - 9.0 m with distances usually greater in downstream than upstream reaches. Most banks appeared stable except in canyon areas which exhibited deeper cuts and steeper banks. Bank vegetation varied from grass to trees, nearly all of which were deciduous, with brush to small-sized trees predominant. Banks were often barren in canyon areas due to steepness.

The influence of man appeared minimal except in Upper Hat Creek where signs of livestock were noted along banks and part of the stream-flow had been diverted for irrigation. Several man-made rock barriers were noted in Lower Hat Creek.

The Bonaparte River can be characterized as swifter flowing and larger than Hat Creek. Width varied from approximately 9 to 30 m and depth from several cm to at least 1.8 m. Substrate appeared to consist primarily of gravel and pebble, although silt-sand was noted in slower reaches with boulders in downstream reaches where the river gradient increased. Bank stability appared good except in canyon areas downstream near Station 1. Vegetation types varied from grass, brush or trees in upstream reaches to sparse grasses along barren cliff walls in the vicinity of Station 1. Overall, fish habitat appeared good, with pools, runs and riffles observed from Station 1 upstream to Station 4. Figure 4-22 presents a longitudinal profile of Hat Creek with rainbow trout and benthic invertebrate densities.

The benthic communities of Hat Creek and the Bonaparte River were typified by organisms characteristic of clean water conditions. There appeared to be no environmental factor which significantly hindered the development of complex invertebrate systems. The Upper Hat Creek reaches were somewhat less stable than the lower areas which may have been a reaction to agricultural



STATION 5
Fish D = 0.39, 0.17, 0.11
R = 50-81, 64-134, 36-187
Benthos: 636, 3107, 1363

STATION 6
Fish D = 026, 0.38, 0.34
R = 40-127, 70-201, 39-207
Benthos: 448, 2082, 1419

STATION 7
Fish D = 0.28, 0.45, 0.39
R = 35-156, 66-187, 32-216
Benthos: 636, 984, 1691

figure 4·22

LONGITUDINAL PROFILE OF HAT CREEK - RAINBOW TROUT AND BENTHIC INVERTEBRATE DENSITIES

legend

Fish D = Density of Rainbow trout /m of stream September 1976, June 1977, August 1977

R = Range of total lengths for Rainbow trout (mm) - September 1976, June 1977, August 1977

Benthos: Totals numbers /m - September 1976, June 1977, August 1977

STATION 10
Fish D = 0.84, 0.73, 1.32
R = 49-210, 71-255, 42-219
Benthos: 523, 882, 1232

STATION 14
Fish D = 1.19, 0.62, 0.64
R = 44-224, 50-244, 73-241
Benthos: 392-1130, 1517

STATION 15
Fish D = 0.40, 0.57, 0.13
R = 31-236, 44-227, 63-92
Benthos: 835, 3846, 2484

activities near this section of stream. Stations are depicted in Figure 4-22.

Dominant foods for rainbow trout were aquatic insects. Ephemeroptera nymphs and Diptera larvae were particularly important, especially to smaller-sized fish. The general importance of these two foods in the diet of trout corresponded to their general y high relative abundance in the benthic community. Ephemeroptera nymphs were usually more important in the diet of trout in the Bonaparte River and Lower Hat Creek while Diptera larvae were more important in Upper Hat Creek. Forage ratios indicated fish utilized these foods in approximately the same proportion they occurred in the environment. Similar to food habits, forage ratios indicated some selection for or ease in utilizing Ephemeroptera nymphs in Lower Hat Creek and Diptera larvae in Upper Hat Creek.

Foods which were important to larger-sized fish and relatively abundant in the benthic community included Trichoptera larvae and Plecoptera nymphs. The prominence of Hymenoptera and Coleoptera adults in stomachs of larger trout in Lower Hat Creek in June and August reflects the importance of drift organisms in the diet.

The above data indicated that rainbow trout are successfully utilizing foods available to them. Field observations and calculation of condition factors and length-weight curves showed most trout were in good condition, indicative of an adequate food supply.

Rainbow trout were the dominant fish species in Hat Creek. Mountain whitefish were also distributed throughout most of Hat Creek, but in much smaller numbers than rainbow trout. Bridgelip sucker, longnose dace and leopard dace, the three most abundant fish collected in the Bonaparte River, were captured only at the downstream most station in Hat Creek.

Densities of rainbow trout were usually greater in Upper than Lower Hat Creek.

In addition, larger rainbow trout were better represented and comprised a greater proportion of the catch in Upper than Lower Hat Creek. Young-of-the-year rainbow trout were collected throughout Hat Creek. Reasons for density and size differences between areas of the creek may be related to the variety and quality of habitat. Upper Hat Creek contained numerous riffle areas which serve as spawning grounds for adults and nursery areas for young, as well as many pools with deeper, slower moving water which provided cover for adults. Conversely, Lower Hat Creek contained a greater proportion of riffles (good spawning and riffle areas) but a lesser proportion of pools (reduced cover for adults) compared to Upper Hat Creek.

Total lengths of rainbow trout in Hat Creek ranged from about 30 to 250 mm and ages from 0+ to 6+. Back-calculated lengths at various ages were 64 mm at age 1, 108 mm at age 2, 143 mm at age 3, 173 mm at age 4, 197 mm at age 5, and 225 mm at age 6. Back-calculated lengths of males and females were nearly identical. The oldest female was age 5+ and the oldest male age 6+. Comparison of the above age-length data to the literature indicates Hat Creek fish are slow growing but by no means stunted. Hat Creek rainbow trout age-length relationships may well be typical of similar sized streams in interior British Columbia.

The similarity of mean back-calculated lengths at a given age among year classes indicated growth of rainbow trout in Hat Creek has remained relatively constant over the past several years. Considerable variation was observed among individual lengths within a year class and appears to be primarily due to an extended spawning season and/or variation in individual growth during the first year of life. Differences in lengths of older fish were observed among stations. Older aged fish were larger in Lower compared to Upper Hat Creek, a pattern inversely related to that of fish density. Growth appeared to be slowest at Station 10 in Upper Hat Creek, a sampling location which often exhibited peak densities. Factors such as available food, space or cover may limit the growth of rainbow trout in Upper Hat Creek. The overall quality and quantity of fish habitat may limit fish densities, particularly densities of larger specimens, in Lower Hat Creek.

Rainbow trout appear to spawn throughout Hat Creek as evidenced by the collection of sexually mature adults and young-of-the-year at all stations. Examination of gonads indicated spawning occurred primarily between mid-June and late July. Water temperatures were approximately 10-14^{o}C during this time. Literature states young emerge from gravels approximately 4 to 7 weeks following spawning. At Hat Creek Stations 5, 6, 7 and 10, young were first captured in early August. The absence of young from samples taken upstream of Station 10 in August suggests spawning occurred later or growth of young was less rapid than further downstream. In the Bonaparte River, young rainbow trout were first collected in June, indicating spawning occurred earlier or young grew more quickly than in the creek. Water temperatures were approximately 2-4^{o}C higher in the river than creek in June and could have induced earlier spawning in the Bonaparte.

The predominance of young rainbow trout in Lower Hat Creek suggested the importance of this reach as a spawning ground ~~and nursery area.~~ It is likely that adult rainbow trout migrate upstream from the Bonaparte to spawn in Lower Hat Creek, even though potential spawning gravels were observed in the river. However, because of natural barriers such as the chute and numerous beaver dams, such spawning migrations probably extend no more than about 6 km up Hat Creek. Because of similar barriers presented by beaver dams further upstream, intra-stream movements of fish in Hat Creek may be limited. It is probable that the existance of potential spawning gravels and deeper cover areas interspersed with beaver dams in most sections of Hat Creek has resulted in largely self-sustaining populations of rainbow trout within short reaches of Hat Creek.

Other fish which probably spawn in the extreme lower reaches of Hat Creek are bridgelip sucker, longnose dace and leopard dace. Sexually mature sucker and longnose dace were collected in the river or creek in June. Examination of gonads of adult mountain whitefish collected at Station 7 in Hat Creek indicated these fish would spawn during Fall. Sexually mature redside shiner were collected in the Bonaparte River during June and may also spawn in the extreme lower reaches of Hat Creek.

Population estimates for rainbow trout in Hat Creek ranged from approximately 18,000 to 23,000. Approximately 35 - 45 % of the total number was estimated to occur in Lower Hat Creek, an area which comprised about 60% of the length of the entire Hat Creek system. Estimates for rainbow trout greater than 150 mm (about 6 inches in length) ranged from approximately 3,500 to 5,000. Even though size classes were better represented and population estimates higher in Upper compared to Lower Hat Creek, a viable fishery appears to exist in both areas of the system.

Population estimates were not made for rainbow trout in the Bonaparte River since swift, deep water prevented effective sampling. However, species collected during the three surveys (bridgelip sucker, longnose dace, leopard dace, rainbow trout, brook trout, mountain whitefish and redside shiner) are probably representative of those actually found in the river system.

Tributaries to Hat Creek appeared to provide negligible fish habitat compared to that in the creek. No fish were observed in Goose/Fish Hook or Finney Lakes.

The Hat Creek system, in total, displayed a variety of habitats which in turn supported a variable spectrum of faunal components in terms of fish populations and benthic invertebrate communities. An analysis of these biological entities, with their inherent ecological relationships, enabled a critical evaluation of present system status. These data will facilitate projections to expected conditions given definable environmental perturbations.

5.0 PROJECT IMPACT

The fundamental purpose of the study is to assess what impacts the proposed development may exert upon the existing environmental characteristics of the area. Within this report the fisheries and benthos resources are the focal point of attention.

The method of impact assessment using matrix techniques has been described in Section 3.4. The organizational framework within which the assessment is presented consists of a broad geographical division based on regional, offsite and local (Hat Creek Valley) areas with further activity division based on construction, operation and decommissioning phases where appropriate. Discussion is subsequently structured on interactions between project activities and environmental characteristics; the direction of interaction being from project activities to environmental characteristics.

The environmental impact matrix for fisheries and benthos resources is presented on Figures 5-1 (Operation and Construction) and 5-2 (Decommissioning). For purposes of impact analysis, the entire study region was sectioned into a series of zones. Zone A includes the mine, plant and majority of offsite facilities. Zone B extends beyond Zone A to a distance of 15 km east, 15 km west, 25 km north and 25 km south of the impact center situated in the middle of Zone A. Zone C extends beyond Zone B to a distance of 30 km east and west, and 40 km north and south. Beyond Zone C, a 100 km demarkation encloses Zone D. Within Zone D is the area where measurable physical affects of the Hat Creek project may be realized. Because many of the project effects are anticipated to be localized, Zones B, C and D have been divided into quadrants, each numbered clockwise beginning with the northwest section (i.e. B1, B2, B3, B4, etc.). Thus, the broad geographical divisions of regional, offsite and local become specified as follows:

Regional - C, D
Offsite - C3
Local - A, B

figure 5·1

ENVIRONMENTAL IMPACT MATRIX · CONSTRUCTION AND OPERATION

legend

CONSTRUCTION

- Negative impact: major; minor
- Beneficial impact: major; minor
- Ambivalent
- No impact

OPERATION

- Negative impact: major; minor
- Beneficial impact: major; minor
- Ambivalent
- No impact

CONSTRUCTION

Area	Component	Activity	BENTHIC INVERTEBRATES	FISH
MINE	MINE	CLEARING, DITCHING, DIVERSION	A	A, B2
MINE	MINE	LAKE DEWATERING	A	A
MINE	MINE	EQUIPMENT / INFRASTRUCTURE		
MINE	MINE	STRIPPING / EXCAVATION		B2
MINE	DUMPS	FORM LAGOONS	A	
MINE	DUMPS	DITCHING & DIVERSION		
MINE	DUMPS	CLEAR SPOIL AREAS	A	A
MINE	CAMP	SITE PREPARATION		
MINE	CAMP	CREW ACTIVITIES		B
MINE	CAMP	WATER SUPPLY		
MINE	CAMP	SEWAGE DISPOSAL		
PLANT	PLANT	ROADS & PARKING		
PLANT	PLANT	GRADING & EXCAVATION		
PLANT	PLANT	FUEL STORAGE		B2
PLANT	PLANT	BUILDINGS & OFFICES		
PLANT	PLANT	TRADE SHOPS		
PLANT	PLANT	CONCRETE BATCH PLANT		
PLANT	PLANT	CIVIL CONSTRUCTION		
PLANT	PLANT	COOLING TOWERS		
PLANT	PLANT	SWITCHYARD		B2
PLANT	PLANT	RESERVOIR		
PLANT	PLANT	ASH LAGOON	A	A
PLANT	PLANT	CONVEYOR SYSTEM		
PLANT	CAMP	SITE PREPARATION		
PLANT	CAMP	WATER SUPPLY		
PLANT	CAMP	CREW ACTIVITIES		B
PLANT	CAMP	SEWAGE DISPOSAL	A	
OFFSITE	ACCESS ROAD	SURVEY		
OFFSITE	ACCESS ROAD	CLEAR		
OFFSITE	ACCESS ROAD	REMOVE TOPSOIL		
OFFSITE	ACCESS ROAD	STREAM CROSSINGS	B2	
OFFSITE	ACCESS ROAD	CULVERTS		
OFFSITE	ACCESS ROAD	PREPARE SUBGRADE		
OFFSITE	ACCESS ROAD	CUT/FILL, SEED SURFACE	B2	
OFFSITE	ACCESS ROAD	PREPARE GRANULAR BASE		
OFFSITE	ACCESS ROAD	PAVE	B2	
OFFSITE	COOL WATER SUPPLY	CLEAR		
OFFSITE	COOL WATER SUPPLY	CONSTRUCT ACCESS ROAD	C3	C3
OFFSITE	COOL WATER SUPPLY	STREAM CROSSINGS	C3	C3
OFFSITE	COOL WATER SUPPLY	TRENCH		
OFFSITE	COOL WATER SUPPLY	PIPE LAYING		
OFFSITE	COOL WATER SUPPLY	BACKFILL		
OFFSITE	COOL WATER SUPPLY	RESEED & CONTROL	B2	
OFFSITE		TRANSMISSION SYSTEM ACCESS ROADS		
OFFSITE	CREEK DIVERSION(S)	CLEAR		
OFFSITE	CREEK DIVERSION(S)	ACCESS ROAD		
OFFSITE	CREEK DIVERSION(S)	TRENCH / CONDUIT	A, B2	A, B2
OFFSITE	CREEK DIVERSION(S)	LINE TRENCH		
OFFSITE	CREEK DIVERSION(S)	FORM RESERVOIRS	A	A, B
OFFSITE		AIRSTRIP		
OFFSITE		EQUIPMENT OFFLOADING		

OPERATION

Area	Component	Activity	BENTHIC INVERTEBRATES	FISH
MINE	MINE	OVERBURDEN REMOVAL		
MINE	MINE	SOIL STOCKPILING		
MINE	MINE	COAL EXCAVATION		
MINE	MINE	COAL TRANSPORT		
MINE	MINE	COAL CRUSHING		
MINE	MINE	PIT DRAINAGE	B2	B2
MINE	MINE	PIT WALL DEWATERING	B2	B2
MINE	MINE	COAL STOCKPILE DRAINAGE(S)	B2	B2
MINE	MINE	SOIL STOCKPILE DRAINAGE		
MINE	DUMPS	UNDER DRAINS		
MINE	DUMPS	SPOIL EMBANKMENTS		
MINE	DUMPS	DEPOSIT SPOIL		
MINE	DUMPS	SPOIL DRAINAGE	B2	B2
MINE	ANCILLARY SERVICES	TRAFFIC		
MINE	ANCILLARY SERVICES	SHOP OIL WASTE		
MINE	ANCILLARY SERVICES	WATER SUPPLY		
MINE	ANCILLARY SERVICES	SEWAGE DISPOSAL		
MINE	ANCILLARY SERVICES	AREA DRAINAGE		B2
MINE	ANCILLARY SERVICES	ROAD DRAINAGE		B2
PLANT		AIR EMISSIONS	B	B, CD
PLANT		BOILER WATER TREATMENT		
PLANT		COOLING WATER BLOWDOWN		
PLANT		BOILER BLOWDOWN		
PLANT		SYSTEM CLEANING		
PLANT		ASH DISPOSAL		
PLANT		AREA DRAINAGE		
PLANT		ASH AREA DIVERSION		
PLANT		COAL PILE DRAINAGE		
PLANT		YARD DRAINAGE		
PLANT		ROAD DRAINAGE		
PLANT		PLANT DRAINS		
PLANT		SEWAGE DISPOSAL		
OFFSITE		BANK STABILITY - ACCESS ROAD		
OFFSITE	COOLING WATER SUPPLY	EROSION & DRAINAGE CONTROL		
OFFSITE	COOLING WATER SUPPLY	LINE DRAINAGE		C3
OFFSITE	COOLING WATER SUPPLY	BURIED CROSSINGS		
OFFSITE	COOLING WATER SUPPLY	CULVERT CROSSINGS		
OFFSITE		DRAINAGE CONTROL - TRANSMISSION L.		
OFFSITE	CREEK DIVERSION	HAT CREEK FLOW CONTROL	B2	B2
OFFSITE	CREEK DIVERSION	MEDICINE CRK. FLOW CONTROL		B2
OFFSITE	CREEK DIVERSION	CANALS AND RESERVOIRS		
OFFSITE		AIRSTRIP		
OFFSITE		EQUIPMENT OFFLOADING		
OFFSITE	TOWNSITE	SITE OCCUPANCY		
OFFSITE	TOWNSITE	STORM SEWER		
OFFSITE	TOWNSITE	SANITARY SEWER		
OFFSITE	TOWNSITE	WATER SUPPLY		
OFFSITE	TOWNSITE	WORK FORCE ACTIVITY		

p. 5-2

DECOMMISSIONING

Negative Impact:
- major
- minor

Beneficial Impact:
- major
- minor

Ambivalent

No Impact

	MINE			PLANT			OFF-SITE	
	FILLING OF PIT	EROSION & DRAINAGE CONTROL	RECLAMATION	REMOVE PLANT	RECLAIM ASH AREA	EROSION & DRAINAGE CONTROL	REMOVE FACILITIES	EROSION & DRAINAGE CONTROL
BENTHIC INVERTEBRATES								
	A	A	A		A	A		A
	B2	B2	B2		B2			B2
FISH								
	A	A	A		A	A		A
	B2	B2	B2		B2	B2		B2

figure 5·2
ENVIRONMENTAL IMPACT MATRIX - DECOMMISSIONING

Activities associated with development of the Hat Creek Project which are expected to impact benthic and fish populations during the construction, operation and decommissioning phases of the project are listed in Figures 5-1 and 5-2. Impacts have been categorized according to the developmental area (plant, mine, offsite) in which an activity will occur. The predicted degree of impact (minor, major) and type of impact (negative, beneficial) are also listed. Those instances where impacts are not expected, but could occur if precautionary measures described by B.C. Hydro fail, or where insufficient information is available to make a definitive assessment are designated as ~~ambivalent~~. ambivalent.

5.1 REGIONAL IMPACT

Those project activities interacting with the regional aquatic resources can be specified as the construction and operation of an intake structure on the Thompson River and the emission to the atmosphere associated with plant operation. Both interactions are considered in detail within other environmental reports for Hat Creek Project, specifically the Intake Study and Air Quality Study. Insofar as an initial inventory of the regional aquatic resources has been included in this study, and shall serve as an information base for other groups, the interactions between plant air emission and fish is designated as ambivalent.

5.2 OFFSITE IMPACTS

The offsite activity component of the Hat Creek Project has been defined in a project description to include not only the access road, cooling water supply, transmission system, airstrip and equipment offloading site but also the diversion of Hat Creek. Notwithstanding this structural aspect of project organization, activities associated with the diversion and storage of water which are designated as offsite activities, do not fall within the geographically defined offsite area. Therefore, these activities have not been assessed herein but rather are placed as an integral component of the Hat Creek Impact (Section 5.3) which corresponds to the area in which their impacts occur.

Given this aerial division of offsite activities, no major impacts in the offsite area are identifiable. Those minor negative and beneficial impacts identified are primarily associated with the following activities:

Construction
1) access roads and pipeline stream crossings (C3);
2) reseeding of cut surfaces and road paving (C3); and

Decommissioning
3) erosion and drainage control (C3).

Construction of the plant access road and water pipeline will require stream crossing of the Bonaparte River, Cornwall Creek, MacLaren Creek and a number of smaller intermittent streams which drain into these systems. Associated construction and decommissioning activities including trenching, culvert implacement, backfilling and slope stabilization may result in stream alterations which could have negative impacts to stream benthos and fish.

In all streams crossed or paralleled by the proposed access road and pipeline, except the Bonaparte River, none are suspected to support significant fish populations and hence impacts related to fish are considered negligible. Short-term losses in benthic standing crops will result at stream crossings due to material emplacement and potential siltation of downstream habitat.

Possibility for impact to fishes may occur in the lower Bonaparte River. The lower Bonaparte provides spawning habitat for pink salmon, steelhead and some chinook salmon. Resident rainbow trout utilize this reach year-round.

The water pipeline and access road are proposed to cross the Bonaparte River approximately 0.40 km upstream from its confluence with the Thompson River. Observations of the International Pacific Salmon Fisheries Commission in 1977 indicated approximately 66% of the total numbers of pink salmon counted in the river were utilizing spawning grounds located within the immediate vicinity and downstream of the proposed crossings (F. Andrews, pers. comm.). Total estimated escapement in 1977 in the Bonaparte River was 611 fish. Mean average escapement for the period of record 1957 - 1971 is 788 fish during odd numbered years.

Stream diversion and trenching activities associated with a buried pipeline and road crossing will require significant stream alterations which could result in serious degradation of the existing quality of spawning bed materials. Should construction occur during the egg incubation and pre-emergent periods (September to March), it can be anticipated that significant losses could result directly from habitat alterations and indirectly by excessive sedimentation of spawning beds located below the construction site. Potential losses to chinook and steelhead spawning would likely be minor considering the generally low numbers thought to utilize the lower Bonaparte River.

Temporary stream blockage may result during construction of stream crossings due to siltation or velocity barriers. However, if periods of peak migration are avoided (September - October) delays to species other than pink salmon would be short term and likely exert minor impact.

The preparation of the access road surface with regard to paving, seeding, and filling surfaces to prevent erosion will be of a minor beneficial impact to invertebrate communities in area B 2. Paved and seeded surfaces will minimize the flow of suspended particulate matter into fresh water areas, consequently minimizing impingement on aquatic resources.

5.3 HAT CREEK IMPACT

The Hat Creek system has been described as it presently exists in Section 4.3. The goal of the Hat Creek area impact assessment is to predict what the nature of the system might be, given that the project proceeds. This section then considers the "with" project case.

Moreover, to provide a basis for comparison between the "with" and "without" cases, a description of what the nature of the future system might be without the project is needed. To undertake this prediction, basic assumptions have been made. It is assumed that the 1976 and 1977 time period during which the fisheries and benthos surveys were undertaken is a time period which is generally representative of the system and that the physical and chemical characteristics of the watershed, angler use and success rates in Hat Creek will be similar in the future as they have been for the past four or five years.

Without the Hat Creek Project, benthic communities and fish populations in Hat Creek in 1980, 2015 and 2022 will be similar to those at present. These three dates correspond to the scheduled construction commencement, operation-completion and decommissioning-completion of the plant if development occurs. Rainbow trout will be the dominant fish in Hat Creek. Mountain whitefish will also occur throughout Hat Creek, but in much smaller numbers than rainbow trout. Lower reaches of Hat Creek will support fishes such as bridgelip sucker, longnose dace, leopard dace, and possibly redside shiner.

Total numbers of rainbow trout in Hat Creek will be approximately 20,000. About one-third to one-half of these will occur in Lower Hat Creek. About 4,000 trout will be longer than 150 mm (about 6 in.) total length. Densities of this size trout will generally be higher in Upper compared to Lower Hat Creek, possibly because of a greater variety and quality of fish habitat there. Rainbow trout which are longer than 250 mm or older than 6 years will be uncommon in Hat Creek.

Rainbow trout will spawn the length of Hat Creek, primarily between mid-June and late July. Emergence of fry will occur from late July through September. Lower Hat Creek will be utilized as a spawning ground by rainbow trout migrating upstream from the Bonaparte River. Further upstream movements will be limited by barriers such as beaver dams and the canyon.

Rainbow trout will feed primarily on aquatic insects. Ephemeroptera nymphs and Diptera larvae will probably be dominant foods with Trichoptera larvae, Plecoptera nymphs and Hymenoptera more important to larger fish. In general, trout will utilize these foods in about the same proportion as they occur in the environment. Few stomachs should be empty and fish should be in good condition.

Impacts on benthic and fish populations during construction, operation and decommissioning phases will be of two general types. The first will result from the direct physical alteration of existing water bodies in Hat Creek valley. The second will be more indirect in nature. It will result from the addition of suspended and/or dissolved solids to Hat Creek.

The nature, degree and location of impacts on benthos and fishes during construction, operation and decommissioning phases is discussed in detail herein. Associated mitigative and compensatory measures are discussed in Section 6.0

(i) Construction (1980)

(A) Physical Alteration

Activities which will result in the physical alteration of existing water bodies, and specific areas in which benthos and fishes will be impacted are summarized by developmental area below:

Offsite

1) diversion of a portion of Hat Creek through an artificial channel or canal (Areas A, B2);
2) establishment of reservoirs on Hat Creek (Area A);

Mine

3) clearing of Medicine Creek and its valley for use as a spoils disposal area (Area A);
4) de-watering of Finney and Aleece Lakes (Area A); and

Plant

5) construction of ash lagoons in Medicine Creek Valley (Area A).

Since each of the above impacts is specific to a certain water body or portion of a water body, they are discussed separately. It should be noted that the activities associated with the diversion of Hat Creek effectively preempt those impacts specific to actual mine construction.

The major impact on fish and benthos during the construction phase will result from the diversion of water from Hat Creek to an artificial channel or canal. The diversion will extend from about km 28.0 immediately downstream of Anderson Creek to km 21.0 about 2 km downstream of Station 7. This will result in the loss of approximately 7,000 m of aquatic habitat and the biota occurring therein. The potential for this reach of Hat Creek to produce about the same numbers of benthos and fish in future years as it does at present will also be lost.

Based on the 1976 - 1977 fisheries studies in Hat Creek, estimated numbers of rainbow trout occurring between km 21.0 and km 28.0 ranged from about 3,000 to 5,000. Estimates for fish larger than 150 mm varied from approximately 400 to 1,200 individuals. Population estimates for this reach of Hat Creek in 1976 and 1977 are presented by fish length interval and sampling period in Table 5-1.

Loss of 7,000 m of Hat Creek represents an approximate 17% reduction of aquatic habitat in Upper and Lower Hat Creek combined (km 0-41). In terms of total numbers of rainbow trout in Upper and Lower Hat Creek, these losses would represent an approximate 15-16% reduction in population size. Expected reduction in numbers of trout greater than 150 mm length in Hat Creek is estimated at 11-24%. In summary, diversion of Hat Creek will result in the loss of existing benthos and fish, future fisheries yield and the aesthetic enjoyment of a portion of a free-flowing stream in its natural state.

The actual diversion of water from Hat Creek will occur in two steps. After construction of a dam approximately 15 m high immediately downstream from the mouth of Anderson Creek, water will be diverted to the artificial channel. Water from a second reservoir dam about 9 m high, to be constructed further downstream on Hat Creek near Finney Creek, will be pumped to the artificial channel. Eventually there will be no free-flowing stream or associated fish

TABLE 5-1

ESTIMATED NUMBERS OF RAINBOW TROUT IN HAT CREEK BY LENGTH INTERVAL (mm)

BETWEEN KILOMETERS 21.0 AND 28.0 DURING SEPTEMBER, 1976 AND JUNE AND AUGUST, 1977

Length Interval (mm)	Sampling Period: September 1976	June 1977	August 1977
0-100	1,638	1,335	1,664
101-150	1,313	1,659	2,070
151-200	269	463	905
201-250	112	240	278
7-250	0	55	0
TOTAL	3,332	3,752	4,917

habitat between the two dams or further downstream to the point where the artificial channel re-enters Hat Creek. Fish and habitat losses resulting from the creek diversion were estimated above.

Populations of rainbow trout in the reservoir, near Finney Creek, could probably survive for some time if adequate flow would be maintained for spawning and rearing areas. With depths of 9 m, the reservoir should provide suitable habitat and an adequate food supply for a small number of trout. However, as there is no allowance for continued flows, it is assumed that fishes occurring in Hat Creek between the two dams will perish. These losses were included in previous estimates of fish production and habitat losses due to the diversion.

Establishment of a reservoir near Anderson Creek would probably have both negative and positive impacts on Hat Creek fish and benthos. Negative effects would include the loss of a portion of free-flowing stream as it presently exists and the fish habitats and benthic communities therein. However, fishes occurring in the creek upstream from this reservoir should not be impacted. Water depths will extend to about 15 m and the food supply, expected to be primarily Diptera and zooplankton, should be adequate. Because of its greater volume, the reservoir should support at least as many rainbow trout as presently occur in that portion of Hat Creek which would be inundated. Reservoir trout may also be faster growing and larger than those presently found in Hat Creek, and provide a good fishery if the public has access. Spawning and nursery areas should remain available further upstream in free-flowing portions of Hat Creek as well as Anderson Creek.

An additional negative impact, related to the establishment of a reservoir near Anderson Creek, is the potential for a greater success of mountain whitefish compared to rainbow trout in Upper Hat Creek. At present, rainbow trout are the dominant species in Hat Creek with mountain whitefish occurring in very small numbers. Mountain whitefish may benefit more from a reservoir habitat than rainbow trout. Nelson (in Scott and Crossman, 1973) noted the adaptability of whitefish to altered environmental conditions. If such changes did occur, this could be considered deleterious since rainbow trout are generally considered a more attractive sport fish by anglers than are mountain whitefish.

With continued flow from Hat and Anderson Creeks, pH in this reservoir should not be excessively high. Goose/Fish Hook Lake, an alkaline pot-hole in the Hat Creek Valley, had no inlet or outlet, a pH of 9.9 and no signs of fish life. However, zooplankton (Cladocera) were abundant in shoreline vegetation. Zooplankton should also occur in the reservoir near Anderson Creek and will probably be an important food for trout.

With respect to mine construction activities, the clearing of Medicine Creek and the surrounding valley for use as a spoils disposal area will result in the loss of fish habitat, benthic communities and fish in this water body. Even though numbers of trout and habitat occurring here are probably negligible compared to that in Hat Creek, their loss and the loss of the stream represents an irreversible impact on the fishery.

Dewatering of Finney and Aleece Lakes will result in the loss of existing benthic communities and potential fish habitat. Although surveys in Finney Lake in September 1976 indicate no fish present, the lake appeared capable of supporting fish. B.C. Fish and Wildlife Branch personnel at Kamloops stated both Finney and Aleece Lakes have supported fish in the past (S. J. McDonald, personal communication).

Construction of ash lagoons in the plant area will result in a major negative impact on the benthic invertebrate communities. Invertebrate systems inhabiting areas within the potential lagoon site will be eliminated. Fish are not known to occur at these sites.

It is assumed, given the existing development descriptions, that plans for initial storage of fuels, containment of transformer cooling fluids and sewage disposal during construction will be such that contaminants will not enter Hat Creek either directly through run-off or indirectly through groundwater.

Impacts from these sources have therefore been noted as ambivalent with the reservation that if fuel and chemical contaminations occur, a severe impact on aquatic biota is possible.

(B) Chemical Alteration

Impacts may also result from construction activities which cause an increased sediment load in Hat Creek or the Bonaparte River. Specific areas in which these impacts will occur are summarized by development area below:

Mine
1) clearing, ditching and trenching (Area B2);
2) initial stripping and excavation in mine area (Area B2);
3) clearing spoil areas and formation of lagoons (Area A2); and

General
4) construction crew activities (Area B).

Sediment lossened during the above construction activities may be controlled given the ditching and settling pond networks planned. However, a portion will undoubtedly enter Hat Creek and possibly impact benthos and fish. Some sediment will either enter the creek initially because of the proximity of activity to the creek or at a later date with precipitation and subsequent run-off. Because of the nature of activities during construction, it is assumed that added sediments will consist primarily of suspended solids (non-filterable residues) and that levels of dissolved solids (filterable residues) in Hat Creek will not increase significantly.

In the above instances, direct impacts from increased sediment loads during the construction phase are expected to be minor. In particular, concentrations of suspended solids in Hat Creek are assumed to not exceed 50 mg/ℓ given that run-off waters from construction area will be intercepted and subsequently directed to settling lagoons. It is also assumed that no catastrophic events such as ditch overflow and dyke failures occur during construction. If such catastrophes did occur they could severely reduce benthic communities and populations of Hat Creek rainbow trout downstream from the source of impact.

Physical-chemical surveys (see Hat Creek Project - Hydrology Report) show levels of suspended solids in Lower Hat Creek in the 2-17 mg/ℓ range. The assumed maximum value is 50 mg/ℓ. Based on the literature, this level is not expected to be harmful to rainbow trout or other fishes in Hat Creek. McKee and Wolf (1963) reported no observable effects on rainbow trout when they were exposed to concentrations of 30 mg/ℓ of inert soils (kaolin and diatomaceous earth). Several trout died at levels of 90 mg/ℓ and over half the fish died in 2-12 weeks when exposed to concentrations of 290 mg/ℓ. No difference was found between lethal effects of kaolin and diatomaceous earth, even though particle size of the former (0.13 - 5.0 microns) was smaller than the latter (1 - 6 microns). McKee and Wolf (1963) reported that in field tests, trout and invertebrates were as abundant in a stream with suspended solids levels of 60 mg/ℓ as they were in a clear control stream. Tarzwell (1962) stated that suspended solids levels of 60 mg/ℓ could effect trout spawning grounds, but probably are not harmful otherwise. In Bluewater Creek, Montana, Peters (in Tarzwell, 1962) found that survival of rainbow trout eggs, intragravel water velocity and dissolved oxygen levels were inversely related to sediment concentration. Egg mortality rates at various mean monthly sediment concentrations were 5% at 13-20 mg/ℓ, 39% at 97-147 mg/ℓ, 90% at 142-276 mg/ℓ and 100% at 246-386 mg/ℓ. Stream flows during hatching ranged from approximately 10 to 35 cfs.

Similar results have been found in other studies. Investigations by the European Inland Fisheries Advisory Commission (in U.S. Department of the Interior, 1968) indicated good or moderate fisheries are found in waters normally containing 25-80 mg/ℓ suspended solids. There was evidence that yields were higher in waters with less than 25 mg/ℓ suspended solids. The Commission reported that waters containing 80-400 mg/ℓ suspended solids were unlikely to support good freshwater fisheries. In the River Fax, England, where suspended solids levels were 100 mg/ℓ, densities of trout were one-seventh and invertebrates one-third those recorded in clear control streams (McKee and Wolf, 1963). In the River Par, England, where suspended solids concentrations were 6000 mg/ℓ, densities of trout were one-seventh and invertebrates one-nineteenth what they were in control streams.

The above data indicate that at predicted levels there will be direct impact on benthos or fish in Hat Creek. However, impacts may occur during the first year of construction (1980) and in later years if there is not adequate stream flow to flush suspended solids from the Hat Creek system. Accumulation of sediments on the creek bottom could reduce spawning and food-producing areas in riffles by filling intragravel spaces. Heavy sedimentation rates could result in the covering and suffocation of trout eggs incubating in the gravel. By reducing water depth, heavy sedimentation could possibly present physical or physiological blocks to fish (particularly rainbow trout) which may migrate upstream to spawn in portions of Lower Hat Creek. Rates of sediment accumulation would probably be greater in natural sinks such as beaver ponds and deeper, slower moving pools. Sediment build-up could severely limit food production and the utilization of these pool areas by rainbow trout, especially larger-sized fish which appeared to prefer this type habitat as indicated by the 1976-77 Hat Creek fisheries studies.

There is also the potential for impact on fish if Hat Creek is flushed only occasionally. This could result in the resuspension of sediments and extremely high suspended solids loads for short periods of time. Although high concentrations can be directly harmful to fish and invertebrates as described earlier, other studies have shown that rainbow trout can survive under extreme stress situations for short periods. Ward (in McKee and Wolf, 1963) found young salmon could be held 3-4 weeks in circulating waters at silt loads of

1,000 mg/ℓ. Griffin (in McKee and Wolf, 1963) found that trout and salmon fingerlings were fed and grew in water with a silt load of 300-750 mg/ℓ for 3-4 weeks. He also found young salmonids could withstand silt loads of 2300-6500 mg/ℓ for short intervals daily when the water was stirred. It would be to the benefit of benthos and fishes in Hat Creek if they were never exposed to levels of the magnitude described above. This is particularly true for rainbow trout from about mid-June to late September. During this time spawning occurs, young undergo the first several months of growth, and year class strength is largely determined.

Discharge of Hat Creek waters with suspended solids levels of 50 mg/ℓ to the Bonaparte River is not expected to impact fishes. Suspended solids levels measured at Station 3 in the Bonaparte River, located about 1 mile downstream from the mouth of Hat Creek, ranged from 3 to 51 mg/ℓ in 1976-77. Because of the relatively low flow contributed by Hat Creek to the Bonaparte, increases in suspended solids levels are expected to be correspondingly small with no direct impacts expected.

Impact of construction crew activities on fish populations, particularly rainbow trout, in Hat Creek is designated as ambivalent. This is so as a result of the uncertainty regarding the degree workers may use and harvest the resource. Over-harvesting rainbow trout could modify population size, growth rates and other life history parameters. Should angling pressure be intense, the positive use might be to direct it toward harvest of fish which will remain in pools in that portion of Hat Creek to be diverted. Fish trapped in pools will probably survive for several weeks. Unless caught by fishermen, they will perish naturally.

(ii) Operation (1983 - 2015)

(A) Physical Alteration

Impacts resulting from the direct physical alteration of water bodies are summarized below. Although most activities which altered water bodies occurred during the construction phase, associated secondary and long-term effects could impact Hat Creek aquatic resources during the operation phase. Activities and specific areas in which impacts will occur are:

1) discharge of reservoir and diversion canal water to Hat Creek (Area B2); and
2) control of Hat Creek flow rates (Area B2).

Water discharged from the reservoir near Anderson Creek and from the diversion canal could be unusually warm during summer and early fall months. Such an occurrence is resultant to the diversion canal design (shallow depth) coupled with high ambient temperatures.

As presently designed, the artificial channel will provide no benefits to fish and may, in fact, impact them in a negative manner. Because of shallow depths in the channel (<150 mm) water temperatures could be greatly influenced by air temperatures and result in extreme elevations during summer and early fall. Daytime ambient temperature tolerance limits for a rainbow trout, generally accepted as 23-24°C or 27°C for short periods of time (Scott and Crossman, 1973).

Field investigations showed water temperature in shallow reaches of Lower Hat Creek at 1520 hr. on 3 August, 1977, was 24°C. Temperature elevations much beyond this level could be critical to trout, especially eggs (mid-June to August) and fry (August and September). If, as expected, seasonal temperature elevations result from channel discharge and mortalities to young-of-the-year are correspondingly high, the population size of rainbow trout in Lower Hat Creek could, in several years, be reduced to a fraction of present numbers.

In addition, the problem of elevated water temperature would be aggravated if reservoir releases were at or near the surface. Reservoir surface temperatures during summer would probably be higher than in Hat Creek, and possibly greater than upper lethal temperatures of rainbow trout. The combined negative effect of warm water releases from the reservoir and diversion canal during summer and early fall months could be severe on fish in Lower Hat Creek. In addition if the reservoir outlet is at the surface, icing problems could develop during winter and reduce or prevent downstream flow. This, in turn, could result in greater freezing of Lower Hat Creek, reduction or loss of over-wintering areas and a major negative impact on fish. Water discharged from a greater depth in the reservoir should be cooler during summer and free-flowing during winter. Temperature problems are not expected for fish occurring within the reservoir. During summer, greater depths can be utilized or they may migrate upstream to portions of free-flowing Hat Creek. During winter, deeper parts of the reservoir and reaches upstream in Hat Creek should be ice-free and provide over-wintering areas for fish.

Notwithstanding potential major impacts due to the temperature of waters entering Lower Hat Creek from the diversion canal, ambivalent impacts associated with the alteration of the flow regime of Hat Creek are also noted. Water depth, velocity and stream width are critical factors which govern the capability of a stream to maintain or perpetuate its aquatic resources. Any alteration of natural flow regimes either through water withdrawal, diversion or impoundment can significantly alter these flow characteristics and ultimately control a streams suitability to support fish. Natural flow regimes in most streams are such that wise water use does not necessarily have to create a negative impact upon existing fisheries. A water use plan which takes into account the instream flow requirements of existing resources can both protect the natural environment and provide water for use by man.

At the present time the water supply scheme for the proposed Hat Creek development is not finalized. Stream flow alterations as a result of construction of the water diversion system and controlled flow capabilities of storage reservoirs proposed in the Upper Hat Creek area, require that a minimum flow regime be recommended. This would provide adequate maintenance flows for fish inhabiting Hat Creek downstream of the proposed development.

Several methodologies can be applied in determining instream flow needs. Two basic approaches have been taken depending upon the extent and availability of stream characterization data;

1) an empirical approach which recommends a minimum flow regime based upon a percentage of the average annual discharge (Tennant, 1977; Stalnecker, Fish and Wildlife Service, Colorado, pers. comm.); and

2) a quantitative approach which recommends a minimum flow regime based upon the habitat requirements of fish during migration, spawning, incubation, rearing (Neuman and Newcombe, 1977; Stalnecker, Fish and Wildlife Service, Colorado, pers. comm.).

The latter of the two basic approaches provides a more precise, site specific determination of instream flow needs. The Neuman and Newcombe (1977) instream flow assessment technique is presently being evaluated as a recommended methodology for assessing instream requirements in British Columbia. However, detailed stream characterization data obtained at high and low flows are required and numerous survey transects, chosen in a manner specific to the quantitative minimum flow assessment technique chosen, are required in various stream reaches. Detailed stream information of this nature is not currently available. In lieu of these data requirements, recommended minimum flow requirements suggested for Hat Creek are necessarily based upon an empirical evaluation of historical stream flows.

Although no single empirical formula can be considered best, an approach generally described as the "Montana Method" has been widely used in determining flows to protect aquatic habitat. The "Montana Method" was developed from field studies conducted between 1964 and 1974, in streams in three western U.S. states containing both cold water and warm water fisheries and has been correlated with similar flow data in 21 different states during the past 11 years (Tennant, 1977).

The "Montana Method" suggests that 30% of the mean annual discharge is recommended as a base flow to sustain good survival conditions for most aquatic life

TABLE 5-2

APPLICATION OF THE MONTANA METHOD FOR EVALUATING

INSTREAM FLOW REQUIREMENTS IN HAT CREEK

Hatitat Maintenance Level	Flow Regime (CFS)[1]		
	October-March	Freshet	April-September
Flushing Flow		49.0 (200%)[2]	
Optimum	15 (60-100%)		15 (60-100%)
Outstanding	10 (40%)		15 (60%)
Excellent	7.5 (30%)		12.5 (50%)
Good	5.0 (20%)		10 (40%)
Fair or Degrading	2.5 (10%)		7.5 (30%)
Poor or Minimum	2.5 (10%)		2.5 (10%)
Severe Degradation	<2.5 (<10%)		<2.5 (<10%)

Recommended Hat Creek Minimum Flow

Base Flow Period	October-March	7.5 CFS
Base Flow Period	April-September	10.0 CFS
Flushing Flows (for two week duration during May-June)		50 CFS

[1] Based upon Upper Hat Creek Station annual discharge of 25 CFS
[2] % values relate to flow regime expressed as a percentage of mean annual discharge

forms while 60% would provide excellent to outstanding habitat for most aquatic forms during their primary periods of growth (Tennant, 1977).

To apply the "Montana Method" a range of flows (percentages of annual discharge) are recommended for two - six month flow regimes that mimic natural hydrologic cycles and coincide with relatively active and inactive biological periods. These flows are flexible and should be interpreted and refined to account for above and below normal water years and maintain flows which approximate appropriate portions of monthly quarterly or annual instream flow supplies (Tennant, 1977).

The "Montana Method" has been applied to Hat Creek (Table 5-2). From this summary presentation, a flow regime can be selected given a choice as to the habitat maintenance level preferred. The maintenance of good to excellent habitat conditions in Lower Hat Creek requires, based on their preliminary analysis, the following regime and flow: during freshet, a flushing flow of 50 CFS for a duration of two weeks; during April to September a minimum flow of 10 CFS, and during the winter low flow period (October - March) a minimum flow of 7.5 CFS. During periods of low flow, as those experienced during the past year (1977), controlled releases of storage water from Upper Hat Creek reservoirs would be required to meet the continued instream flow requirements downstream of the Hat Creek development. Flushing flows at 200% (50 CFS) of annual mean discharge for a duration of two weeks during the normal high flow period (May - June) are recommended to achieve sufficient depths and velocities necessary within the stream channel to remove silt, sediment and other bed load material from spawning beds and maintain an active stream channel.

The conduit at the lower end of the diversion is an effective barrier on Hat Creek and could negatively affect Hat Creek fishes. Passage of fish from Lower to Upper Hat Creek will be impossible because of the grade and length of the conduit and expected velocity of transported water. Fisheries studies 1976-77 suggested that populations of rainbow trout in Hat Creek were largely self-supportive within relatively short reaches of stream. Numerous beaver dams probably prevent massive spawning migrations of rainbow trout from Lower to Upper Hat Creek. However, it cannot be unequivocably stated that the survival of fish downstream from the point where the conduit enters Hat Creek is not dependent on their having access to areas further upstream. Therefore, impacts related to this particular aspect of creek diversion have been designated as ambivalent.

(B) Chemical Alteration

Activities which will cause increased sediment or dissolved solids loads in Hat Creek or the Bonaparte River, and specific areas in which this impact will occur are summarized below:

Mine

1) drainage of the mine pit, coal stockpile and spoils areas (Area B2);
2) de-watering of the mine pit wall (Area B2);
3) surface run-off from mine, pit and road-way areas (Area B2); and

Plant

4) plant emissions of sulfur dioxide (Area B).

Drainage and de-watering during the operation phase of the project are expected to result in increased dissolved solids levels in Hat Creek. Based on present information, it is assumed that waters draining from the development area will cause no more than a 50% increase over present dissolved solids levels. Also, it is assumed that the proportional relationships of dissolved chemicals found in Hat Creek will remain the same as at present.

Concentrations of dissolved solids in Lower Hat Creek in 1976-77 ranged from 333-413 mg/ℓ. Increases of 50% bring maximum predicted levels to about 620 mg/ℓ. Based on the literature these levels are not expected to impact benthic communities, rainbow trout or other fishes in Hat Creek. McKee and Wolf (1963) stated that dissolved solids levels of up to 2,000 mg/ℓ should not interfere with freshwater fish or other aquatic life. They added that limiting concentrations for some species of fish may be as high as 5,000-10,000 mg/ℓ if acclimated gradually. Shifts to more tolerant benthic forms may result, depending on the chemical nature of drain waters. However, sudden increases of dissolved solids in low-level waters could be fatal. Because of the expected gradual incorporation of lagoon drainage to Hat Creek, designed surge controls, and the predicted upper level, no impacts are expected. However, should a large volume of water with a unique chemical nature suddenly be discharged to Hat Creek, a severe impact could occur.

Surface run-off can be expected to result in increased suspended solid levels in Hat Creek. Fine suspended material will enter Lower Hat Creek but, as during the construction phase, concentration levels are expected to be no greater than 50 mg/ℓ. Resultant impacts are expected to be very minor or absent, unless a catastrophic failure occurs.

The effect of plant emissions, particularly sulfur dioxide, on the aquatic resources in the Hat Creek Valley is difficult to assess at the current time and will be dependent upon the results and conclusions of other study groups assessing the Hat Creek Project. Therefore, impact of this activity has been designated as ambivalent.

(iii) Decommissioning (After 2015)

Activities which will impact the Hat Creek fishery during the decommissioning phase, and specific areas in which impacts will occur are summarized below:

Mine, Plant

1) reclamation of the ash area and overall mine area (Areas A and B2);
2) erosion and drainage controls in the reclaimed plant and mine areas (Areas A and B2); and

Mine

3) filling of the mine pit (Areas A and B2).

Reclamation and erosion control are expected to have positive, beneficial impacts on Hat Creek benthos and fishes. Reclamation of land in the vicinity of the plant and mine and implementation of erosion and drainage controls on these lands should reduce the sediment load to Hat Creek during run-off. Levels of dissolved and suspended solids should be less than during construction or operation phases and limit the potential for impacts associated with chemical alterations as have been discussed in Sections (i)B and (ii)B.

Impacts on benthic communities and fishes resulting from filling of the mine pit are undefinable at this time. Nature of the impact, if any, will depend on chemical characteristics of waters within the pit. Waters too acidic or too alkaline will be unproductive for aquatic biota. Huet (in Tarzwell, 1962) stated that for fish life, it is desirable to maintain a pH between 6.5 and 8.5. McKee and Wolf (1963) reported that for best productivity, water pH should be between 6.5 and 8.2.

Based on information provided by B.C. Hydro on the mine description, water in the mine pit is expected to be highly alkaline and perhaps similar to that in Goose/Fish Hook Lake. The absence of large quantities of organic matter in the lake basin, which would decompose and lower the pH, and the naturally high pH of water in the valley (median Hat Creek pH = 8.4) would tend suggest a trend of high pH in the mine pit. In addition, the absence of any significant flushing in the pit over a 26-year period combined with normal evaporation should concentrate chemicals (high dissolved solids levels) and maintain high pH levels.

Given the potential for the "lake" waters to exhibit high dissolved solids and high pH levels after the 26-year filling period passes, the commencement of an active discharge of such water to the Lower Hat Creek system could result in a negative impact upon the benthos and fish inhabitants therein.

Slope of the mine-pit walls and the extended period of time (26 years) during which the pit is expected to be filled may result in low biological productivity. The system will generally be unstable at least until after filling has been completed. Gradual filling over the 26-year period (estimated mean increase in water depth being approximately 8 m per year) will limit colonization and the establishment of stable shoreline flora with their associated invertebrate communities and fish life. Most of the rooted shoreline flora within a given year period will probably be lost from the system as a result of rising water levels and eventual removal from the euphotic zone. This would ultimately result in a constantly changing littoral environment. Shoreline communities would be expected to initiate successional changes, with the inherent gradual increase in biomass production and overall system stability, subsequent to complete filling and stabilization of water levels.

for near pit? It will be a man-made lake, not a reservoir!

Another factor which may limit productivity in the ~~reservoir~~ PIT is the potential for this water body to act as a nutrient sink. Incoming nutrients and decomposing organic matter would probably be lost to the system and accumulate in deeper areas of the pit. Even though some of this material will probably settle on the pit benches and undergo resuspension during and after periods of filling, the amount of material present in these relatively small portions of the reservoir will probably be small compared to that lost to greater depths in open-water areas. Spring and fall turnovers resulting from thermal stratification should occur particularly after the ~~reservoir~~ PIT is filled. However, the amount of nutrients released during turnover and available to organisms establishing themselves near shore would probably be minimal.

6.0 MITIGATION & COMPENSATION

Mitigative actions which could lessen impacts discussed in the previous section are recommended below. Those measures assessed as most important are the control of water temperature, the maintenance of downstream flows and control of potential sedimentation in Lower Hat Creek.

Temperature elevations in the diversion canal should be controlled in order to avoid reaching upper lethal limits of rainbow trout in Hat Creek. This could be accomplished by inserting a deep, narrow channel within the diversion canal such that the lower range of flows (<15 CFS) would be contained therein. Establishing shade cover along the banks and withdrawal of cooler water from near bottom depths in the reservoir near Anderson Creek should also assist in controlling downstream temperatures at below lethal levels for rainbow trout.

The maintenance of downstream flow in Lower Hat Creek is difficult to discuss in the specific context of mitigation in that the project description discusses utilization of the water resource for plant use as an alternate course of action. Nevertheless, as noted in Section 5.3 (ii), a range of options regarding minimum flow requirements are available and a preliminary pattern of flow regulation is provided. The decision regarding flow that follows from this information is then directly related to whether the aquatic resources of Lower Hat Creek are degraded, maintained or enhanced.

In the event that sedimentation in Hat Creek does occur to a degree not projected within this report, certain mitigative actions require consideration. To avoid biological problems associated with sedimentation, Ellis (in McKee and Wolf, 1973) recommended the stream bottom should not be covered by more than 6.3 mm of sediment. He also recommended that to avoid sedimentation, suspended solids with a mineralogic hardness of 1 or more, and therefore of a dense nature, should be small enough to pass through a 1,000 mesh screen

($\sim<15\ \mu$). Initial mitigative steps to prevent such sedimentation problems are currently within the project description in the form of the ditching and settling pond network. Notwithstanding these existing plans, should sedimentation difficulties be experienced the appropriate mitigative action would be the reassessment of the design criteria of the settling ponds, particularly with respect to such parameters as retention time, settling rates and pond capacities. In addition, sedimentation in Lower Hat Creek would become a factor in assessing the controlled flow regime in that the re-suspension of sediment during periods of high flow could result in elevated suspended solids over a short term.

Three additional points regarding actions are noteworthy. Diversions of Hat Creek could result in the loss of most fish which presently occur within the diversion area. A portion of this resource could be harvested by the general public and construction crews, thus preventing a complete loss of existing fish life in this section of Hat Creek. Attempts may also be made to evaluate the development of the reservoir fishery and the possibility of making it available to the public. Some consideration should be given to imposing special angling regulations (size and number limits) on Upper and Lower Hat Creek if use by construction crews is intense. This may be necessary to sustain the rainbow trout fishery at acceptable yield levels.

Further evaluations should be made of expected water chemistry in the pit and the likelihood of its supporting productive aquatic resource. In the event pit waters appear supportive of aquatic biota, grading of the upper shores should be considered in order to decrease slopes and maximize the ~~euphotic~~ littoral zone. By increasing availability of this habitat, there exists a greater potential for higher productivity, more rapid successional changes and ultimately narrowing the gap between an immature and a more homeostatic lake ecosystem.

The major impact of the project for which compensation actions should be assessed is the loss of the fisheries and benthos resource in the 7,000 m section of Hat Creek alienated by the mine. A range of compensation options might be considered; examples being the establishment or enhancement of an existing fishery resource in the local area or the provision of increased access to existing but poorly accessible fisheries.

7.0 RECOMMENDED MONITORING PROGRAM

Three areas of future study are recommended. Specific to monitoring, in order to determine direction and magnitude of any potential biological disruption associated with the project, it is recommended that a monitoring program be implemented concomitant with the construction phase. Tagging studies should be initiated prior to spawning with recapture during June, July and early September supplemented by additional marking. Stations 1, 3, 5, 6, 14 and 15 should be sampled in June and early September to document fish and invertebrate populations and conditions. Comparable information should be obtained from the proposed reservoir near Anderson Creek. Efforts should also be directed to document aquatic habitat conditions, particularly with respect to possible sediment build-up below the mine site. The program should be conducted annually during the construction and start-up phases and decreased in frequency and scope thereafter if the system has achieved relative stability in the post-construction period.

Two additional field programs of a more task specific nature are recommended. These programs should commence at first available opportunity in that they reflect information needs to more definitively assess major impacts described as ambivalent in the study.

Firstly, a regional field program should be designed such that a more definitive data base is available on particularly sensitive areas. Specifically, water quality and the fauna and flora of select lakes and streams should be monitored such that baseline conditions, on a regional basis, are known. This can only be achieved with a well designed field program. Care should be taken that the frequency, spatial extent and scope of the program are in accordance with the value of the information to be obtained.

Secondly, given the interest in assessing Hat Creek as a potential water source for some of the plant system, quantitative, in-stream studies should be conducted to determine in-stream flow needs. This would allow for an objective assessment of trade-offs involved with alternate resource use.

The in-stream field studies recommended at this time would be designed and carried out in accordance with Stalneker (Fish and Wildlife Service, Colorado). Field data obtained would be processed with existing computer models. The habitat model selected would analyze depth/velocity changes with changes in flow. Output is presented on a series of matrix tables which compartmentalize the experimental reaches. Further modelling in reference to biological requirements of fish at all life stages including eggs, fry, juveniles and adults then follows.

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APPENDIX A

B2 Terms of Reference - June 1977

APPENDIX A

FISHERIES AND BENTHIC FAUNA

INVENTORY OF FISH POPULATIONS

1. Establish the species and relative number of fish in Hat Creek, especially, but not exclusively, in development area.
2. Record the basic life history data, as well as ages, growth, food, etc., of major fish species.
3. Determine fish spawning and rearing areas and general habitat and minimum flow requirements.
4. Prepare annotated (physical, biological) Thalweg curves for mainstream and tributaries of Hat Creek.
5. Establish the species and relative abundance of benthic fauna, including baseline downriver stations and diversity indices.
6. Relate relative abundance of the food to the fish present (see 1. above).
7. Provide input to Appendix C3, Section 2.

EFFECT OF DEVELOPMENT

1. Evaluate the effect of various diversion, reservoir, pondage requirements on Hat Creek fish populations.
2. Comment on the value of the pit as a future lake for fish. Suggest improvements that would enhance its value to fish populations.
3. Comment on the possible impact of increased fishing by the construction work force.
4. Estimate consequences of project impact on benthic fauna.
5. Advise on methods and possibilities to avoid, mitigate and compensate for adverse impacts of project developments on Hat Creek fishery resources.
6. Establish a range of options for compensation lying outside Hat Creek

Valley, their feasibilities, productivities (species, populations and catch) and costs.

7. Evaluate impact relative to regional and local fish values.

REGIONAL FISHERIES RESOURCES

1. Hydrology

   a) Inventory

      Prepare an inventory of the major watersheds shown on the 1/250,000 project base map. Drainage basins should be depicted graphically and an inventory of the primary streams, rivers and lakes listed.

   b) Hydrogeomorphology

      i) Classify and summarize all water bodies in terms of their pH regime (i.e. acid, neutral, alkaline), total dissolved solids, sulphates, hardness, temperature and buffering capacity.

      ii) Identify the major geological formations underlying each watershed, including geochemical data on them.

2. Regional Fisheries

   a) Inventory

      i) Provide an inventory of the regional anadromous fisheries resources for the area covered by the 1/250,000 base map.

      ii) Map the runs of anadromous fishes on the 1/250,000 and 1/50,000 base map and indicate all known spawning areas.

      iii) Map the juvenile migrations of anadromous fish and show known rearing areas (1/250,000 and 1/50,000 scale).

      iv) Describe the timing of juvenile and adult migrations in i) and ii) above for peak and 90 percent of run.

v) Describe Provincial management practices, including: seasons gear restrictions, closures, stocking and enhancement programs.

vi) Provide an inventory of the non-anadromous fishes in the region covered by the 1/250,000 and 1/50,000 base map, noting important lake and river sport fisheries.

vii) Identify known rare, endangered or threatened fish species and their distribution in the region.

b) Harvest - Sport

i) Provide a description of the regional (1/250,000) and local (1/50,000) sports fishery.

ii) Estimate the current fishery yield of the resource in i) above by evaluating Provincial creel census data, steelhead punch card results, stocking practices and other pertinent management information.

c) Harvest - Commercial

i) Summarize the commercial fishing statistics for fish populations in the Thompson River, including commercial catch for the period of record.

ii) Summarize the escapement estimates for this fishery.

iii) Summarize the catch-escapement ratio for the period of record for the species shown in i) and ii) above.

d) Harvest - Other

i) Estimate the catch and significance of subsistence fishing by Native Indians exclusive of commercial and sport landings (i.e. for tribal and ceremonial purposes, etc...).

e) Summarize, briefly, the existing stresses from natural causes, present industry and land-use practices and competition - predation by "pest" species which limit the success of the anadromous fish (1/250,000 and 1/50,000).

3. Hat Creek Valley Fishery in Regional Perspective

a) Summarize the current status of the Hat Creek Valley fishery resource (1/50,000).

b) Summarize usage estimates from available data.

c) Comment on the potential capability of the Hat Creek fishery.

APPENDIX B

Life Histories of Resident and Anadromous Fish
Occurring Within the Regional Study Area

Supplementary Tables

B1.0 LIFE HISTORIES OF RESIDENT FISH

(a) Rainbow Trout

Rainbow trout (*Salmo gairdneri*) are native to the eastern Pacific Ocean and freshwater west of the Rocky Mountains. They are probably also endemic to the Peace and Athabasca Rivers east of the Rocky Mountains. Their native range extends north from northwest Mexico to the Kuskokwin River, Alaska, but have been introduced widely throughout the world. In British Columbia, rainbow trout are present throughout the Fraser and most of the Columbia River systems (Carl *et al.*, 1973).

Distinguishing characteristics of rainbow trout (and steelhead) are the absence of a red dash under the jaw, lack of teeth at the base of the tongue, and whitish edges on dorsal, anal and pelvic fins (Scott and Crossman, 1973). Steelhead are those individuals which enter freshwater to spawn but otherwise spend their adult life at sea. Rainbow trout are those individuals which spend their entire life in freshwater. Dwarf forms of rainbow trout occur in many headwater streams in British Columbia and are often distinguished by parr marks (dark vertical markings on the sides of fish) which they retain throughout life (Carl *et al.*, 1973). Because this form was collected in Hat Creek, its general life history and not that of steelhead is presented here.

Rainbow trout are the most important sport fish in British Columbia (Carl *et al.*, 1973). They typically occur in lakes but are also common in large and small streams which exhibit moderate flows, gravel bottoms, and both pools and riffles. Spawning occurs primarily from mid-April to late June in smaller tributaries of rivers or inlets or outlet streams of lakes (Scott and Crossman, 1973). Carl *et al.*,(1973) stated that in British Columbia most fish enter streams to spawn after ice break-up in May or June. Age at spawning usually ranges from 3-5 years with males generally maturing one year younger than females. Carl *et al.*, (1973) stated that in small lakes and streams, some rainbow trout may first spawn at a length of only about 100 - 125 mm.

The spawning site is usually a bed of gravel or small rubble in a riffle, often located upstream of a pool (Scott and Crossman, 1973; Baxter and Simon, 1970). Lagler (1966) stated spawning may also occur at the tail of a pool where swift currents and clean gravel exist. The female prepares the nest or redd by turning on her side, fanning the caudal fin, and removing gravel from a pit longer and deeper than her body. The female is joined by one or several males at time of spawning, usually when water temperatures are between 10.0 and 15.5°C. Eggs and milt are released simultaneously. Eggs fall in gravel spaces and are covered by gravel displaced from the upstream edge of the redd by the female. The female may prepare and spawn in several redds, depositing from 800 to 1,000 eggs per redd. In interior British Columbia, number of eggs per female has been given as 1,366 - 2,670, but may be as low as 200 (Scott and Crossman, 1973).

Eggs hatch in about 4-7 weeks, depending on time of spawning and water temperature. Alevins become free-swimming about 3-7 days after hatching, and fry begin feeding about 1-2 weeks later. They usually emerge from the redds from mid-June to mid-August when spawning occurs in April or May (Scott and Crossman, 1973). Some fry of lake-resident adults migrate up or downstream to the lake either after emergence or by autumn, and others remain in the natal stream 1 to 3 years. Fry of stream-resident spawners may remain in tributaries during summer or begin downstream migrations shortly after emergence (Erman and Leidy, 1975).

Maximum size of rainbow trout varies widely with area and habitat. Interior forms usually weigh no more than 2.7 - 3.6 kg although Scott and Crossman (1973) reported an individual taken in Jewel Lake, British Columbia weighed 23.6 kg. Life expectancy may be as low as 3 - 4 years in stream and lake populations, but a longevity of 6-7 years is probably more representative.

Back-calculated fork lengths for various ages of rainbow trout from 27 British Columbia lakes were presented by Larkin *et al.*,(1957). Ranges presented below show the size variation which occurs within the province: age 1, 53-103 mm; age 2, 136-318 mm; age 3, 182-468 mm; age 4, 192-551 mm. Larkin *et al.*, stated that in many mountain lakes mature rainbow trout may grow no longer than 150 to 200 mm.

Rainbow trout food habits vary with size and season. Smaller fish often feed on Cladocera and aquatic insect larvae while larger fish utilize large insects, leeches, molluscs and fish (Carl *et al.*, 1973). Scott and Crossman (1973)stated that with increased fish size, diet progresses from plankton to insects and crustaceans, and then to fish. They added that in certain lakes trout reach weights of 1.8 or 2.3 kg on a diet comprised only of invertebrates.

Optimum water temperatures for rainbow trout were reported to be 21.0°C or slightly less (Scott and Crossman, 1973). Specimens occurring in cooler waters exhibited slower growth rates and a reduced maximum size. Lagler (1966) stated rainbow trout are best suited to water temperatures ranging from about 3.3°C in winter to 21.1°C in summer. He added this species may sustain water temperatures up to about 27.0°C (81°F) but only for short periods of time. Black (in Scott and Crossman, 1973) found the upper lethal temperature for rainbow trout fingerlings was 24.0°C when acclimated at a temperature of 11.0°C.

(b) Mountain Whitefish

Mountain whitefish (*Prosopium williamsoni*) occur only in western North America. In British Columbia, they have been collected from the Fraser, Okanagan, Kootenay and other river systems (Carl *et al.*, 1973; Scott and Crossman, 1973). Distinguishing characteristic of this species of salmonid are the trout-like body, large scales, large unspotted adipose fin, and narrow peduncle. Mountain whitefish are important both as a food and game fish in British Columbia. McHugh (in Scott and Crossman, 1973) stated that prior to its sale being banned in 1940, this species was sold door to door as a food fish in the province.

Mountain whitefish are present in lakes and larger rivers, preferring larger to smaller streams (Scott and Crossman, 1973). They have been recorded from turbid pools in a stream as well as from eutrophic lakes. Nelson (in Scott and Crossman, 1973) noted the adaptability of this species to changing environmental conditions (hydro-electric development) in Alberta waters.

Spawning occurs near mid-November in the Okanagan system and eggs hatch about the following March (Carl *et al.*, 1973). Fish reach sexual maturity at age 3 or 4 and spawn over gravel or rubble without constructing a redd. Brown (in Carl *et al.*, 1973) reported that in Montana, whitefish spawned at depths of 127 - 1,219 mm. Females average about 5,000 eggs per pound of body weight (Scott and Crossman, 1973). The larvae or fry remain in shallow stream areas until reaching a length of about 30 to 40 mm, then move offshore.

Scott and Crossman (1973) reported the maximum age of mountain whitefish as 17 or 18 years. McPhail and Lindsey (in Scott and Crossman, 1973) stated the world record whitefish was taken from Lardeau River, British Columbia, and had a weight of 2.0 kgm and length of 572 mm. Following is a list of total length ranges at ages 1-9 modified from Nortcote (1957) Scott and Crossman (1973): age 1, 66-135 mm; age 2, 107-224 mm; age 3, 163-297 mm; age 4, 196-328 mm; age 5, 221-330 mm; age 6, 284-358 mm; age 7, 325-391 mm; age 8, 351-417 mm; age 9, 376-442 mm. Lengths are for individuals taken from British Columbia, Alberta, Utah and California waters and illustrate the size variation over this species' range.

Mountain whitefish are primarily bottom feeders, their sub-terminal mouth making them well adapted for this type behaviour. Aquatic insect larvae comprise an important part of the diet, although whitefish have been observed feeding throughout the water column (Scott and Crossman, 1973). This species was reported by Foerster and Simon (in Scott and Crossman, 1973) to eat eggs of its own and other species. Ricker (in Scott and Crossman, 1973) found that in Cultus Lake, British Columbia, whitefish occasionally fed on small sockeye salmon. Because of similar food habits, it can compete with rainbow trout and salmon (Carl *et al.*, 1973).

(c) Brook Trout

Brook trout (*Salvelinus fontinalis*) are native to northeastern North America, but have been introduced throughout the world because of their appeal as sport fish. In British Columbia, brook trout occur in streams and lakes in the southern interior. Distinguishing characteristics of this salmonid are the red spots with blue halos and dark green marbling on the back and dorsal fin. It is a popular game fish and is reared in hatcheries for stocking in both public and private waters (Scott and Crossman, 1973; Carl *et al.*, 1973).

Brook trout occur in clear, cool, well-oxygenated lakes and streams and seek water temperatures below 20.0°C (Scott and Crossman, 1973). As temperatures increase to this point, individuals in lakes move to deeper water while those in streams migrate downriver to larger bodies of water or lakes. Carl *et al.*, (1973) reported that individuals stocked in slow-moving streams and shallow lakes in British Columbia exhibit a sluggish behaviour.

Spawning takes place during fall, usually over gravel in shallow headwater streams. Brook trout also spawn over gravel in lake shallows if a moderate current and spring upwelling exist. Sexually mature fish (usually age 3 and older) migrate upstream, males generally arriving before and in greater numbers than females. The female clears the redd of silt and debris by fanning the caudal fin. After deposition of eggs and milt, the female covers the eggs with gravel by similar fanning movements. Eggs remain in the gravel over winter and hatch the following spring. Hatching time varies from 50 days to 10.0°C to 100 days as 5.0°C. The upper lethal temperature for eggs is 11.7°C. Larvae or fry remain in the gravel until the yolk sac is absorbed and become free swimming at a length of about 38 mm (Scott and Crossman, 1973).

Brook trout seldom live longer than 5 years or grow larger than 4.5 kgm (Scott and Crossman, 1973). A 6.6 kgm specimen was caught in Nipigon River, Ontario, in 1915. Following is a list of length ranges of brook trout for various Canadian waters: age 0+, 35-45 mm; age 1+, 90-155 mm; age 2+, 130-295 mm; age 3+, 180-390 mm; age 4+, 220-440 mm; age 5+, 260-490 mm; age 6+, 300-535 mm. Lengths are expressed as approximations since raw data presented by Scott and Crossman were for standard, fork or total length depending on study location. However, the wide range in sizes for all but 0+ aged fish illustrates the variation in this species' growth rates.

Brook trout feed primarily on insects although larger individuals consume various fish species (including young brook trout and brook trout eggs), amphibians, reptiles and small mammals (Carl *et al.*, 1973; Scott and Crossman, 1973). Ricker (in Scott and Crossman, 1973) found that in Ontario brook trout fed on over 80 genera of aquatic insects with Ephemeroptera, Trichoptera, Chironomidae, and Simuliidae larvae common.

(d) Bridgelip Sucker

Bridgelip sucker (*Catostomus columbianus*) are restricted to northwestern North America. In British Columbia, they occur in the Columbia and Fraser River systems. Distinguishing characteristics of this species of sucker (family Catostomidae) are the incompletely cleft lower lip and the absence of notches at the corners of the mouth. Small bridgelip sucker may be utilized as a forage fish by economically important salmonids. Otherwise, this species has no known direct or indirect value to man (Carl *et al*, 1973);Scott and Crossman, 1973).

Bridgelip sucker generally inhabit colder waters of small, swift rivers with gravel to rocky substrates. They also occur in rivers with a slow current and mud-sand substrate, but seldom in lakes (Scott and Crossman, 1973; Carl *et al.*, (1973) concluded that in British Columbia spawning occurs in late spring, as evidenced by the collection of ripe males and females north of Prince George in early June. Scott and Crossman (1973) stated that in Idaho young attain lengths from

40-80 mm at the end of their first summer. They reported maximum lengths of bridgelip sucker range from 250-381 mm.

Food habits of bridgelip sucker apparently consist of scraping algae off rocks. Carl *et al.* (1973) stated this type of feeding behaviour is characteristic of fish with a flat mouth and sharp-edged lower jaw, long intestine, and black peritoneum, all of which are exhibited by bridgelip sucker. Scott and Crossman (1973) noted that benthic invertebrates would also be ingested while feeding in this manner.

(e) Longnose Dace

Longnose dace (*Rhinichthys cataractae*) occur across north-central North America. They are widely distributed in British Columbia and have been reported from the Thompson River drainage (Carl *et al.*, 1973). Distinguishing characteristics of this species of minnow (family Cyprinidae) are the long snout and fusion of the snout and upper lip. Scott and Crossman (1973) reported longnose dace are a seldom used bait species in Canada. Baxter and Simon (1970) stated that in the North Platte River, Wyoming, longnose dace are an important bait fish and also an important forage fish for trout. They may presumably be an important forage fish for trout in British Columbia waters.

Longnose dace are usually found in running water, although they have been reported in shore areas of large lakes (Carl *et al.*, 1973). Their presence in a stream generally characterizes it as clean and swift-flowing with a gravel to boulder substrate (Scott and Crossman, 1973). They usually occur on the bottom in riffles of both small and large streams. Their often reduced swim bladder reflects an adaptation to this type habitat (Baxter and Simon, 1970).

Spawning usually begins from May to early July and can continue into late August (Scott and Crossman, 1973). In the Nicola River drainage, British Columbia, Carl *et al.*, (1973) reported collecting ripe males and females in early June at a water temperature of 11.7°C. Males guard a territory, usually in riffles over a gravel substrate, where females spawn. McPhail and Lindsey (in Scott and

Crossman, 1973) reported that in Manitoba females deposited 200 to 1,200 adhesive eggs which hatched in 7 to 10 days at a water temperature of 15.6°C. The young absorbed the yolk sac about 7 days after hatching then rose to the surface. They remained pelagic for about 4 months, inhabiting quiet shore waters of streams, before moving to the stream bottom.

Scale analysis has shown longnose dace grow rather slowly but are relatively long-lived. Kuehn (in Scott and Crossman, 1973) reported total lengths in Minnesota waters as 48 mm at age 1, 61 mm at age 2, 74 mm at age 3, 86 mm at age 4, and 99 mm at age 5. Maximum length reported by Scott and Crossman for Manitoba and Lake Erie specimens is 124 mm.

(f) Leopard Dace

Leopard dace (*Rhinichthys falcatus*) occur in the Fraser River system and in the Columbia River basin east of the Cascades. In Canada, they have been reported only from British Columbia (Scott and Crossman, 1973). Distinguishing characteristics of this species of minnow are pelvic stays (fleshy tissue connecting inner rays of pelvic fin to body), distinct black "leopard" blotches on the body, and a protactile upper lip (Carl *et al.*, 1973). Leopard dace are of no apparent commercial importance to man, but may serve as a forage fish for larger predators such as trout.

Leopard dace generally occur in running water, but have been reported in shallows of several large lakes (Carl *et al.*, 1973). They are often found in the same river system as longnose dace, although these species exhibit different current preferences. Leopard dace prefer slow-moving water, probably less than 0.5 m/s, while longnose dace prefer swifter currents (Scott and Crossman, 1973).

Little information is available on time of spawning. Based on examination of gonads, Gee and Northcote (in Scott and Crossman, 1973) reported leopard dace probably spawn in early July. Carl *et al.* (1973) stated breeding males develop red lips in spring and some are covered with small white tubercles.

Based on length-frequency distributions, Gee and Northcote (in Scott and Crossman, 1973) presented the following age-fork length relationships for leopard dace: age 0 in August, 9-18 mm; age 1 in June, 18-36 mm; age 2 in June, 44-61 mm; age 3 in June, 60-80 mm; age 4+, 80-120 mm. They found females were heavier and slightly longer than males. Carl *et al.*, (1973) noted similarly that on the average, females were larger than males.

Leopard dace feed primarily on insects (Scott and Crossman, 1973; Carl *et al.*, 1973). Young-of-the-year utilize Diptera (Chironomidae) larvae. Yearlings feed largely on Ephemeroptera and Diptera during June and July, but switch to terrestrial insects by September. Principal foods of age 2 and older fish are aquatic (Ephemeroptera, Diptera, Plecoptera, and Trichoptera) and terrestrial insects and earthworms.

(g) Redside Shiner

Redside shiner (*Richardsonius balteatus*) are restricted to North America and are found primarily west of the Rocky Mountains (Scott and Crossman, 1973). In British Columbia, they are generally distributed in lakes and streams of the Fraser, Columbia, and Skeena systems (Carl *et al.*, 1973). Distinguishing characteristics of this minnow are the very long anal fin base and posterior location of the dorsal fin. The importance of redside shiner as food for larger sport fish in British Columbia was noted by Carl *et al.* (1973). However, they added that redside shiner and young trout may compete for the same food and that shiners may feed on trout fry.

Redside shiner spawn from May to late July or early August. Males and females apparently reach sexual maturity during their third year of life. Many individuals, particularly males, may spawn several times during the summer and up to 46 percent of these survive to spawn the following summer. Adults migrate into spawning streams when stream temperature exceeds 10.0°C and exhibit some homing tendency. Eggs are deposited in riffles over gravel or, for those individuals spawning in lakes, over submergent vegetation near shore. Hatching time varies from 15 days at a water temperature of 12.0°C to 3 days at 21.0°C.

In streams, young are carried downstream at night by currents, apparently about 10 days after hatching. They are still in a very immature stage when they reach the lake. Both young and adults exhibit schooling behaviour (Scott and Crossman, 1973).

Approximate age-fork length relationships for redside shiner during mid-summer in Sixteen Mile Lake, British Columbia are as follows: age 0, 5-10 mm; age 1, 25-55 mm; age 2, 55-70 mm; and age 4+, 110+ mm (Scott and Crossman, 1973). Maximum age was reported as probably no greater than 7 years and maximum size about 180 mm. Females were observed to grow faster and live longer than males.

Primary foods of adult redside shiner in British Columbia are aquatic and terrestrial insects, and occasionally small fish such as trout, other minnows, and other redside shiners (Carl *et al.*, 1973; Scott and Crossman, 1973). Redside shiner have also been noted to consume eggs of their own species. Food of fry includes diatoms, copepods and ostracods. Scott and Crossman stated that although redside shiner are often an important forage fish for species such as rainbow and cut-throat trout, they can be serious competitors for food and space.

B1.1 LIFE HISTORIES OF ANADROMOUS FISH

(a) Pink Salmon

Oncorhynchus gorbuscha. Adult pink salmon occur in the Pacific and Arctic Oceans, the Bering and Okhotsk Seas, and the Sea of Japan. They have been successfully introduced in the upper Great Lakes. Spawning occurs in most coastal tributaries of western North America extending from the Sacramento River, California to the Bering Sea, Alaska. In northeast Asia, spawning occurs from Peter the Great Bay north to the Lena River (Scott and Crossman, 1973).

Pink salmon are the most abundant salmon in British Columbia (Hart, 1973), and the second most abundant (after sockeye) in the Fraser River system (Department of the Environment, Fisheries and Marine Service, 1975). They spawn in most major rivers (except those along southeast Vancouver Island) and many smaller coastal streams. However, about 75 percent of the stock spawns in only 78 (or 8%) of these rivers (Carl *et al.*, 1973; Hart, 1973; Scott and Crossman, 1973).

Adult pink salmon migrate from the sea to freshwater rivers from June to September, depending on location (Scott and Crossman, 1973). Males and larger fish generally enter the river first and usually do so on high water (Hart, 1973). Spawning migrations usually extend no more than about 65 km upstream, not far from salt water, although upriver movements of about 480 km have been reported (Scott and Crossman, 1973).

Most adults exhibit homing behaviour, returning to the stream in which they were spawned. However, some have been captured in spawning streams 600 km from their parent stream (Scott and Crossman, 1973; Hart, 1973).

Spawning occurs in rivers and tributary streams from mid-July to late October. Spawning streams are usually small with medium-sized gravel substrate, although main channels of the Fraser and Yukon Rivers serve as pink salmon spawning grounds (Scott and Crossman, 1973). In the Fraser River system, pink salmon exhibit an early peak spawning run in mid-September and a late peak run in early October (Hoos and Packman, 1974).

Eggs hatch from late December to late February, depending on water temperature (Scott and Crossman, 1973; Carl *et al.*, 1973). Alevins remain in the gravel from late February to early May until the yolk sac is absorbed, then become free-swimming at a length of about 33-38 mm (Scott and Crossman, 1973).

Fry commence downstream migrations soon after leaving the redd, usually at water temperatures of 4-5°C (Wickett, 1962). During 1974, peak downstream migration in the Fraser River occurred on 5 April with the median date for duration of downstream movement on 10 April (Department of Environment, Fisheries and Marine Service, 1975). Hoos and Packman (1974) reported young in the Fraser River generally exhibit a random depth distribution during downstream migrations, although most occur nearer the surface in daylight. The downstream migration of an individual generally takes no more than 24 hours (Hoos and Packman, 1974).

Upon reaching estuarine waters, the young form large schools and are active during the day (Scott and Crossman, 1973). They remain in inshore waters during their first summer, then move to deeper, open-sea waters in September. Many young from the Fraser River spend their first summer in less saline waters near the outlet before moving further offshore (Hart, 1973). In some areas young probably disperse along the shoreline several days after completing downstream migrations.

After spending approximately 18 months at sea, pink salmon return as two-year-old spawning adults. Individuals three years of age have been reported but are uncommon (Scott and Crossman, 1973). Average weight of returning adults is about 2.2 kg and average length is from 432-483 mm (Hart, 1973; Scott and Crossman, 1973). Spawning runs in a given stream occur predictably in even or odd years. Generally, runs in northern British Columbia occur on even years. Some streams which support runs each year may have a dominant run one year and a small run the next (Scott and Crossman, 1973).

The food of pink salmon varies with fish size. The young occasionally utilize insect nymphs and larvae while in fresh water, although they spend only a short time there (Scott and Crossman, 1973). From April to June, young from the Fraser River feed primarily on copepods but by July are large enough to utilize chaetognaths, amphipoda and euphausids (Hart,1973). They also feed on young fishes such as herring, eulachon, smooth-tongue, hake, pricklebacks and gobies during their first summer (Hart, 1973). Studies by the Department of Environment, Fisheries and Marine Service (1975) showed that, in the south arm of the Fraser, young pinks feed on amphipods and harpacticoid copepods. In estuarine areas young feed on plankton and estuarine benthos. At sea, foods include euphausids, amphipods, copepods, pteropods, squid and fishes. Adults do not normally feed after entering spawning rivers (Scott and Crossman, 1973).

(b) Coho Salmon - *Oncorhynchus kisutch*.

Spawning populations of coho salmon utilize North American coastal streams from Monterey Bay, California to Point Hope, Alaska. The majority of the North American population occurs between Oregon and south-eastern Alaska. Asian populations spawn in coastal streams from the Anadyr River, U.S.S.R., south to Kokkaido, Japan. Coho salmon usually do not range far out to sea; most appear to remain within 1900 km of shore. Adults have occasionally been reported as far south as Baja, California (Hart, 1973; Scott and Crossman, 1973).

Sexual maturity usually is reached between the ages of 3 and 4 years (Hoos and Packman, 1974). Normally coho spend two summers (approximately 18 months) in the open ocean before migrating to fresh water for spawning. Occasionally males, and more infrequently females, may reach sexual maturity the first fall after migrating to salt water (age 2 years). In British Columbia, precocious individuals occur mainly in the southern spawning areas (Scott and Crossman, 1973).

Mature coho salmon leave their feeding areas in the open ocean and migrate south along the coasts of Alaska and Canada on their way to freshwater spawning areas. During this migration they grow rapidly while feeding mainly on fish (Hart, 1973). Coho salmon have a very strong tendency to return to their natal stream. Scott and Crossman (1973) reported that 85% of spawners return to their natal stream.

Before leaving salt water, coho adults usually congregate at the mouth of their natal river system. Their movement into fresh water is often triggered by the increased river flows caused by fall rains (Scott and Crossman, 1973). In the Fraser River, migrating adults enter the main stem between July and December (Department of Environment, Fisheries and Marine Service, 1975; Scott and Crossman, 1973). Escapement of migrating spawners is dependent on fishing pressure and the environmental conditions influencing survival in ocean and freshwater environments.

Coho salmon generally select smaller streams for spawning (Hart, 1973; Hoos and Packman, 1974). For this reason the Fraser River is only moderately utilized by Coho. Spawning occurs between September and March with peak spawning periods occurring from October to November and in December (Hoos and Packman, 1974).

Emergence occurs between early March and late July (Scott and Crossman, 1973). Migration to salt water may begin immediately, but more often the juveniles remain in fresh water through March or April of the follwing year.

Just prior to migration to salt water, juvenile coho become more active and form small schools. At this time they are about 10 cm in length (Scott and Crossman, 1973). Migration itself is accomplished by the juveniles (smolts) moving into swift current and being swept downstream (Hart, 1973). Often the peak migration period coincides with spring and summer freshets (Hocs and Packman, 1974).

Coho smolts generally arrive at the mouth of their natal stream in late May (Scott and Crossman, 1973). They are thought to remain in the estuary or lower river through the spring and summer before moving to open ocean feeding areas (Hoos and Packman, 1974; Scott and Crossman, 1973). Not all juveniles migrate to open ocean. Occasionally individuals remain in fresh water (Scott and Crossman, 1973). Others will take up residence in the Strait of Georgia (Hart, 1973). Both those that remain in fresh water and in the Strait of Georgia grow less than coho that migrate to the open ocean.

Larval and juvenile herring and other fishes were the important food items in terms of biomass, for juvenile coho in estuarine areas (Department of Environment, Fisheries and Marine Service, 1973).

(c) Sockeye Salmon - *Oncorhynchus nerka.*

Sockeye salmon occur throughout the north Pacific Ocean ranging from the Sacramento River, California, north to the Canadian Arctic and westward to the Sea of Okhotsk, near Japan. Sockeye abundance along the Asian coast is centered around the Kamchatka Peninsula (Hart, 1973). The primary areas of abundance of this commercially sought species range from the Columbia River to Bristol Bay, Alaska, with the heaviest concentrations centered around the Fraser River in British Columbia (Hart, 1973).

Adult sockeye salmon migrate eastward over the continental shelf toward British Columbia during the summer months (Hart, 1973). The time of arrival at the estuary or river mouth is related to the distance upriver which must be travelled. Generally early arrivals will migrate further upriver to spawn (Scott and Crossman, 1973). Verhoeven and Davidoff (1962) discovered from adult sockeye tagging studies, that the principal migration extends through the Strait of Juan de Fuca past Salmon Banks, South Lopez, Rosario Strait, Lummi Island and on to Point Roberts.

Sockeye stocks originating from British Columbia normally reside somewhat more than one year in fresh water and 2 or more years in salt water (Hart, 1973). The average lifespan is composed of four summers in salt water and two winters in fresh water (Carl, 1973; Hart, 1973; Ricker, 1950). However, precocious males or "jacks" may return to their natal streams after three years (Carl, 1973). Sockeye demonstrate a cyclic dominance in the Fraser River, yielding dominant (every fourth year) and subdominant years (Ricker, 1950).

The prespawning migration in the Fraser River first occurs during early July, when fish move immediately into fresh water and quickly upstream. Later runs of sockeye appear in early August, delay at the river mouth from 19-34 days, and proceeed slowly upstream (Hoos and Packman, 1974; Verhoeven and Davidoff, 1962). Time of entry into the Fraser River"...varies between years, between cycle years, between races within a cycle year, and between cycle years within a particular race" (Hoos and Packman, 1974, p. 108). Typically, mature fish enter fresh water and arrive near their natal stream in early summer and remain until fall when spawning occurs (Carl *et al*, 1973; Scott and Crossman, 1973).

The presence of a lake is generally a requisite for successful sockeye spawning and rearing. Most fish spawn in tributaries to a lake, however, some fish may spawn on the lake's shoreline or in the lake's outlet. Occasionally they will spawn in systems without lakes (Hart, 1973; Scott and Crossman, 1973); however, sockeye do not spawn in the Fraser River mainstem.

After emergence, the fry proceed to the lake where they are found principally along the shoreline (Hart, 1973). Young sockeye in lakes consume zooplankton and insect larvae. Predators of young sockeye include rainbow trout, coho salmon, Dolly Varden, char, squawfish, and the prickly sculpin (Hart, 1973).

Downstream migration occurs in the spring when the sockeye have obtained lengths ranging from 6.0 to 9.5 cm (Hart, 1973; Scott and Crossman, 1973). Downstream migration occurs both day and night in the turbid waters of the Fraser (Hoos and Packman, 1974). Sockeye salmon smolts remain in brackish and water during the early summer. During this period food consists of various insects, crustaceans, and larval and young fish such as the sand lance, eulachon, hake, herring, pricklebacks, starry flounder, big eye whiting and rockfishes (Hart, 1973).

(d) Chinook Salmon - *Oncorhynchus tshawytscha.*

Adult chinook salmon occur in the Pacific Ocean, in the Bering and Okhotsk Seas, the Sea of Japan, and rarely, in the Arctic Ocean (Scott and Crossman, 1973). Chinook are anadromous in large rivers flowing into these seas. Young and spawning adults range from southern California's Ventura River through Oregon, Washington and British Columbia (Hart, 1973). In British Columbia, chinook salmon ascend all major streams including migration up the Yukon River to spawn in tributaries of Bennett and Teslin Lakes (Carl *et al.*, 1973). Chinook adults appear in certain British Columbia rivers in August and September, and egg deposition occurs during October and November (Carl *et al.*, 1973). They spawn either immediately above the tidal limit or migrate hundreds of miles upriver (Hart, 1973).

Generally, runs in more northerly rivers occur earlier. However, chinook appear off the mouth of the Fraser River as early as January and their run reaches a maximum in August and September. Spawning time varies with time of arrival at the river mouth, area, and length of river migration (as much as 960 km in the Fraser River). Spawning occurs in the Fraser River system from July to November (Scott and Crossman, 1973). Several runs are recognized in the Fraser River system (Hoos and Packman, 1973) each of which represents a run to a Fraser tributary or group of tributaries. Chinook utilize about 260 British Columbia streams but 50% of the production comes from only 14 streams, one of which is the Fraser River (Scott and Crossman, 1973).

Usually young chinook migrate to sea soon after hatching, however, they may remain one or two years in fresh water. Young chinook salmon are found off the mouth of the Fraser River from April on. There they are 4 to 5 centimeters long in April, 9 centimeters in June, and 13 centimeters by July (Hart, 1973). Food at this stage was found to include herring, sand lance, eulachon, zooplankton, insects and crustaceans (Hart, 1973).

Chinook migrate northwest along the coast before returning to spawning steams (Hart, 1973). The major growth takes place in the sea, the fish becoming mature in three to seven years (Carl *et al.*, 1973). In Canada, most chinook spend 2 - 3 years in the sea but spawning adults have been found as old as 9 years (Scott and Crossman, 1973). Fish make up the bulk (97%) of adult food in the ocean. Herring and sand lace are the most frequently eaten fish (Scott and Crossman, 1973).

(f) Steelhead - *Salmo gairdneri*

Steelhead is the anadromous form of rainbow trout. Rainbow trout originally occurred only in North America, mainly west of the Rocky Mountains from extreme northern Baja California, to the Kickokwim River, Alaska (Scott and Crossman, 1973). It has been introduced throughout North America as well as in many other parts of the world (Hart, 1973; Scott and Crossman, 1973). Steelhead occur in coastal streams and rivers from northern California to Alaska (Smith, 1969). Steelhead have been observed as far out to sea as 150 w longitude (Hart, 1973). A typical river system in British Columbia could be expected to contain both resident rainbow trout and steelhead (Scott and Crossman, 1973).

While in salt water, steelhead adults feed mainly on fish and various crustaceans (Hart, 1973). Ocean life may last a few months to several years (Hoos and Packman, 1974). Sexual maturity is usally reached between 4 and 6 years of age (Carl *et al.*, 1973). In the Fraser River, two distinct spawning runs of steelhead exist, a summer run entering the river between June and September and a winte run entering between November and April (Hoos and Packmar, 1974). Both runs spawn in the spring. Tendencies toward summer and winter spawning runs appear to be inherited and are found in many river (Hart, 1973). Generally the summer run of steelhead will move farther up a river system to spawn than winter run steelhead. Summer run fish usually are not sexually mature when they enter a river, while winter run fish are mature (Smith, 1969). Rainbow trout (including steelhead) mainly spawn in small tributaries of rivers, and inlet or outlet streams of lakes (Hart, 1973). Unlike Pacific salmon, steelhead occasionally survive spawning. Hoos and Packman (1974) reported that approximately 10 percent survive spawning to spawn a second time. They also reported that less than 1 percent survive to spawn a third time.

Migration of juveniles to sea generally occurs during spring freshets (Hoos and Packman, 1974). Before moving out to sea, young steelhead are thought be remain near the mouth of their natal river (Hoos and Packman, 1974). Young steelhead occur in the Strait of Georgia off the outlet of the Fraser River and in Saanich Inlet (Hart, 1973). In June these fish were feeding on insects, euphausids, copepods, amphipods and other crustaceans, and young fish such as sand lance, herring, eulachon, red devil, searcher and smooth tongue.

In Canada and the United States the steelhead is considered a sport fish. Indians in British Columbia harvest steelhead commercially (Hoos and Packman, 1974). Hoos and Packman (1974) also reported that steelhead are taken incidentally while gillnetting for salmon at the Fraser River mouth and upstream near Mission City. They also reported that Indians fishing the Fraser River and Howe Sound area (including the Squamish system)harvested between 3875 (1965) and 1510 (1969) steelhead. Steelhead are pursued by sportsmen in many coastal and tributary streams. The Indian commercial catch of steelhead has been declining since 1960 and sport catches have been declining since 1966 (Hoos and Packman, 1974).

TABLE B-1

ESTIMATED NUMBER OF ANGLER DAYS LISTED BY MANAGEMENT UNIT

SPENT ON LAKES IN THE STUDY REGION IN 1976

Lake	Angler Days
Management Unit 3-12	
Bolis	1,000
Brenda	2,628
Corbette	2,500
Courtney	10,000
Douglas	2,000
Ellen	1,000
Hatheume	5,000
Jackson	5,000
Loon	40,000
Lundbom	10,500
Marquart	200
Mellin	1,000
Minnie	5,000
Penask	30,000
Pinnacle	3,000
Pothole	1,000
Rat	1,000
Reservoir	1,000
Rock	1,000
Skunk	1,000
Total Angler Days	123,828
Number Lakes Fished	20
Management Unit 3-13	
Edna	1,500
Gillis	2,000
Gwen	2,500
Harmon	5,000
Kane (left)	4,000
Kane (right)	4,000
Lily	5,000
Murray	6,000
Shea	3,000
Total Angler Days	33,000
Number Lakes Fished	9

Lake	Angler Days
Management Unit 3-14	
Fishblue	10,000
Total Angler Days	10,000
Number Lakes Fished	1
Management Unit 3-15	
Frances	1,000
Hannah	1,000
Kwoiek	300
Nahatlach	1,500
Stein	100
Total Angler Days	4,800
Number Lakes Fished	5
Management Unit 3-16	
Duffey	5,000
Gates	500
Seton	500
Total Angler Days	6,000
Number Lakes Fished	3
Management Unit 3-17	
Alkali	1,000
Blue Earth	1,200
Botanie	1,000
Crown	6,000
Kwotlenemo	10,000
Langley	1,000
Leighwood	2,000
McLean	150
Pasulko	50

TABLE B-1 Cont'd.

ESTIMATED NUMBER OF ANGLER DAYS LISTED BY MANAGEMENT UNIT

SPENT ON LAKES IN THE STUDY REGION IN 1976

Lake	Angler Days
Management Unit 3-17 Cont'd.	
Pavillion	10,000
Turnip	100
Turquoise	6,000
Total Angler Days	38,500
Number Lakes Fished	12
Management Unit 3-18	
Abbott	1,000
Antler	2,000
Barnes	6,000
Big Divide	1,000
Billy	1,000
Bose	5,000
Chataway	3,500
Dot	1,000
Earnes	600
Gordon	5,000
Gump	500
Gypsum	1,000
Leighton	10,000
Mamit	1,000
O.K.	50
Pimainus	1,500
Quiltanton	1,000
Roscoe	1,000
Tunkwa	30,000
Twentyfour Mile	1,000
Tynes	1,000
Total Angler Days	74,150
Number Lakes Fished	21

Lake	Angler Days
Management Unit 3-19	
Chewhels	1,500
Dairy	2,000
Duffy	7,000
Face	7,000
Frogmoore	2,000
Hull	1,000
Jacko	8,000
Lac le Jeune	30,000
Mab	1,000
McConnel	8,000
Mildred	2,000
Nicola	10,000
Norman	1,000
Paska	7,000
Pat	5,000
Rey	1,000
Russ Moore	2,000
Stake	8,000
Surrey	4,000
Sussex	4,000
Walloper	8,000
Wyse	1,000
Total Angler Days	120,500
Number Lakes Fished	22
Management Unit 3-20	
Black	3,000
Blackwell	2,000
Bleeker	50
Ernest	4,000
Frisker	4,000

TABLE B-1 Cont'd.

ESTIMATED NUMBER OF ANGLER DAYS LISTED BY MANAGEMENT UNIT

SPENT ON LAKES IN THE STUDY REGION IN 1976

Lake	Angler Days
Management Unit 3-20 Cont'd.	
Glimpse	8,000
Hosli	2,000
John Frank	4,000
McGlashan	2,000
Peter Hope	5,000
Plateau	6,000
Pratt	2,000
Roche	25,000
Shumway	50
Smith	1,000
Stump	2,000
Todd	2,000
Trapp	4,000
Total Angler Days	76,100
Number Lakes Fished	18
Managment Unit 3-27	
Andy	1,000
Badger	5,000
Community	1,500
Devick	1,000
Heffley	5,000
Knouff	8,000
Little Badger	1,000
Little Heffley	4,000
Paul	15,000
Pinanton	6,000
Spooney	3,000
Sullivan	1,000
Total Angler Days	51,500
Number Lakes Fished	12

Lake	Angler Days
Management Unit 3-28	
Beaugard	500
Black	1,000
Couture	1,000
Disappointment	1,000
Gorman	2,000
Hoover	1,000
Mulholland	2,000
Noble	1,000
Scott	500
Smith	2,000
Thuya	4,000
Whitewood	1,500
Windy	1,000
Total Angler Days	18,500
Number Lakes Fished	13
Management Unit 3-29	
Bare	6,000
Deadman	150
Elbow	500
Fatox	5,000
Hiahkwah	1,000
Horsepasture	500
Kamloops	1,000
Last Course	1,500
Moose	500
Mowich	500
Pass	1,000
Red	5,000
Saul	1,000
Shelly	1,000
Snchoosh	500

TABLE B-1 Cont'd.

ESTIMATED NUMBER OF ANGLER DAYS LISTED BY MANAGEMENT UNIT

SPENT ON LAKES IN THE STUDY REGION IN 1976

Lake	Angler Days
Management Unit 3-29 Cont'd.	
Tranquille	4,000
Tsinisunko	1,000
Vidette	1,000
Willow Grouse	2,000
Total Angler Days	33,150
Number Lakes Fished	19
Management Unit 3-30	
Belcache	500
Bonaparte	2,000
Bridge	4,000
Caverhill	1,500
Crystal	2,000
Dagger	1,000
Dewey	1,000
Dumbel	1,000
Egan	1,000
Frankie	1,000
Frogpond	1,500
Grant	1,500
Hammer	5,000
Hihium	5,000
Hoopatatkwa	5,000
Keith	1,000
Lac des Roche	1,000
Machete	2,000
Martha	1,500
Mayson	1,000
Norma	1,000
Osprey	1,500
Phinetta	500
Pinerock	500
Pothole	1,000

Lake	Angler Days
Management Unit 3-30 Cont'd.	
Pressy	500
Renee	1,000
Siam	1,000
Six Mile	500
Snake	1,000
Stinking	1,000
Summit	1,000
Twin	1,000
Wavey	1,000
Willow	1,000
Young	2,000
Total Angler Days	55,000
Number Lakes Fished	36
Management Unit 3-31	
Beaverdam	4,000
Big Bar	4,000
Meadow	1,500
Poison	250
Ridge	1,000
Total Angler Days	10,750
Number Lakes Fished	5
Management Unit 3-33	
Carpenter	1,000
Total Angler Days	1,000
Number Lakes Fished	1

TABLE B-1 Cont'd.

ESTIMATED NUMBER OF ANGLER DAYS LISTED BY MANAGEMENT UNIT

SPENT ON LAKES IN THE STUDY REGION IN 1976

Lake	Angler Days
Management Unit 3-38	
Dunn	1,500
Genier	5,000
Hallamore	1,000
McTaggart (N)	1,000
McTaggart (S)	1,000
Total Angler Days	9,500
Number Lakes Fished	5
Management Unit 3-39	
Crater	150
Deer	150
Emar	5,000
Epdee	5,000
Fourteen Mile	450
Friendly	1,500
Goose	1,500
Grizzley	5,000

Lake	Angler Days
Management Unit 3-39 Cont'd.	
Hardcastle	1,500
Latremouille	2,000
Lemieux	450
Lolo	500
Long Island	2,000
Lost	3,000
Lost Horse	3,000
Lynn	1,000
Meadow	2,000
Moose	5,000
Moosehead	3,000
Rock Island	2,000
Silver	900
Sock	5,000
Star	1,000
Surprise	5,000
Tintlhohtan	3,000
Tsotin	1,000
Total Angler Days	60,100
Number Lakes Fished	26

From: B.C. Ministry of Recreation & Conservation, Fish & Wildlife Branch 1977a.

TABLE B-2

FISH STOCKING RECORDS OF LAKES IN THE REGIONAL STUDY AREA[1]

Lake	Species[2]	First Year Stocked	Last Year Stocked	Average Last Ten Years[3]	No. Years Stocked
Alkali Lks.	BT (RT)	1956	1974	870	16
Andy	RT	1935	1952	0	9
Badger	RT	1932	1975	13,086	16
Barnes	RT	1970	1975	10,495	5
Beaverdam	RT, BT	1943	1974	9,890	21
Big Bar	RT	1926	1975	11,870	17
Black	RT, BT	1938	1974	1,780	6
Blackwell	RT	1962	1969	0	5
Bleeker	RT	1969	1975	2,964	6
Blue Earth	RT	1960	1975	2,000	13
Bob	RT	1954	1969	0	4
Bose	RT	1965	1975	3,030	10
Botanie	RT	1962	1962	0	2
Boyer	RT	1962	1964	0	2
Brenda	RT	1941	1975	2,628	22
Bridge	RT	1929	1962	9	25
Brigade	RT	1929	1936	0	2
Brown	RT	1968	1969	0	2
Bull	RT	1966	1968	0	3
Calling	RT	1932	1932	0	1
Campbell	RT	1911	1957	0	5
Carpenter	KOK, RT	1950	1971	38,936	4
Caverhill	RT.(KOK)	1949	1952	0	7
Community	RT	1924	1975	3,750	8
Corbette	RT (BT)	1952	1975	10,234	37
Cougar	RT	1932	1932	0	1
Courtney	RT	1948	1975	12,180	27
Crater	RT	1946	1972	609	33
Crescent	RT	1939	1975	0	6
Crown	RT	1936	1974	3,598	36
Crystal	RT	1936	1975	8,535	26
Curry	RT	1937	1937	0	1
Dairy Lks.	RT (BT)	1940	1975	3,782	24
Dardenalles	RT	1960	1960	0	1
Deadman	RT	1941	1975	400	5
Desmond	RT	1957	1958	0	2
Devick	RT	1934	1954	0	18

TABLE B-2 Cont'd.

FISH STOCKING RECORDS OF LAKES IN THE REGIONAL STUDY AREA[1]

Lake	Species[2]	First Year Stocked	Last Year Stocked	Average Last Ten Years[3]	No. Years Stocked
Dewey	RT	1950	1951	0	2
Dominic	RT	1938	1975	3,360	11
Dorothy	RT	1961	1961	0	1
Dot	RT	1963	1975	2,528	11
Douglas	RT	1937	1937	0	1
Duffy	RT	1947	1975	9,615	20
Dunn	RT	1939	1964	0	5
Edith	RT, BT	1950	1965	0	2
Edna	RT, BT	1925	1974	2,848	8
Elbow	RT	1946	1975	3,888	12
Ellen	RT	1949	1949	0	1
Emar	RT	1968	1969	0	2
Ernest	RT	1952	1975	0	2
Face	RT	1961	1961	0	1
Farr	RT	1962	1962	0	1
Fatox	RT	1960	1961	0	2
Finney	BT	1961	1961	0	1
Fishblue	RT (ST)	1939	1972	1,452	12
Fourteen Mile	RT	1967	1969	0	3
Friendly	RT	1915	1970	0	7
Frisken	RT	1967	1975	3,072	9
Frogmoore Lks.	RT	1927	1927	0	1
Garcia	RT (CT,BT)	1938	1970	0	20
Gates	RT (AT)	1921	1974	4,022	10
Genier Lks.	RT	1937	1975	8,068	32
Gillis	RT	1944	1975	5,136	14
Glimpse	RT	1929	1975	10,932	27
Goose	RT (BT)	1955	1975	0	26
Gordon	RT	1950	1975	0	25
Gorman	RT	1969	1975	2,688	7
Griffin	RT (BT)	1928	1972	0	12
Grizzley Lks.	RT	1947	1968	0	4
Gwen	RT	1962	1969	0	5
Gypsum	RT	1966	1975	1,104	5
Hallamore	RT	1953	1953	0	1
Hammer	RT	1960	1975	3,124	17

TABLE B-2 Cont'd.

FISH STOCKING RECORDS OF LAKES IN THE REGIONAL STUDY AREA[1]

Lake	Species[2]	First Year Stocked	Last Year Stocked	Average Last Ten Years[3]	No. Years Stocked
Hannah	RT	1940	1940	0	1
Hardcastle	RT	1952	1967	0	6
Harmon	RT	1945	1975	10,680	23
Hatheume	RT	1928	1975	13,600	19
Heffley	RT	1947	1975	44,660	25
Hensell	RT	1949	1949	0	1
Hihium	RT	1973	1975	7,430	3
Hoopatatkwa	RT	1949	1949	0	1
Horseshoe	RT	1968	1968	0	1
Hosli	RT	1971	1975	2,020	3
Hull	RT	1939	1939	0	1
Jacko	RT	1954	1975	26,374	25
Jacks	RT	1964	1972	1,081	9
Jackson	RT	1931	1975	4,407	26
John Frank	RT	1970	1975	2,172	4
Kamloops	RT	1946	1956	0	9
Kane (Left)	RT	1945	1975	8,010	13
Kane (Right)	RT	1945	1975	0	13
Knife Lks.	RT	1960	1960	0	1
Knouff	RT	1930	1975	22,916	44
Kullagh	RT	1937	1937	0	1
Kwotlenemo	RT	1940	1954	3,956	8
Lac Du Bois	RT	1951	1951	0	1
Lac Le Jeune	RT	1937	1941	24,178	2
Last Course	RT	1962	1963	0	2
Latremouille	RT	1935	1954	0	10
Leighton	RT	1939	1975	18,520	23
Leighwood	BT	1962	1970	0	40
Lemieux	RT	1957	1957	516	1
Little Badger	RT	1938	1941	0	2
Lodge Pole	RT	1936	1957	0	5
Lolo	RT	1960	1975	2,160	7
Long Island	RT	1956	1957	0	2
Loon[4]	RT (BT)	1931	1958	0	9
Lost	RT	1960	1969	0	5
Lundbom	RT	1961	1975	5,532	12
Lynn	RT	1955	1975	9,080	20
Mab	RT	1923	1923	0	1

TABLE B-2 Cont'd.

FISH STOCKING RECORDS OF LAKES IN THE REGIONAL STUDY AREA[1]

Lake	Species[2]	First Year Stocked	Last Year Stocked	Average Last Ten Years[3]	No. Years Stocked
Mabel	RT	1941	1952	0	10
Machete	RT	1937	1955	0	5
Marquart	RT (BT)	1962	1970	0	4
Marsh	RT	1960	1963	0	4
McConnell	RT	1935	1975	10,903	37
McGlashan	RT (BT)	1941	1975	5,340	9
McLeod	BT, CT	1911	1965	0	2
Meadow	BT	1960	1960	0	1
Meadow	RT	1930	1957	0	3
Mellin	RT	1963	1974	1,904	7
Mildred	RT	1936	1936	0	1
Minnie	RT	1932	1975	20,632	20
Montana	RT	1939	1952	0	3
Moose	RT	1929	1968	0	6
Morgan	RT	1950	1952	0	3
Mowich	RT	1952	1955	0	4
Murray	RT	1939	1975	0	18
Napier	RT	1923	1923	0	1
Nesbitt	CT	1931	1931	0	1
Neveu	RT	1928	1951	0	14
Nicola	RT	1941	1957	0	8
Noble	RT	1955	1975	1,643	20
Norma	RT	1962	1962	0	1
O.K.	RT	1968	1975	1,718	6
Paska	RT	1929	1929	0	1
Pass	RT	1946	1975	5,687	18
Pasulko	RT	1960	1974	396	3
Paul	RT (AT,LT,BT)	1909	1975	59,642	64
Pavillion	RT	1930	1975	49,188	49
Peel	RT	1961	1961	0	1
Pefferle	RT	1929	1968	0	7
Pennask	RT	1929	1952	0	16
Pennie	RT	1961	1971	528	6
Peter Hope	RT	1932	1975	22,864	29
Phinetta	RT	1972	1975	2,540	5
Pinantan	RT	1908	1075	16,680	58
Pinnacle	RT	1962	1975	0	7
Plateau	RT	1940	1975	7,516	11

TABLE B-2 Cont'd.

FISH STOCKING RECORDS OF LAKES IN THE REGIONAL STUDY AREA[1]

Lake	Species[2]	First Year Stocked	Last Year Stocked	Average Last Ten Years[3]	No. Years Stocked
Poison	RT	1965	1975	5,232	5
Pothole	RT	1936	1941	0	4
Powder	RT	1975	1975	0	1
Pratt	RT	1962	1975	500	5
Pressy	RT	1940	1944	0	4
Rat	RT	1963	1963	0	1
Red	BT (RT)	1935	1974	4,747	13
Rey	RT	1954	1956	0	3
Roche	RT	1952	1975	35,629	13
Rock	RT	1923	1973	0	15
Rose	RT	1946	1975	0	8
Ross	RT	1942	1969	1,692	13
Rouse	RT	1934	1937	0	4
Sabiston	RT	1962	1970	0	5
Saul	RT	1925	1969	0	5
Scheidam	RT	1963	1964	0	2
Scuitto	RT	1925	1942	0	5
Seton	KOK	1951	1951	0	1
Sharpe	RT	1953	1965	0	6
Shea	RT	1945	1975	3,640	20
Shumway	BT	1967	1970	0	3
Six Mile	RT (BT)	1940	1975	1,330	23
Skinhead	RT	1962	1966	0	3
Smith[5]	BT, RT	1940	1969	0	5
Sock	RT	1950	1951	0	2
Sophia	RT	1968	1969	0	2
Spectacle	RT	1954	1959	0	5
Stake	RT	1938	1975	10,903	31
Star	RT	1968	1975	11,268	7
Steer	RT	1928	1928	0	1
Stuart	BT	1974	1975	0	2
Stump	RT (CT)	1911	1975	82,078	38
Surrey	RT	1940	1963	0	2
Tintlhohtan	RT	1951	1969	0	10
Todd	RT	1962	1975	2,020	9
Tranquille	RT (KOK)	1923	1940	0	7
Trapp	BT	1967	1975	5,368	3

TABLE B-2 Cont'd.

FISH STOCKING RECORDS OF LAKES IN THE REGIONAL STUDY AREA[1]

Lake	Species[2]	First Year Stocked	Last Year Stocked	Average Last Ten Years[3]	No. Years Stocked
Tsotin		NOT IN RECORDS		1,782	
Tunkwa	RT	1939	1975	34,187	37
Turquois	RT	1945	1975	3,870	26
Tyner	RT	1960	1975	2,528	12
Vidette	RT (KOK)	1952	1975	6,344	7
Walloper	RT	1932	1975	10,862	24
Wasley	RT	1949	1949	0	1
White	LT	1909	1909	0	1
Whitewood	RT	1962	1964	0	3
Willow Grouse	RT	1950	1951	0	2
Windy	RT	1967	1975	0	2
Young	RT	1953	1967	0	4

Source: Fish and Wildlife Branch (1976b, 1977a)

Footnotes:

1 Lakes not stocked are not listed

2 Species:
- RT = rainbow trout
- BT = brook trout
- KOK = kokanee
- ST = steelhead
- CT = cutthroat trout
- AT = atlantic salmon
- LT = lake trout
- () = occassional stockings only

3 Stocking rate is in numbers of fish (the size of fish is measured by number of fish per lb). For the purpose of averaging, fish were converted to the 50 fish/lb. size. That is the size with which Fish and Wildlife Branch can most comfortably predict the survival rate of stocked fish i.e. 50%.

4 Loon Lake refers to Loon Lake in management unit 3-12

5 Smith Lake refers to Smith Lake in management unit 3-20

APPENDIX C

Basic Physiognomy of Benthos and Fisheries Sampling Stations

Station 1 - Bonaparte River

Substrate:	10% boulder, 80% pebble, 10% gravel.
Banks:	Left facing downstream - cliff, unstable at base, some deciduous brush, right facing downstream - sand and pebble with interspersed deciduous brush, stable.
DepthL	0.3 - 1.3 m
Width:	10.6 m
Pool:Riffle:	10%:90%
Current:	Very fast, white water (torrential), surface current 1.9 m/s in June and 1.5 m/s in August.
Temperature:	14.0°C at 1400 hr. on 18 September 1976, and 15.0°C at 1500 hr. on 30 September 1976; 13.7°C at 0740 hr. on 14 June 1977; 22.0°C at 1245 hr. on 3 August 1977.
Notes:	Current too swift and water too deep for actual depth, width and current measurements along a transect; biological sampling conducted within approximately 1.5 m of shore. Water level in June about 7.6 cm higher than in September and in August about 2.5 cm lower than in September.

Station 2 - Bonaparte River

Substrate:	5% pebble, 90% gravel, 5% sand-silt.
Banks:	Grass, stable. Some deciduous brush. Some under-cutting on river bends.
Depth:	0.1 - 0.5 m

Width:	32.3 m
Pool:Riffle:	5%:95%
Current:	<0.3 - 1.3 m/s in September; surface current 1.8 m/s in June and 1.5 m/s in August.
Temperature:	14.5°C at 1530 hr. on 18 September 1976 and 12.0°C at 0930 hr. on 30 September 1976; 13.7°C at 1030 hr. on 14 June 1977; 18.5°C at 0745 hr. on 4 August 1977.
Notes:	Logs had been moved from mid-stream to shore areas by the August survey and resulted in more riffles and fewer pools.

Station 3 - Bonaparte River

Substrate:	5% pebble, 90% gravel, 5% sand-silt.
Banks:	Left facing downstream - sand to pebble, grass and shrubs, unstable; right facing downstream - grass, stable with some under-cutting.
Depth:	0.1 - 0.7 m
Width:	26.0 m
Pool:Riffle:	5%:95%
Current:	0.06 - 1.1 m/s in September; surface current 1.3 m/s in June and 1.5 m/s in August.
Temperature:	14.5°C at 1730 hr. on 17 September 1976 and 12.0°C at 1130 hr. on 30 September 1976; 16.4°C at 1530 hr. on 14 June 1977; 18.0°C at 1040 hr. on 3 August 1977.

Station 4 - Bonaparte River

Substrate:	10% pebble, 80% gravel, 10% sand-silt.
Banks:	Grass and bush, unstable on right bank facing downstream.
Depth:	0.3 - 1.2 m

Width: 13.4 m
Pool:Riffle: 10%:90%
Current: 0.1 - 1.1 m/s in September; surface current 1.5 m/s in June and 1.2 m/s in August.
Temperature: 11.0°C at 1000 hr. on 16 September 1976; 14.0°C at 1400 hr. on 30 September 1976; 15.4°C at 1315 hr. on 14 June 1977; 17.5°C at 0915 hr. on 3 August 1977.

Notes: Water level in June about 5.1 cm higher than in September and in August about the same as in September.

Station 5 - Hat Creek

Substrate: 60% pebble, 30% gravel, 10% sand-silt.
Banks: Left facing downstream - grass, undercut and unstable; right facing downstream - grass, unstable.
Depth: 0.03 - 0.4 m
Width: 4.6 m
Pool:Riffle: 10%:90%
Current: 0.09 - 0.4 m/s in September; surface current C.8 m/s in June and 0.3 m/s in August.
Temperature: 12.0°C at 1800 hr. on 29 September 1976; 17.1°C at 1730 hr. on 14 June 1977; 24.0°C at 1520 hr. on 3 August 1977.

Notes: Water level in June similar to that in September and in August about 10.2 cm lower than in September. Green algae rooted aquatic plants and some silting (particularly in June and August) observed during each survey.

Station 6 - Hat Creek

Substrate: 5% boulder, 75% pebble, 20% gravel.

Banks:	Grass and shrubs, stable.
Depth:	0.03 - 0.3 m
Wdith:	7.0 m
Pool:Riffle:	10%:90%
Current:	<0.03 - 1.1 m/s in September; surface current 0.9 m/s in June and 0.4 m/s in August.
Temperature:	11.0°C at 1630 hr. on 29 September 1976; 10.1°C at 0750 hr. on 16 June 1977; 20.0°C at 0900 hr. on 3 August 1977.
Notes:	About 50% of the bottom was covered by algae.

Station 7 - Hat Creek

Substrate:	75% pebble, 20% gravel, 5% sand-silt.
Banks:	Trees and grass, stable.
Depth:	0.03 - 0.8 m.
Width:	6.4 m
Pool:Riffle:	60%:40%
Current:	<0.03 - 0.3 m/s in September; surface current 0.7 m/s in June and 0.4 m/s in August.
Temperature:	12.0°C at 1730 hr. on 16 September 1976; 12.0°C at 1230 hr. on 28 September 1976; 10.2°C at 0755 hr. on 15 June 1977; 13.5°C at 1145 hr. on 5 August 1977.
Notes:	Fisheries sampling included areas upstream, within and downstream of this site with a pool:riffle ratio of about 20%:80%. Water level in June similar to that in September and in August about 15.2 cm lower than in September. Algae similar to that at Station 6 observed in June.

Station 8 - Unnamed Creek

Substrate:	Varied from sand to small pebble, some detritus.
Banks:	Left facing downstream - sand to pebble; right facing downstream - grass and brush; banks stable except for some signs of livestock.
Depth:	5.1 - 15.2 cm
Width:	0.9 m
Pool:Riffle:	0%:100%
Current:	Sluggish.
Temperature:	8.9°C at 0830 hr. on 17 September 1976; 9.8°C at 0845 hr. on 15 June 1977; 14.0°C at 1245 hr. on 5 August 1977.

Station 9 - Finney Creek

Lower Finney Creek was not observed. It apparently flows underground upstream of its confluence with Hat Creek.

Station 10 - Hat Creek

Substrate:	10% boulder, 80% pebble, 5% gravel, 5% sand-silt.
Banks:	Grass, shrubs and trees, stable except for small area where bank in steep.
Depth:	0.03 - 0.6 m
Width:	4.6 m
Pool:Riffle:	10%:90%
Current:	<0.03 - 0.9 m/s in September; surface current 1.0 m/s in June and 0.4 m/s in August.
Temperature:	11.0°C at 1600 hr. on 28 September 1976; 11.2°C at 1040 hr. on 16 June 1977
Notes:	Fisheries sampling included areas upstream, within and

downstream of this site with a pool:riffle ratio of about 30%:70%.

Station 11 - Medicine Creek

Substrate:	Sand to small pebble, some algae.
Banks:	Grass and brush, stable.
Depth:	5.1 - 7.6 cm
Width:	1.5 m
Pool:Riffle:	0%:100%
Current:	Sluggish to rapid, but with no pools in area sampled.
Temperature:	8.1°C at 1000 hr. on 17 September 1976; 13.5°C at 1000 hr. on 16 June 1977; no data in August.

Notes: Barrier about 2 m high located about 10 m upstream from Medicine Creek mouth.

Station 12 - Ambusten Creek

Substrate:	Sand to large pebble, some detritus.
Banks:	Grass and brush, stable.
Depth:	2.5 - 12.7 cm
Width:	0.9 m
Pool:Riffle:	0%:100%
Current:	Rapid, but with no pools in area sampled.
Temperature:	7.7°C at 1700 hr. on 17 September 1976.

Notes: Drops from its bed about 0.9 - 1.2 m to the confluence with Hat Creek. Water had been diverted for irrigation in June and August 1977; Ambusten Creek was dry and not sampled.

Station 13 - Anderson Creek

Substrate:	Sand to large pebble.
Banks:	Boulder, pebble, sand and grass; left facing downstream unstable and right stable.
Depth:	10.2 - 15.2 cm
Width:	1.5 - 3.0 m
Pool:Riffle:	5%:95%
Current:	Rapid
Temperature:	11.3°C at 1200 hr. on 17 September 1976; 13.2°C at 1230 hr. on 16 June 1977; 11.5°C at 1530 hr. on 5 August 1977.
Notes:	Relatively steep gradient from mouth 30.5 m upstream to sampling site.

Station 14 - Hat Creek

Substrate:	Boulder 5%, pebble 35%, gravel 25%, sand-silt 30%, other (logs) 5%.
Banks:	Brush and grass, some instability due to livestock activity.
Depth:	0.03 - 0.3 m
Width:	4.3 m
Pool:Riffle:	25%:75%
Current:	0.09 - 0.2 m/s in September; surface current 0.5 m/s in June and 0.3 m/s in August.
Temperature:	9.6°C at 1500 hr. on 17 September 1976; 11.5°C at 1400 hr. on 15 June 1977; 14.0°C at 1430 hr. on 5 August 1977.
Notes:	Fisheries sampling included areas upstream, within and downstream of this site with a pool:riffle ratio of approximately 50%:50%.

Station 14A - Hat Creek

Substrate:	Gravel 5%, sand-silt 95%.
Banks:	Shrubs and grass, stable.
Depth:	0.3 - 1.1 m
Width:	6.1 m
Pool:Riffle:	95%:5%
Current:	Not measured in September but appeared sluggish; surface current 0.3 m/s in June and 0.3 m/s in August.
Temperature:	10.0°C at 1500 hr. on 29 September 1976; 12.0°C at 1610 hr. on 15 June 1977; 14.0°C at 1815 hr. on 4 August 1977.
Notes:	Beaver pond (abandoned) and appeared representative of many observed in Upper Hat Creek. Bottom appeared more silty in June than September.

Station 15 - Hat Creek

Substrate:	Gravel 70%, sand-silt 25%, other (logs) 5%.
Banks:	Trees, brush and grass, stable.
Depth:	0.3 - 0.5 m
Width:	1.8 m
Pool:Riffle:	50%:50%
Current:	<0.03 - 0.1 m/s in September; surface current 0.5 m/s in June; little or no flow in August, not measured.
Temperature:	10.2°C at 1545 hr. on 17 September, 1976; 10.1°C at 1115 hr. on 15 June 1977; 11.0°C at 1745 hr. on 4 August 1977.
Notes:	During September and August sampling, most flow had been diverted for irrigation. Appeared spring fed in August. Algae was abundant in August.

Station 16 - Goose/Fish Hook Lake

Substrate consisted of black muck-like material. Shore-line vegetation was profuse to a depth of about 1.5 m. Maximum water depth appeared to be about 3.0 m. Surface area was approximately five acres. Water temperature 15.0°C at 1100 hr. on 16 September 1976.

Station 17 - Finney Lake

Substrate consisted of brown pead-like material. Shoreline vegetation was profuse to a depth of about 2.4 m. Maximum water depth appeared to be about 5.5 m. Surface area was approximately 25 acres. Water temperature 17.0°C at 1550 hr. on 16 September 1976.

APPENDIX D

Supplementary Tables - Fisheries and Water Quality Data

TABLE D-1

DENSITY ESTIMATES FOR FISH COLLECTED AT HAT CREEK AND BONAPARTE RIVER STATIONS

DURING 28-30 SEPTEMBER 1976, 14-16 JUNE 1977 AND 3-5 AUGUST 1977

Station		Month	No. of Fish Collected	Fish/m	Fish/m^2	Fish/min.
Bonaparte River	1	September	33	0.72	0.24	0.73
		June	8	0.17	0.06	0.20
		August	6	0.17	0.02	0.17
	2	September	32	0.60	0.20	0.53
		June	23	0.32	0.07	0.58
		August	62	0.89	0.05	1.68
	3	September	9	0.24	0.08	0.20
		June	15	0.56	0.06	0.50
		August	34	0.63	0.08	0.76
	4	September	30	0.98	0.32	0.67
		June	17	0.64	0.16	0.42
		August	4	0.15	0.04	0.16
Lower Hat Creek	5	September	47	0.63	0.08	1.18
		June	21	0.28	0.04	0.84
		August	15	0.20	0.04	0.60
	6	September	19	0.26	0.04	0.63
		June	28	0.38	0.06	1.12
		August	25	0.34	0.06	0.96
	7	September	19	0.28	0.05	0.34
		June	33	0.49	0.09	1.10
		August	26	0.39	0.07	1.08

TABLE D-1 Cont'd.

DENSITY ESTIMATES FOR FISH COLLECTED AT HAT CREEK AND BONAPARTE RIVER STATIONS

DURING 28-30 SEPTEMBER 1976, 14-16 JUNE 1977 AND 3-5 AUGUST 1977

Station		Month	No. of Fish Collected	Fish/m	Fish/m²	Fish/min.
Upper Hat Creek	10	September	38	0.84	0.24	1.03
		June	34	0.75	0.22	1.13
		August	60	1.32	0.38	1.71
	14	September	63	1.22	0.26	1.58
		June	32	0.62	0.13	1.28
		August	33	0.64	0.14	1.32
	14A	September	31	1.16	0.17	1.03
		June	14	0.52	0.08	1.40
		August	17	0.64	0.09	1.13
	15	September	28	0.40	0.17	0.80
		June	40	0.57	0.25	1.14
		August	9	0.13	0.06	0.53

beak

TABLE D-2

STREAM LENGTH, STREAM SURFACE AREA, AND LENGTH OF TIME SHOCKED AT HAT CREEK AND BONAPARTE RIVER STATIONS

DURING 28-30 SEPTEMBER 1976, 14-16 JUNE 1977 AND 3-5 AUGUST 1977

Station		Month	Length (m)	Area (m^2)	Time (min)
Bonaparte River	1	September	45.73	139.41	45
		June	45.73	139.41	40
		August	35.00	280.00	35
	2	September	53.35	162.64	60
		June	72.95	316.65	40
		August	69.60	1,150.75	37
	3	September	38.11	116.17	45
		June	38.11	268.70	30
		August	53.74	422.30	45
	4	September	30.49	92.94	45
		June	26.68	104.53	40
		August	26.68	104.53	25
Lower Hat Creek	5	September	75.00	588.72	40
		June	75.00	588.72	25
		August	75.00	366.68	25
	6	September	72.99	445.24	30
		June	72.99	445.24	25
		August	72.99	445.24	26
	7	September	67.28	379.16	56
		June	67.28	379.16	30
		August	67.28	379.16	24

TABLE D-2 Cont'd.

STREAM LENGTH, STREAM SURFACE AREA, AND LENGTH OF TIME SHOCKED AT HAT CREEK AND BONAPARTE RIVER STATIONS

DURING 28-30 SEPTEMBER 1976, 14-16 JUNE 1977 AND 3-5 AUGUST 1977

Station		Month	Length (m)	Area (m^2)	Time (min)
Upper Hat Creek	10	September	45.35	156.55	37
		June	45.35	156.55	30
		August	45.35	156.55	35
	14	September	51.83	243.44	40
		June	51.83	243.44	25
		August	51.83	243.44	25
	14A	September	26.73	181.30	30
		June	26.73	181.30	10
		August	26.73	181.30	15
	15	September	70.76	160.53	35
		June	70.76	160.53	35
		August	70.76	160.53	17

beak

TABLE D-3

LENGTH-FREQUENCY DISTRIBUTIONS (%) FOR RAINBOW TROUT COLLECTED AT HAT CREEK

AND BONAPARTE RIVER STATIONS, 28-30 SEPTEMBER 1976

Length Class Interval (mm)	Bonaparte River		Lower Hat Creek			Upper Hat Creek			
	1	2	5	6	7	10	14	14A	15
0 - 20	-	-	-	-	-	-	-	-	-
21 - 40	-	-	-	5	5	-	-	3	17
41 - 60	20	50	52	53	32	6	6	10	11
61 - 80	80	50	41	27	-	8	5	3	4
81 - 100	-	-	7	5	-	33	23	-	-
101 - 120	-	-	-	5	37	8	16	14	11
121 - 140	-	-	-	5	16	25	21	27	17
141 - 160	-	-	-	-	10	8	11	17	-
161 - 180	-	-	-	-	-	6	11	3	11
181 - 200	-	-	-	-	-	-	3	3	11
201 - 220	-	-	-	-	-	6	2	17	7
221 - 240	-	-	-	-	-	-	2	-	11
241 - 260	-	-	-	-	-	-	-	3	-
Sample Size	5	2	29	19	19	38	62	30	28

TABLE D-4

LENGTH-FREQUENCY DISTRIBUTIONS (%) FOR RAINBOW TROUT COLLECTED AT HAT CREEK

AND BONAPARTE RIVER STATIONS, 14-16 JUNE 1977

Length Class Interval (mm)	Bonaparte River			Lower Hat Creek			Upper Hat Creek			
	1	2	3	5	6	7	10	14	14A	15
0 - 20	-	-	-	-	-	-	-	-	-	-
21 - 40	-	100	-	-	-	-	-	-	-	-
41 - 60	100	-	100	-	-	-	-	3	23	12
61 - 80	-	-	-	31	25	26	6	13	-	2
81 - 100	-	-	-	31	43	24	9	8	8	5
101 - 120	-	-	-	31	7	10	27	13	23	10
121 - 140	-	-	-	7	10	24	13	13	30	15
141 - 160	-	-	-	-	4	10	27	18	8	22
161 - 180	-	-	-	-	7	3	-	13	8	12
181 - 200	-	-	-	-	-	3	3	13	-	7
201 - 220	-	-	-	-	4	-	9	3	-	10
221 - 240	-	-	-	-	-	-	3	-	-	2
241 - 260	-	-	-	-	-	-	3	3	-	-
Sample Size	4	1	3	13	28	30	33	32	13	40

TABLE D-5

LENGTH-FREQUENCY DISTRIBUTIONS (%) FOR RAINBOW TROUT COLLECTED AT HAT CREEK AND BONAPARTE RIVER STATIONS, 3-5 AUGUST 1977

Length Calss Interval (mm)	Bonaparte River		Lower Hat Creek			Upper Hat Creek			
	1	3	5	6	7	10	14	14A	15
0 - 20	-	-	-	-	-	-	-	-	-
21 - 40	-	-	12	4	8	-	-	-	-
41 - 60	-	-	-	8	-	2	-	-	-
61 - 80	-	-	-	-	4	9	9	28	78
81 - 100	-	-	25	20	26	22	12	6	22
101 - 120	-	-	38	32	19	15	12	-	-
121 - 140	-	-	13	16	19	18	24	18	-
141 - 160	-	50	-	-	8	10	15	24	-
161 - 180	-	-	-	8	4	9	3	18	-
181 - 200	100	50	12	8	4	10	15	6	-
201 - 220	-	-	-	4	8	5	3	-	-
221 - 240	-	-	-	-	-	-	3	-	-
241 - 260	-	-	-	-	-	-	3	-	-
Sample Size	2	2	8	25	26	60	33	17	9

TABLE D-6

LENGTH-FREQUENCY DISTRIBUTIONS (%) FOR BRIDGELIP SUCKER

COLLECTED IN THE BONAPARTE RIVER

DURING 28-30 SEPTEMBER 1976, 14-16 JUNE 1977 AND 3-5 AUGUST 1977

Length Class Interval (mm)	September	June	August
0 - 10	-	-	-
11 - 20	-	-	13
21 - 30	15	-	48
31 - 40	8	-	-
41 - 50	38	-	7
51 - 60	19	-	29
61 - 70	4	-	-
71 - 80	12	-	3
81 - 90	-	-	-
91 - 100	-	-	-
101 - 110	4	-	-
111 - 120	-	-	-
121 - 130	-	45	-
131 - 140	-	11	-
141 - 150	-	22	-
151 - 160	-	-	-
161 - 170	-	-	-
171 - 180	-	11	-
181 - 190	-	11	-
Sample Size	26	9	31

TABLE D-7

LENGTH-FREQUENCY DISTRIBUTIONS (%) FOR LONGNOSE DACE

COLLECTED IN THE BONAPARTE RIVER

DURING 28-30 SEPTEMBER 1976, 14-16 JUNE 1977 AND 3-5 AUGUST 1977

Length Class Interval (mm)	September	June	August
0 - 10	-	-	-
11 - 20	-	-	16
21 - 30	26	13	50
31 - 40	19	40	4
41 - 50	26	26	7
51 - 60	14	4	10
61 - 70	5	9	9
71 - 80	4	4	3
81 - 90	2	-	-
91 - 100	4	4	1
Sample Size	56	23	70

TABLE D-8

Observed total lengths (mm) at various ages of rainbow trout collected at Hat Creek and Bonaparte River stations, 28-30 September 1976 ($\bar{X}$ = mean, r = range, n = sample size)

Age (Year Class)		Bonaparte River	Lower Hat Creek			Upper Hat Creek	
		Station 1	Station 5	Station 6	Station 7	Station 10	Station 14
0+	$\bar{X}$	66	58	59	55	81	82
(1976)	r	55-75	51-66	50-71	52-59	57-98	74-93
	n	4	10	9	3	10	6
1+	$\bar{X}$	79	-	114	110	111	113
(1975)	r	-	-	100-127	102-119	87-134	98-124
	n	1	0	2	5	4	6
2+	$\bar{X}$	-	-	-	138	134	161
(1974)	r	-	-	-	123-156	118-153	-
	n	0	0	0	5	6	1
3+	$\bar{X}$	-	-	-	-	156	169
(1973)	r	-	-	-	-	144-169	161-183
	n	0	0	0	0	2	3
4+	$\bar{X}$	-	-	-	-	206	195
(1972)	r	-	-	-	-	203-210	164-224
	n	0	0		0	2	3
5+	$\bar{X}$	-	-	-	-	-	210
(1971)	r	-	-	-	-	-	-
	n	0	0	0	0	0	1

TABLE D-9

Observed total lengths (mm) and ranges at various ages of rainbow trout collected at Hat Creek and Bonaparte River Stations, 14-16 June 1977 ($\bar{X}$ = mean, r = range, n = sample size)

Age (Year Class)		Bonaparte River		Lower Hat Creek			Upper Hat Creek	
		Station 1	Station 3	Station 5	Station 6	Station 7	Station 10	Station 14
0+	$\bar{X}$	48	42	-	-	-	-	-
(1977)	r	41-52	41-43	-	-	-	-	-
	n	4	3	0	0	0	0	0
1+	$\bar{X}$	-	-	88	85	77	82	86
(1976)	r	-	-	64-110	70-104	66-89	71-91	65-101
	n	0	0	12	12	10	5	8
2+	$\bar{X}$	-	-	134	133	126	117	117
(1975)	r	-	-	-	127-140	104-149	103-136	-
	n	0	0	1	3	7	3	1
3+	$\bar{X}$	-	-	-	174	167	138	150
(1974)	r	-	-	-	160-201	152-187	121-150	141-160
	n	0	0	0	4	3	4	5
4+	$\bar{X}$	-	-	-	-	-	151	177
(1973)	r	-	-	-	-	-	149-153	170-184
	n	0	0	0	0	0	3	4
5+	$\bar{X}$	-	-	-	-	-	201	202
(1972)	r	-	-	-	-	-	195-208	198-211
	n	0	0	0	0	0	3	3
6+	$\bar{X}$	-	-	-	-	-	229	244
(1971)	r	-	-	-	-	-	201-255	-
	n	0	0	0	0	0	3	1

TABLE D-10

OBSERVED TOTAL LENGTHS (mm) AND RANGES AT VARIOUS AGES OF RAINBOW TROUT COLLECTED AT HAT CREEK AND BONAPARTE RIVER STATIONS, 3-5 AUGUST 1977 ($\bar{x}$ = MEAN, r = RANGE, n = SAMPLE SIZE)

Age (Year Class)		Bonaparte River Station 1	Bonaparte River Station 3	Lower Hat Creek Station 5	Lower Hat Creek Station 6	Lower Hat Creek Station 7	Upper Hat Creek Station 10	Upper Hat Creek Station 14
0+	$\bar{x}$	-	-	36	42	34	42	-
(1977)	r	-	-	-	39-45	32-37	-	-
	n	0	0	1	3	2	1	0
1+	$\bar{x}$	-	-	104	105	104	90	79
(1976)	r	-	-	95-119	91-127	78-131	80-115	73-126
	n	0	0	4	10	13	10	8
2+	$\bar{x}$	193	170	133	152	149	132	136
(1975)	r	-	159-182	-	125-171	134-160	126-140	132-141
	n	1	2	1	3	3	4	3
3+	$\bar{x}$	-	-	187	187	177	156	180
(1974)	r	-	-	-	183-191	162-192	149-163	167-188
	n	0	0	1	2	2	2	4
4+	$\bar{x}$	-	-	-	207	214	198	197
(1973)	r	-	-	-	-	213-216	198	189-210
	n	0	0	0	1	2	2	3
5+	$\bar{x}$	-	-	-	-	-	208	232
(1972)	r	-	-	-	-	-	-	222-241
	n	0	0	0	0	0	1	2
6+	$\bar{x}$	-	-	-	-	-	-	-
(1971)	r	-	-	-	-	-	-	-
	n	0	0	0	0	0	0	0

TABLE D-11

Means and ranges for condition factors of rainbow trout 0-100 mm and 100 mm total length collected at Hat Creek and Bonaparte River stations during 28-30 September 1976, 14-16 June 1977, and 3-5 August 1977 (u = Sample size, x = Mean, r = Range)

"n"

		>0-100 mm Total Length			>100 mm Total Length		
Station	Month	n	x̄	r	n	x	r
1	Sept.	5	0.96	0.87-1.01	0	-	-
	June	4	0.70	0.59-0.83	0	-	-
	Aug.	0	-	-	2	1.05	1.03-1.07
2	Sept.	2	0.78	0.74-0.83	0	-	-
	June	1	0.70	-	0	-	-
	Aug.	0	-	-	0	-	-
3	Sept.	0	-	-	0	-	-
	June	3	1.01	0.75-1.26	0	-	-
	Aug.	0	-	-	2	1.09	1.04-1.13
4	Sept.	0	-	-	0	-	-
	June	0	-	-	0	-	-
	Aug.	0	-	-	0	-	-
5	Sept.	29	0.81	0.60-0.97	0	-	-
	June	8	0.85	0.73-0.99	5	0.94	0.86-1.04
	Aug.	3	0.68	0.21-0.92	5	0.95	0.81-1.06
6	Sept.	17	0.91	0.27-1.14	2	0.70	0.66-0.73
	June	19	0.93	0.76-1.16	9	0.96	0.85-1.10
	Aug.	8	0.87	0.77-1.00	17	0.97	0.82-1.07
7	Sept.	7	1.15	1.07-1.40	12	0.81	0.73-0.93
	June	5	1.01	0.85-1.13	15	1.02	0.86-1.45
	Aug.	10	0.82	0.59-1.07	16	0.91	0.80-1.08
10	Sept.	18	0.80	0.63-0.90	20	0.83	0.72-0.95
	June	5	1.09	0.90-1.26	28	1.02	0.78-1.24
	Aug.	19	0.89	0.27-1.65	41	0.90	0.74-1.09
14	Sept.	21	0.80	0.35-1.16	41	0.97	0.68-1.22
	June	8	0.95	0.84-1.20	24	0.93	0.66-1.16
	Aug.	7	0.92	0.85-9.95	26	0.89	0.74-1.05

TABLE D-11

Contd.

Station	Month	>0-100 mm Total Length n	x	r	>100 mm Total Length n	x	r
14A	Sept.	5	0.88	0.78-1.03	25	0.96	0.85-1.19
	June	4	0.83	0.33-1.08	9	0.93	0.85-1.03
	Aug.	6	0.97	0.81-1.07	11	0.95	0.86-1.07
15	Sept.	9	0.29	0.13-0.59	19	0.84	0.68-0.99
	June	8	1.23	0.98-1.81	32	0.94	0.82-1.40
	Aug.	9	1.08	0.91-1.36	0	-	-

TABLE D-12: Water Quality Characteristics of Lakes and Streams in the Study Region Listed According to Alkalinity Criteria[1]

Waterbody	Source	Total Alkalinity	Hardness	Filtrable Residue	Sulfates	Specific Conductivity	pH
Category I - Alkalinity Range $\leq$50 mg/l							
Nahatlatch River	2	17.0 (7.2)[2]	15.5 (7.6)	29.0 (27.0)	5.0 (-)	43.1 (37.2)	7.4 (0.3)
Seton River	2	35.8 (4.5)	40.6 (5.9)	58.2 (6.9)	11.3 (2.5)	97.2 (23.2)	7.7 (0.2)
Stein River	2	30.2 (11.6)	26.7 (11.2)	45.8 (15.7)	6.9 (2.5)	71.0 (26.4)	7.5 (0.2)
Clearwater River	2	35.2 (3.1)	36.4 (3.8)	50.2 (4.9)	5.7 (0.8)	104.9 (104.1)	7.6 (0.4)
N. Thompson River	2	36.4 (9.1)	38.8 (11.0)	57.0 (13.6)	7.6 (2.0)	86.4 (31.8)	7.6 (0.3)
N. Thompson River at Kamloops	2	36.9 (8.9)	40.2 (9.2)	57.0 (13.4)	7.5 (2.2)	99.4 (27.3)	7.5 (3.4)
Thompson River at Savona	2	34.8 (4.4)	37.8 (4.7)	56.6 (9.1)	7.1 (1.3)	95.3 (21.7)	7.6 (0.3)
Thompson River at Walhachin	2	34.0 (3.7)	37.4 (4.5)	56.4 (8.7)	6.8 (1.5)	95.5 (17.1)	7.5 (0.6)
Thompson River at Spences Bridge	2	38.2 (5.6)	42.9 (6.4)	64.2 (10.0)	8.9 (2.8)	107.0 (31.7)	7.7 (0.2)
Brarrie River	2	48.0 (8.2)	44.9 (5.7)	71.0 (8.3)	5.7 (0.9)	132.4 (111.5)	7.6 (0.3)
Tranquille River at 21 mile	2	40.4 (4.2)	34.1 (3.7)	60.0 (10.0)	-	80.8 (8.9)	7.6 (0.2)
Seymour River	1	12.1 (3.4)	-	24.8 (4.6)	-	48.3 (41.8)	7.0 (0.3)
Eagle River	1	19.0 (6.6)	-	42.0 (-)	-	50.6 (18.7)	-
Adams River	1	22.5 (0.7)	-	39.3 (3.0)	-	55.0 (3.8)	-
Pennask Lake	1	-	-	27.0 (-)	-	-	-
Little Shuswap Lake	1	30.5 (-)	-	52.7 (-)	-	73.0 (-)	-
South Thompson River	1	37.0 (8.0)	-	55.5 (12.7)	-	94.7 (21.5)	7.5 (0.7)
Scotch Creek	1	37.1 (11.7)	-	61.0 (19.0)	-	-	-
Shuswap Lake	1	40.7 (-)	-	61.7 (-)	-	112.9 (-)	-
Mara Lake	1	42.7 (5.1)	-	64.2 (-)	-	118.1 (-)	-
Adams Lake		-	-	57.0 (-)	-	-	-
Dunn Lake		-	-	63.0 (-)	-	-	-

TABLE D-12 Cont'd: Water Quality Characteristics of Lakes and Streams in the Study Region Listed According to Alkalinity Criteria[1]

Waterbody	Source	Total Alkalinity	Hardness	Filtrable Residue	Sulfates	Specific Conductivity	pH
Category II - Alkalinity Range >50 - ≤100 mg/l							
Cultus Lake	1	49.0	-	86.0	-	165	7.5
Nicola River near Spences Bridge	1	92.6 (26.2)	85.9 (26.7)	126.8 (35.1)	15.6 (5.8)	204.4 (64.7)	8.2 (0.4)
Brich Lake		-	-	144	-	-	-
North Barriere Lake	1	-	-	80.5	-	-	-
Bridge River	2	90.0 (22.9)	103.6 (29.1)	152.0 (2.0)	21.2 (5.8)	207.1 (75.7)	8.0 (0.3)
Yalakom River	2	86.5 (20.8)	92.7 (22.5)	110.4 (24.0)	15.6 (3.9)	197.0 (69.2)	8.0 (0.2)
Fraser River at Lillooet	2	63.5 (13.4)	68.0 (13.8)	95.8 (18.1)	9.2 (4.1)	154.4 (38.9)	7.9 (0.2)
Fraser River at Lytton	2	61.3 (8.6)	64.4 (8.9)	91.4 (13.9)	9.7 (5.3)	153.4 (48.2)	8.0 (0.3)
Nicola River below Douglas Lake	2	69.2 (17.4)	88.0 (32.9)	145 (39.6)	35.3 (16.1)	206.1 (74.3)	8.0 (0.3)
Nicola River at outlet of North Lake	2	92.3 (7.4)	98.9 (8.2)	145.7 (10.9)	19.7 (5.5)	222.4 (26.0)	8.1 (0.3)
Jamieson Creek	2	94.1 (27.0)	105.8 (36.2)	139.7 (45.5)	22.7 (14.3)	210 (83.4)	8.0 (0.3)
Criss Creek	2	93.0 (55.8)	82.6 (49.3)	127.4 (58.6)	8.5 (-)	196.9 (99.8)	7.9 (0.3)
Coldwater River at Merritt	2	62.7 (19.7)	62.8 (20.3)	85.3 (25.0)	-	140.4 (44.4)	7.8 (0.3)
Nicola River below Coldwater	2	92.5 (17.2)	96.3 (19.4)	141.4 (26.1)	-	213 (44.5)	8.0 (0.2)
Nicola Lake at east end	2	87.2 (2.8)	94.1 (2.3)	140.7 (5.7)	-	212.3 (6.6)	7.9 (0.4)
Nicola Lake opposite Nicola River	2	87.9 (4.0)	94.8 (3.4)	140.2 (5.7)	20.8 (0.2)	223.7 (25.9)	7.8 (0.4)
Nicola Lake at deepest Point	2	88.1 (2.5)	95.0 (2.6)	144.7 (6.8)	21.4 (0.2)	213.7 (8.0)	7.7 (0.4)
Nicola Lake at outlet	2	88.1 (0.7)	94.6 (0.6)	143.3 (3.0)	21.1 (-)	222.2 (10.6)	8.1 (0.1)

TABLE D-12 Cont'd: Water Quality Characteristics of Lakes and Streams in the Study Region Listed According to Alkalinity Criteria[1]

Waterbody	Source	Total Alkalinity	Hardness	Filtrable Residue	Sulfates	Specific Conductivity	pH
Category III - Alkalinity Range >100 mg/l							
Bonaparte River above Hat Creek	2	141 (28.0)	128.5 (25.5)	183.0 (33.0)	5.9	268.0 (61.6)	8.1 (0.1)
Bonaparte River below Hat Creek	2	193.1 (39.2)	194.3 (45.5)	271.5 (52.7)	38.6 (15.2)	439.8 (93.1)	8.3 (0.3)
Hat Creek	1	242.2 (33.3)	-	336.7 (42.7)	-	521.0 (85.4)	8.5 (0.3)
Clinton Lake	1	272.5 (18.3)	- -	340.5 (35.7)	-	539.4 (84.5)	8.3 (0.2)
Clinton Creek	2	323.1 (36.2)	338.6 (30.7)	398.2 (39.8)	40.6 (8.6)	599.5 (110.2)	8.5 (0.3)
Loon Lake at inlet	2	293.0 (-)	210.0 (-)	334.0 (-)	5.0 (-)	530.0 (-)	8.7 (-)
Loon Lake at White Moose	2	293.0 (-)	212.0 (-)	328.0 (-)	5.0 (-)	532.0 (-)	8.7 (-)
Loon Creek	2	434.0 (-)	345.0 (-)	500.0 (-)	5.4 (-)	735 (-)	8.5 (-)
Cache Creek	2	206.1 (60.0)	192.6 (64.3)	293.7 (70.2)	39.6 (9.9)	421.4 (131.9)	8.3 (0.6)
Pavilion Lake							
Deadman River near mouth	2	134.6 (57.9)	125.0 (54.1)	176.6 (59.1)	17.8 (-)	281.4 (118.3)	8.1 (0.4)
Deadman River above Criss Creek	2	149.1 (44.2)	134.9 (40.5)	192.3 (48.2)	17.4 (4.9)	308.6 (95.7)	8.2 (0.3)
Red Lake	1	-	-	-	-	362.0 (-)	-
Pukaist Creek near mouth	2	183.8 (47.4)	187.3 (43.0)	288.5 (65.3)	34.2 (53.0)	396.1 (71.6)	8.3 (0.3)
Witches Brook	2	172.3 (65.2)	167.0 (59.2)	227.2 (63.2)	9.8 (5.8)	364.9 (106.9)	8.2 (0.4)
Tunkwa Lake	1	-	-	200.0	-	-	-
Guichon Creek near mouth	2	188.1 (30.8)	187.4 (23.4)	246.3 (31.1)	17.8 (4.1)	375.9 (62.3)	8.3 (0.3)
Guichon Creek below Logan Lake	2	161.0 (33.1)	163.2 (22.8)	214.5 (26.5)	6.0 (1.2)	330.1 (50.0)	8.1 (0.3)
Guichon Creek above Logan Lake	2	181.0 (-)	163.0 (1.1)	230.0 (-)	5.8 (1.0)	333.0 (9.9)	8.2 (1.0)
Guichon Creek at Tunkwa Div.	2	110.8 (12.2)	99.1 (9.4)	160.9 (10.4)	5.0 (-)	219.7 (35.1)	8.0 (0.4)
Duffy Lake	2	430.5 (3.8)	575.8 (2.8)	768.0 (8.5)	191.0 (2.8)	1008.8 (36.0)	8.7 (0.1)
Jacko Lake	2	240.0 (5.2)	285.3 (2.4)	456.7 (3.8)	121.7 (4.7)	658.0 (8.5)	8.2 (0.4)
Peterson Creek	2	317 (19.0)	385.0 (3.0)	590.0 (8.0)	864.8 (45.6)	189.0 (-)	7.9 (0.2)
Lac le Jeune	1	130 - 135.3	-	172.7-181.3	-	266.6-271.9	7.7-8.1
Stump Lake	2	-	-	1200	-	-	-
Tranquille River at mouth	2	102.4 (25.6)	87.9 (22.1)	138.4 (23.9)	7.1 (3.3)	205.5 (56.4)	8.3 (0.6)

TABLE D-12 Cont'd: Water Quality Characteristics of Lakes and Streams in the Study Region Listed According to Alkalinity Criteria[1]

Waterbody	Source	Total Alkalinity	Hardness	Filtrable Residue	Sulfates	Specific Conductivity	pH
Tranquille River at mouth	2	112.0 (5.0)	98.8 (3.5)	143.0 (5.0)	-	218.2 (6.5)	8.6 (0.3)
Tranquille River at 9 mile	2	101.4 (4.6)	93.3 (5.0)	126.0 (6.0)	-	198.7 (8.9)	8.1 (0.1)
Paul Creek above Paul Lake	2	205.0 (-)	215.0 (-)	254 (-)	-	420 (-)	8.2 (-)
Paul Lake east end	2	161.0 (-)	170.0 (-)	222.0 (-)	25.8 (-)	335.0 (15.0)	8.5 (-)
Paul Lake west end	2	160.0 (-)	169.0 (-)	224.0 (-)	25.8 (-)	352.0 (-)	8.3 (-)
Paul Creek at outlet Paul Lake	2	178.2 (41.1)	190.4 (40.8)	243.6 (54.9)	31.8 (6.8)	393.3 (99.5)	8.1 (0.3)
Nicola River at Nicola Lake	2	101 (22.8)	105.5 (24.1)	146.8 (35.0)	0.5 (-)	240.1 (60.9)	8.3 (0.4)
Nicola River above Coldwater	2	114.5 (12.0)	124.3 (14.6)	174.9 (18.8)	26.2 (4.2)	283.1 (40.2)	8.0 (0.2)
Nicola River above Coldwater	2	134.0 (-)	120.4 (15.3)	175.4 (17.9)	-	269.8 (33.4)	8.0 (2.3)
Green Lake near Mt. Jack	2	873.0 (14.0)	498.5 (10.5)	976.0 (-)	-	1306.7 (9.4)	9.2 (0.1)
Green Lake opposite Nolan Creek	2	867.0 (8.0)	496.5 (12.5)	976.0 (-)	-	1353.3 (105.0)	-
Watch Lake	1	-	-	243	-	-	-
Taylor Lake	1	-	-	313	-	-	9.0
Edmund Lake	1	-	-	280	-	-	8.3
Exeter Lake	1	-	-	362	-	-	>8.4
108 Mile Lake	1	-	-	610	-	-	-
103 Mile Lake	1	-	-	655	-	-	-
Chris Lake	1	-	-	160	-	-	>8.5
Drewy Lake	1	-	-	385	-	400	>8.5
Hathaway Lake	1	-	-	480	-	600	>8.5
Deka Lake	1	-	-	320	-	390	>8.5
Longbon Lake	1	-	-	250	-	-	7.5
Sulphurous Lake	1	-	-	393	-	500	>8.5
Fawn Lake	1	-	-	310	-	-	-
Sheridan Lake	1	-	-	272	-	-	-
Buffalo Lake	1	-	-	390	-	450	-
Horse Lake	1	-	-	200	-	-	>8.5
Helena Lake	1	-	-	482	-	-	>8.5
Sucken Lake	1	-	-	475	-	-	7.5

TABLE D-12 Cont'd: Water Quality Characteristics of Lakes and Streams in the Study Region Listed According to Alkalinity Criteria[1]

Waterbody	Source	Total Alkalinity	Hardness	Filtrable Residue	Sulfates	Specific Conductivity	pH
Soda Lake	1	-	-	1150	-	-	>8.4
Lac la Hache	1	-	-	-	-	-	-
Bridge Creek							
Bridge Creek at outlet Horse Lake	2	151.7 (16.4)	136.0 (6.9)	179.0 (14.6)	50.0 (-)	313.6 (90.6)	8.0 (0.5)
Lac des Roches	1	-	-	153.0	-	-	-
Fishtrap Creek	2	101.4 (19.6)	108.7 (20.6)	140.0 (23.2)	11.6 (2.6)	218.2 (42.5)	8.0 (0.3)
Demers Creek	2	143.5 (6.1)	165.8 (10.1)	196.7 (9.0)	18.8 (-)	305.8 (52.2)	7.9 (0.4)
Lemieux Creek	2	112.0 (7.8)	118.2 (8.9)	142.0 (12.7)	3.0 (1.0)	234.3 (27.6)	8.0 (0.2)

[1] Following criteria outlined by Newcomb (1977)
[2] ± 1 Standard deviation

Sources:

1. Newcombe, C.P. 1977. Water Quality Near the Proposed Hat Creek Thermal Generating Station: Potential Streams and Lakes Affected by Acid Precipitation. Fisheries Management Report No. . June 1977.

2. Department of Environment. Water Resource Service. Ministry of the Environment. Data of Selected Streams for Period of Record 1 January 1965 to 15 August 1977. Waterbody title refers to site description as given in Computer printouts.

APPENDIX E

First Order and Detailed Identification
of Benthic Invertebrates

TABLE 1: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 1 - Bonaparte River (Surber Sampler)

	SAMPLE NUMBER 1	2	3*	4	5*	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	16	24	12	1	15	8	12.7
Trichoptera	8	3	13	1	2		4.5
Plecoptera	3	3	6		4	1	2.8
Coleoptera			1	2	1		0.7
Odonata						1	0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	23	32	16	14	27	51	27.2
Other Diptera	2	7	2	3	3	4	3.5
GROUP 1 ORGANISMS							
Oligochaeta				1			0.2
TOTAL NO. OF ORGANISMS	52	69	50	22	52	65	52
TOTAL NO. OF TAXA	5	5	6	6	6	5	6

Laboratory Sample Residue: sand, gravel, wood pieces, fine plant debris, algae

* Sample selected for detailed identification

TABLE 2: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 2 - Bonaparte River (Surber Sampler)

	SAMPLE NUMBER						
	1*	2*	3*	4*	5*	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	1	3	8	5	6	13	6.0
Trichoptera		2			1	1	0.7
Plecoptera	1	1	1	1	1	2	1.2
Coleoptera	1						0.2
Odonata	1						0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	1	2	1			1	0.8
Other Diptera	1		4		3	2	1.7
GROUP 1 ORGANISMS							
Oligochaeta			1				0.2
TOTAL NO. OF ORGANISMS	6	8	15	6	11	19	11
TOTAL NO. OF TAXA	6	4	5	2	4	5	4

Laboratory Sample Residue: sand, gravel, wood pieces, plant matter

* Sample selected for detailed identification

TABLE 3: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 3 - Bonaparte River (Surber Sampler)

	SAMPLE NUMBER 1	2	3*	4	5	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	13	11	21	2	9	9	10.8
Trichoptera	10	2	14	4	1	15	7.7
Plecoptera		1	6		1	2	1.7
Coleoptera		1				2	0.5
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	2	3	3	1	4	6	3.2
Other Diptera	11	10	14	2	4	11	8.7
Pelecypoda	1						0.2
Nematoda	1						0.2
GROUP 1 ORGANISMS							
Oligochaeta						2	0.3
TOTAL NO. OF ORGANISMS	38	28	58	9	19	47	33
TOTAL NO. OF TAXA	6	6	5	4	5	7	6

Laboratory Sample Residue: sand, wood pieces, bark, plant matter

* Sample selected for detailed identification

TABLE 4: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 4 - Bonaparte River (Surber Sampler)

	SAMPLE NUMBER						Av./ Sample
	1*	2*	3*	4*	5*	6*	
GROUP 3 ORGANISMS							
Ephemeroptera	3		4	2	1	2	2.0
Odonata						1	0.2
GROUP 2 ORGANISMS							
Other Diptera		1				1	0.3
TOTAL NO. OF ORGANISMS	3	1	4	2	1	4	2.5
TOTAL NO. OF TAXA	1	1	1	1	1	3	1

Laboratory Sample Residue: sand, gravel, wood debris, plant debris

* Sample selected for detailed identification

TABLE 5: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 5 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER 1*	2*	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS				SAMPLE DESTROYED			
Ephemeroptera	14	6	8		11	17	11.2
Trichoptera		4	26		2	14	9.2
Plecoptera	20	7	13		21	22	16.6
Coleoptera		4				3	1.4
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	2	27			4	9	8.4
Other Diptera	3	19	5		5	15	9.4
GROUP 1 ORGANISMS							
Oligochaeta		3				3	1.2
TOTAL NO. OF ORGANISMS	39	70	52		43	83	57
TOTAL NO. OF TAXA	4	7	4		5	7	5

Laboratory Sample Residue: sand, algae, plant matter

* Sample selected for detailed identification

TABLE 6: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 6 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER 1	2*	3	4	5*	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	8	16	9	11	13	16	12.2
Trichoptera	12	23	7	13	8	5	11.3
Plecoptera	2	5	2	6	2	2	3.2
Coleoptera		1			1		0.3
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	1	2		3	1		1.2
Other Diptera	9	9	2	15	26	11	12.0
Nematoda						2	0.3
TOTAL NO. OF ORGANISMS	32	56	20	48	51	36	41
TOTAL NO. OF TAXA	5	6	4	5	6	5	5

Laboratory Sample Residue: sand, plant debris, wood pieces

* Sample selected for detailed identification

TABLE 7: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 7 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER 1	2*	3	4	5	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	9	4	7	11	74	19	20.7
Trichoptera		10	17	40	27	58	25.3
Plecoptera		1	5	2	22	3	5.5
Coleoptera			1				0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	1	2	5	3	6	6	3.8
Other Diptera	1	1	1		4	2	1.5
Hydracarina		1					0.2
Nematoda					1		0.2
TOTAL NO. OF ORGANISMS	11	19	36	56	134	88	57
TOTAL NO. OF TAXA	3	6	6	4	6	5	5

Laboratory Sample Residue: algae, sand, gravel, wood pieces

* Sample selected for detailed identification

TABLE 8: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 8 - Hat Creek Tributary (Surber Sampler)

	SAMPLE NUMBER						
	1*	2	3	4	5*	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	9	2	3	9	6	9	6.3
Trichoptera	7	2	6	27	19	18	13.2
Plecoptera	5	1		13	12	12	7.2
Coleoptera				1			0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae					1	1	0.3
Other Diptera	1			1	2		0.7
Turbellaria				2	2		0.7
GROUP 1 ORGANISMS							
Oligochaeta					4	1	0.8
TOTAL NO. OF ORGANISMS	22	5	9	53	46	41	29
TOTAL NO. OF TAXA	4	3	2	6	7	5	5

Laboratory Sample Residue: fine plant debris, plant debris, sand, wood pieces

* Sample selected for detailed identification

TABLE 9: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 10 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER						
	1*	2	3	4	5*	6	Av./ Sample
GROUP 3 ORGANISMS	22	24	13	23	24	16	20.3
Trichoptera	13	8	7	23	11	6	11.3
Plecoptera	2	2	8	5	9	3	4.8
Coleoptera	1			1	4	2	1.3
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	2	2		6	6	13	4.8
Other Diptera	2	1	4	3	3	3	2.7
Nematoda			1				0.2
Turbellaria				1	1		0.3
Hydracarina					1		0.2
GROUP 1 ORGANISMS							
Oligochaeta			1		1	5	1.2
TOTAL NO. OF ORGANISMS	42	37	34	62	60	48	47
TOTAL NO. OF TAXA	6	5	6	7	9	7	7

Laboratory Sample Residue: sand, algae, gravel, plant debris, wood pieces

* Sample selected for detailed identification

TABLE 10: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 11 - Medicine Creek (Surber Sampler)

	SAMPLE NUMBER						
	1*	2	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	37	69	42	49	47	31	45.8
Trichoptera	34	7	1	1	5	11	9.8
Plecoptera	19	4	25	18	11	9	14.3
Coleoptera		19	6	7	3	1	6.0
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	12	11	1	2	3	3	5.3
Other Diptera	8	3	5	3	3	5	4.5
Turbellaria		1		10	3		2.3
Nematoda			1			1	0.3
GROUP 1 ORGANISMS							
Oligochaeta		7		4	3	5	3.2
TOTAL NO. OF ORGANISMS	110	121	81	94	78	66	92
TOTAL NO. OF TAXA	5	8	7	8	8	8	7

Laboratory Sample Residue: sand, algae, gravel, fine plant debris

* Sample Selected for detailed identification

TABLE 11: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 12 - Ambusten Creek (Surber Sampler)

	SAMPLE NUMBER 1	2*	3	4*	5*	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	4	10	2	6	7	6	5.8
Trichoptera		1	1				0.3
Plecoptera	1	4		2	6		2.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae		1					0.2
Other Diptera	1				3		0.7
Turbellaria	4	5		6		3	3.0
GROUP 1 ORGANISMS							
Oligochaeta	6	2	1	10	26	14	9.8
TOTAL NO. OF ORGANISMS	16	23	4	24	42	23	22
TOTAL NO. OF TAXA	5	6	3	4	4	3	4

Laboratory Sample Residue: sand, gravel, fine wood pieces, plant debris, stones

* Sample selected for detailed identification

TABLE 12: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 13 - Anderson Creek (Surber Sampler)

	SAMPLE NUMBER 1	2	3*	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	13	9	33	23		26	17.3
Trichoptera			3	1		4	1.3
Plecoptera	5	1	2	9		2	3.2
GROUP 2 ORGANISMS							
Other Diptera	1	2	91	2			16.0
Turbellaria		1	5	2		1	1.5
Hydracarina			1				0.2
GROUP 1 ORGANISMS							
Oligochaeta		1		1		2	0.7
TOTAL NO. OF ORGANISMS	19	14	135	38	0	35	40
TOTAL NO. OF TAXA	3	5	6	6	0	5	4

Laboratory Sample Residue: sand, fine plant debris, wood pieces, stones

* Sample selected for detailed identification

TABLE 13: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 14 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER						
	1*	2	3*	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	39	6	36	26	26	24	26.2
Trichoptera		1	1	1	1		0.7
Plecoptera	1	1		2		2	1.0
Coleoptera	1				4		0.8
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	5		2	5	3	2	2.8
Other Diptera	1	1				2	0.7
Nematoda	2						0.3
Turbellaria			1	1		1	0.5
GROUP 1 ORGANISMS							
Oligochaeta	12				1	2	2.5
TOTAL NO. OF ORGANISMS	61	9	40	35	35	33	36
TOTAL NO. OF TAXA	7	4	4	5	5	6	5

Laboratory Sample Residue: gravel, wood debris, algae, plant debris

* Sample selected for detailed identification

TABLE 14: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 15 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER 1	2	3*	4	5*	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	30	53	50	104	33	68	56.3
Trichoptera				2		1	5.0
Plecoptera		6	4	8	7	4	4.8
Coleoptera						1	0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae		1	1		2		0.7
Other Diptera	1	5	2	2		1	1.8
Turbellaria	5	11	5	7	3		5.2
Nematoda						1	0.2
GROUP 1 ORGANISMS							
Oligochaeta	2	2	1	2		1	1.3
TOTAL NO. OF ORGANISMS	38	78	63	125	45	77	76
TOTAL NO. OF TAXA	4	6	6	6	4	7	6

Laboratory Sample Residue: gravel, sand, fine plant debris, plant debris, stones

* Sample selected for detailed identification

TABLE 15: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 16 - Goose Lake (Ponar Dredge)

	SAMPLE NUMBER						
	1	2*	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera					1		0.2
Odonata					19		3.2
GROUP 2 ORGANISMS							
Hemiptera					2		0.3
Diptera							
Chironomidae	4	6	3	4	9	34	10.0
Other Diptera	9	5	2	14		7	6.2
Amphipoda	14	101	36	13	241	78	80.5
TOTAL NO. OF ORGANISMS	27	112	41	31	272	119	100
TOTAL NO. OF TAXA	3	3	3	3	4	3	3

Laboratory Sample Residue: gravel, fine plant debris, plant debris, mud balls

* Sample selected for detailed identification

Cladocera and Copepoda abundant

TABLE 16: Benthic Macroinvertebrates - First Order Identification
September 1976

STATION: 17 - Finney Lake (Ponar Dredge)

	SAMPLE NUMBER						
	1*	2*	3	4	5	6*	Av./ Sample
GROUP 3 ORGANISMS							
Odonata	1	1		3	1		1.0
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	9	10	33	23	34	28	22.8
Other Diptera	1	9	1		6	5	3.7
Pelecypoda		1	2	1			0.7
Gastropoda	1	2	1	5			1.5
Coelenterata	2						0.3
Cladocera	36	58	16	72	18	8	34.7
Copepoda	4		1	2		1	1.3
Hirudinea	1	4	3	2	5		2.5
Amphipoda	4		5	6	2	6	3.8
Nematoda		1		1			0.3
GROUP 1 ORGANISMS							
Oligochaeta	1	10		6	14	16	7.8
TOTAL NO. OF ORGANISMS	60	96	62	121	80	64	81
TOTAL NO. OF TAXA	10	9	8	10	7	6	8

Laboratory Sample Residue: fine plant debris

* Sample selected for detailed identification

TABLE 17: Benthic Macro-Invertebrates - Detailed Identifications, September 1976

TAXA	LIFE STAGE*	STATION NO. 1	2	3	4	5	6	7	8
GROUP 3 ORGANISMS									
EPHEMEROPTERA									
F. Heptageniidae									
Rhithrogena sp.	N	12	12	7	10	3	1	7	7
Cinygmula sp.	N			1					2
Heptageniidae sp. indet.	N						1	1	
F. Baetidae									
Baetis sp.	N	13	19	17	1	9	4	3	3
Ephemerella sp. 1	N	2	5	5	1	7	23	10	
Ephemerella sp. 2	N								2
Paraleptophlebia sp.	N					1			
Ameletus sp.	N							2	10
TRICHOPTERA									
F. Hydropsychidae									
Hydropsyche sp.	L	10	1	15		3	24	60	20
Diplectrona sp.	L							1	21
F. Rhyacophilidae									
Agapetus sp.	L	2	2	12			4	3	3
Rhyacophila sp.	L	3		2					
F. Brachycentridae									
Brachycentrus sp.	L					1	3	3	
F. Limnephilidae									
Limnephilidae sp. indet.	L		1						
Trichoptera sp. indet.	L							1	

TABLE 17: Benthic Macro-Invertebrates - Detailed Identifications, September 1976

TAXA	LIFE STAGE*	STATION NO. 1	2	3	4	5	6	7	8
GROUP 3 ORGANISMS Cont'd									
PLECOPTERA									
F. Perlidae									
Claassenia sp.	N	3		1		24	7	2	2
F. Pteronarcidae									
Pteronarcella sp.	N	6	6	2		1			
Pteronarcys sp.	N			2					
F. Chloroperlidae									
Hastaperla sp.	N	1				2			2
F. Perlodidae									
Isoperla sp.	N								6
Isogenus sp.	N		1	3					1
F. Nemouridae									
Nemoura sp.	N							2	15
Plecoptera sp. indet.	N								3
COLEOPTERA									
F. Elmidae									
Zaitzevia sp.	L	2	1	2		4	2		
ODONATA									
S.O. Zygoptera									
F. Agrionidae									
Agrionidae sp. indet.	N		1						
S.O. Anisoptera									
F. Gomphidae									
Ophiogomphus sp.	N				1				

TABLE 17: Benthic Macro-Invertebrates - Detailed Identifications, September 1976

TAXA	LIFE STAGE*	STATION NO. 1	2	3	4	5	6	7	8
GROUP 2 ORGANISMS									
DIPTERA									
F. Chironomidae									
S.F. Chironominae									
Micropsectra sp.	L		2	1		23			
S.F. Orthocladiinae									
Cricotopus sp.	L	27							
Cricotopus sp.	P	3							
Cardiodadius sp.	L	13	1				1	8	
Orthocladius sp.	L		2	8		5			2
Thienemanniella sp.	L					1			
Orthocladiinae sp. indet.	L						1		
Chironomidae sp. indet.	L						1		
F. Tipulidae									
Hexatoma sp.	L	3	9	5		1		1	
Antocha sp.	L			3		12	32	1	
Tipulidae sp. indet.	L	1							
F. Rhagionidae									
Atherix sp.	L	1	1	15	2	8	1		1
F. Simuliidae									
Simulium sp.	L			1		1	2		
Simulium sp.	P			1					
F. Psychodidae									
Pericoma sp.	L							1	
F. Empididae									
Empididae sp. indet.	L								1
F. Syrphidae									
Syrphidae sp. indet.	L								1

TABLE 17: Benthic Macro-Invertebrates - Detailed Identifications, September 1976

TAXA	LIFE STAGE*	STATION NO. 1	2	3	4	5	6	7	8
GROUP 2 ORGANISMS Cont'd									
HYDRACARINA									
F. Lebertiidae									
Lebertia sp.	A							1	
TURBELLARIA									
Turbellaria sp. indet.	A								2
GROUP 1 ORGANISMS									
OLIGOCHAETA									
F. Naididae	A			2					
F. Lumbricidae	A								5
Oligochaeta sp. indet.	A		1			3			
TOTAL NO. OF ORGANISMS		102	65	105	15	109	107	107	109
TOTAL NO. OF TAXA		15	16	19	5	18	15	17	20

* N = nymph
L = larvae
P = pupae
A = adult

TABLE 18: Benthic Macro-Invertebrates - Detailed Identifications, September 1976

TAXA	LIFE STAGE*	STATION NO. 10	11	12	13	14	15	16	17
GROUP 3 ORGANISMS									
EPHEMEROPTERA									
F. Heptageniidae									
Rhithrogena sp.	N	18	7		8	32	37		
Cinygmula sp.	N	1		23	15		5		
F. Baetidae									
Baetis sp.	N	17	5	4	2	28	28		
Ephemerella sp. 1	N	6	25		5	13	2		
Ephemerella sp. 2	N	1			3	2	10		
Ameletus sp.	N	3		2			1		
TRICHOPTERA									
F. Hydropsychidae									
Hydropsyche sp.	L	19	31		1	1			
Diplectrona sp.	L	2							
F. Rhyacophilidae									
Agapetus sp.	L	1		1	1				
F. Brachycentridae									
Brachycentrus sp.	L	2	3						
Trichoptera sp. indet.	L				1				
PLECOPTERA									
F. Perlidae									
Claassenia sp.	N	5	16				3		
F. Pteronarcidae									
Pteronarcella sp.	N		2						

TABLE 18: Benthic Macro-Invertebrates - Detailed Identifications, September 1976

TAXA	LIFE STAGE*	STATION NO. 10	11	12	13	14	15	16	17
GROUP 3 ORGANISMS Cont'd									
PLECOPTERA Cont'd									
F. Chloroperlidae									
Hastaperla sp.	N	6		4	2		1		
F. Perlodidae									
Isogenus sp.	N			2					
F. Nemouridae									
Nemoura sp.	N		1	6		1	7		
COLEOPTERA									
F. Elmidae									
Lara sp.	L	1							
Zaitzevia sp.	L	2							
Narpus sp.	L	2							
F. Elmidae sp. indet.	L					1			
Coleoptera sp. indet.	L								
ODONATA									
S.O. Zygoptera									
F. Agrionidae									
Ischnura sp.	N								2
GROUP 2 ORGANISMS									
DIPTERA									
F. Chironomidae									
S.F. Tanypodinae									
Procladius sp.	L							4	1

TABLE 18: Benthic Macro-Invertebrates - Detailed Identifications, September 1976

TAXA	LIFE STAGE*	STATION NO. 10	11	12	13	14	15	16	17
GROUP 2 ORGANISMS Cont'd									
DIPTERA Cont'd									
S.F. Chironominae									
Micropsectra sp.	L	3	7			2	2		
Chironomus sp.	L							2	46
S.F. Orthocladiinae									
Cardiocladius sp.	L	4	2	1		5	1		
Orthocladius sp.	L		3						
Orthocladiinae sp. indet.	L	1							
F. Tipulidae									
Hexatoma sp.	L	1							
Antocha sp.	L		6						
Tipula sp.	L			3					
F. Simuliidae									
Simulium sp.	L	1	2				2		
F. Psychodidae									
Pericoma sp.	L				91				
F. Ceratopogonidae									
Leptoconops sp.	L	3							
F. Culicidae									
Chaoborus sp.	L							5	15
Diptera sp. indet.	L					1			
HYDRACARINA									
F. Lebertiidae									
Lebertia sp.	A	1			1				

TABLE 18: Benthic Macro-Invertebrates - Detailed Identifications, September 1976

TAXA	LIFE STAGE*	STATION NO. 10	11	12	13	14	15	16	17
GROUP 2 ORGANISMS Cont'd									
TURBELLARIA									
Turbellaria sp. indet.	A	1		14	5	1	8		
NEMATODA									
Nematoda sp. indet.	A					2			1
AMPHIPODA									
F. Talitridae									
Hyalella azteca	A							101	10
COELENTERATA									
Hydra sp.									2
HIRUDINEA									
F. Glossiphoniidae									
Glossiphoniidae sp. indet.	A								5
BIVALVIA									
F. Sphaeriidae									
Sphaerium sp.	A								1
GASTROPODA									
F. Planorbidae									
Planorbidae sp. indet.	A								3

TABLE 18: Benthic Macro-Invertebrates - Detailed Identifications, September 1976

TAXA	LIFE STAGE*	STATION NO. 10	11	12	13	14	15	16	17
GROUP I ORGANISMS									
OLIGOCHAETA									
F. Naididae	A	1				12	1		27
F. Lumbricidae	A			52					
TOTAL NO. OF ORGANISMS		102	110	112	135	101	108	112	113
TOTAL NO. OF TAXA		24	13	11	12	13	14	4	11

* N = nymph
L = larva
A = adult

JUNE 1977

TABLE 1: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 1 - Bonaparte River (Surber Sampler)

	SAMPLE NUMBER 1	2	3	4	5*	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	16	33	43	2	54	39	31.2
Trichoptera	2	4	1	1	1	1	1.7
Plecoptera		1	3			2	1.0
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	1	1				2	0.7
Other Diptera	2	1	1			1	0.8
Gastropoda						1	0.2
TOTAL NO. OF ORGANISMS	21	40	48	3	55	46	36
TOTAL NO. OF TAXA	4	5	4	2	2	6	4

Laboratory Sample Residue: fine plant debris, gravel and sand

* Sample selected for detailed identification

beak

TABLE 2: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 2 - Bonaparte River (Surber Sampler)

	SAMPLE NUMBER 1*	2*	3*	4*	5*	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	9	8		4			3.5
GROUP 2 ORGANISMS							
Diptera							
Chironomidae					1		0.2
Other Diptera	2		1			1	0.7
Bivalvia	1						0.2
TOTAL NO. OF ORGANISMS	12	8	1	4	1	1	5
TOTAL NO. OF TAXA	3	1	1	1	1	1	1

Laboratory Sample Residue: gravel, rocks

* Sample selected for detailed identification

TABLE 3: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 3 - Bonaparte River (Surber Sampler)

	SAMPLE NUMBER 1	2	3*	4*	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	33	12	10	57	21	47	30.0
Trichoptera	13	2	2	14	3	3	6.2
Coleoptera	1						0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	7	3		14		5	4.8
Other Diptera	4	2	2	8	6	8	5.0
TOTAL NO. OF ORGANISMS	58	19	14	93	30	63	46
TOTAL NO. OF TAXA	5	4	3	4	3	4	4

Laboratory Sample Residue: gravel, stones, wood pieces and plant debris

* Sample selected for detailed identification

TABLE 4: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 4 - Bonaparte River (Surber Sampler)

	SAMPLE NUMBER						
	1	2	3*	4	5*	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	5	5	19	3	5	31	11.3
Trichoptera		19	3	10	43	3	13.0
Plecoptera		1	1		2	3	1.2
Coleoptera		1	2		1		0.7
Odonata	1		1		1	2	0.8
GROUP 2 ORGANISMS							
Diptera							
Chironomidae		4	10		4	5	3.8
Other Diptera	1	1	9		1	5	2.8
Bivalvia				1			0.2
Hirudinea	1						0.2
Nematoda				1		1	0.3
Hydracarina					1		0.2
GROUP 1 ORGANISMS							
Oligochaeta			1				0.2
TOTAL NO. OF ORGANISMS	8	31	46	15	58	50	35
TOTAL NO. OF TAXA	4	6	8	4	8	7	6

Laboratory Sample Residue: gravel, sand, rocks, some plant debris, wood pieces

* Sample selected for detailed identification

TABLE 5: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 5 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER						
	1*	2	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	54	118	116	58	42	13	66.8
Trichoptera	10	17	11	6	3	2	8.2
Plecoptera	4	12	8	9		2	5.8
Coleoptera	2		3	1	5	2	2.2
Odonata						1	0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	87	276	280	205	108	162	186.3
Other Diptera	6	9	24	11	21	10	13.5
GROUP 1 ORGANISMS							
Oligochaeta	2	7	2	8	7	2	4.7
TOTAL NO. OF ORGANISMS	165	439	444	298	186	194	288
TOTAL NO. OF TAXA	7	6	7	7	6	8	7

Laboratory Sample Residue: gravel, sand, organic debris

* Sample selected for detailed identification

TABLE 6: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 6 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER						Av./
	1	2	3*	4	5	6	Sample
GROUP 3 ORGANISMS							
Ephemeroptera	24	22	18	55	24	35	29.7
Trichoptera	18	12	6	3	4	51	15.7
Plecoptera	2	10	3	5	5	10	5.8
Coleoptera						1	0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	113	128	88	178	129	90	121.0
Other Diptera	11	7	4	9	3	12	7.7
Turbellaria				1			0.2
Nematoda				1			0.2
GROUP 1 ORGANISMS							
Oligochaeta	11	12	38	9	4		12.3
TOTAL NO. OF ORGANISMS	179	191	157	261	169	199	193
TOTAL NO. OF TAXA	6	6	6	8	6	6	6

Laboratory Sample Residue: gravel, algal balls, fine plant debris

* Sample selected for detailed identification

TABLE 7: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 7 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER 1	2	3	4*	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	5	56	55	49	33	22	36.7
Trichoptera	3	10	9	7	39	45	18.8
Plecoptera	1	7	6	10	6	5	5.8
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	58	4	26	19	3	4	19.0
Other Diptera	4		22	13	5	9	8.8
Nematoda	2						0.3
Turbellaria			1	2		1	0.7
GROUP 1 ORGANISMS							
Oligochaeta			2	1	2	1	1.0
TOTAL NO. OF ORGANISMS	73	77	121	101	88	87	91
TOTAL NO. OF TAXA	6	4	7	7	6	7	6

Laboratory Sample Residue: sand, gravel, algae, plant debris

* Sample selected for detailed identification

TABLE 8: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 8 - Small Tributary (Surber Sampler)

	SAMPLE NUMBER 1*	2	3	4	5	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	36	78	31	42	19	29	39.2
Trichoptera	3	5		5	3	3	3.2
Plecoptera	5	28	1	10	1	1	7.7
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	1			1			0.3
Other Diptera	4	8		4	1	2	3.2
Turbellaria	2	5	2	4		5	3.0
Nematoda						1	0.2
GROUP 1 ORGANISMS							
Oligochaeta	3	10	1	2	3	9	4.7
TOTAL NO. OF ORGANSISM	54	134	35	68	27	50	62
TOTAL NO. OF TAXA	7	6	4	7	5	7	6

Laboratory Sample Residue: rocks, gravel, leaf debris, twigs

* Sample selected for detailed identification

TABLE 9: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 10 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER 1	2	3	4*	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	55	65	36	63	25	31	45.8
Trichoptera	7	6	9	5	2	4	5.5
Plecoptera	14	9	13	10	1	1	8.0
Coleoptera	1	3		1			0.8
GROUP 2 ORGANSIMS							
Diptera							
Chironomidae	18	2	42	22	5	15	17.3
Other Diptera	3	2	5	3	4		2.8
Turbellaria		2					0.3
Nematoda						1	0.2
GROUP 1 ORGANISMS							
Oligochaeta		3	1	1	1		1.0
TOTAL NO. OF ORGANISMS	98	92	106	105	38	52	82
TOTAL NO. OF TAXA	6	8	6	7	6	5	6

Laboratory Sample Residue: leaves, gravel, fine plant debris, small wood pieces

* Sample selected for detailed identification

TABLE 10: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 11 - Medicine Creek (Surber Sampler)

	SAMPLE NUMBER 1*	2	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	5	12	14	2	20	11	10.7
Trichoptera	8	15	13	2	18	15	11.8
Plecoptera	8	17	8	3	8	12	9.3
Coleoptera	10	5	4	1	3	6	4.8
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	45	77	163	40	87	236	108.0
Other Diptera	4	13	4	1	13	12	7.8
Turbellaria	27	9	4		34	81	25.8
Nematoda	2			4			1.0
GROUP 1 ORGANISMS							
Oligochaeta	67	28	6	9	7	30	24.5
TOTAL NO. OF ORGANISMS	176	176	216	62	190	403	204
TOTAL NO. OF TAXA	9	8	8	8	8	8	8

Laboratory Sample Residue: gravel, sand, organic debris, plant debris

* Sample selected for detailed identification

TABLE 11: Benthic Macroinvertebrates - First Order Identificatior
June 1977

STATION: 13 - Anderson Creek (Surber Sampler)

	SAMPLE NUMBER						
	1*	2*	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	80	56	164	147	166	142	125.8
Trichoptera	1	1	2	2	2	5	2.2
Plecoptera	2	3	3		19	5	5.3
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	1	1	3		4	7	2.7
Other Diptera	1	1	3	2	1	3	1.8
Turbellaria	9		4	4	18	12	7.8
Amphipoda				1			0.2
GROUP 1 ORGANISMS							
Oligochaeta	1	1	2	3	4	4	2.5
TOTAL NO. OF ORGANISMS	95	63	181	159	214	178	148
TOTAL NO. OF TAXA	7	6	7	6	7	7	7

Laboratory Sample Residue: gravel, leaves, twigs, sand

* Sample selected for detailed identification

TABLE 12: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 14 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER 1	2	3	4	5*	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	108	68	40	47	77	68	68.0
Trichoptera	1	3		5	8		2.8
Plecoptera	3	3	1	1	2	3	2.2
Coleoptera						1	0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	11	14	10	36	22	11	17.3
Other Diptera	3	3	1		2	2	1.8
Bivalvia	2	1			1	2	1.0
Turbellaria	1	3	2		2	1	1.5
Nematoda	1	1	1			1	0.7
Hydracarina		1					0.2
GROUP 1 ORGANISMS							
Oligochaeta	2	27	12	8	2	3	9.0
TOTAL NO. OF ORGANISMS	132	124	118	97	116	92	105
TOTAL NO. OF TAXA	9	10	7	5	8	9	8

Laboratory Sample Residue: sand & gravel, organic debris

* Sample selected for detailed identification

TABLE 13: Benthic Macroinvertebrates - First Order Identification
June 1977

STATION: 15 - Hat Creek (Surber Sampler)

	SAMPLE NUMBER 1	2*	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	1	2		3	1	1	1.3
Trichoptera	5	3	4	5	6	6	4.8
Plecoptera	22	22	10	48	25	23	25.0
Coleoptera			1				0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	85	25	41	90	37	78	59.3
Other Diptera	56	20	479	18	372	227	195.3
Turbellaria	76	59	29	67	89	84	67.3
GROUP 1 ORGANISMS							
Oligochaeta	7	2	3			6	3.0
TOTAL NO. OF ORGANISMS	252	133	567	231	530	425	356
TOTAL NO. OF TAXA	7	7	7	6	6	7	7

Laboratory Sample Residue: gravel, leaves, organic debris, plant pieces, some fine wood pieces

* Sample selected for detailed identification

TABLE 14: Benthic Macro-Invertebrates - Detailed Identification, June 1977

TAXA	LIFE STAGE*	1	2	3	4	5	6	7	8
GROUP 3 ORGANISMS									
EPHEMEROPTERA									
F. Heptageniidae									
Rhithrogena sp.	N	60	17	28	5	6	-	2	-
Ironopsis sp.	N	-	-	-	-	-	-	4	22
Cinygmula sp.	N	-	-	-	-	-	-	5	15
F. Baetidae									
Baetis sp.	N	15	1	33	3	14	13	30	28
Ephemerella sp. 1	N	15	3	4	12	26	4	7	-
Ephemerella sp. 2	N	3	-	2	2	6	-	1	-
Paraleptophlebia sp.	N	-	-	-	2	-	1	-	-
Caenis sp.	N	-	-	-	-	2	-	-	-
TRICHOPTERA									
F. Hydropsychidae									
Hydropsyche sp.	L	1	-	1	-	-	4	1	2
F. Brachycentridae									
Brachycentrus sp.	L	1	-	15	46	1	-	3	-
F. Hydroptilidae									
Hydroptilidae sp. indet.	EI	-	-	-	-	9	-	-	-
F. Limnephilidae									
Limnephilidae sp. indet.	L	-	-	-	-	-	2	2	-
F. Glossosomatidae									
Agapetus sp.	L	-	-	-	-	-	-	1	-
F. Rhyacophilidae									
Rhyacophila sp.	L	-	-	-	-	-	-	-	4

beak

TABLE 14 CONT'D: Benthic Macro-Invertebrates - Detailed Identification, June 1977

TAXA	LIFE STAGE*	STATION NO. 1	2	3	4	5	6	7	8
GROUP 3 ORGANISMS Cont'd.									
PLECOPTERA									
F. Perlidae									
Claassenia sp.	N	2	-	-	1	3	3	2	-
F. Chloroperlidae									
Hastaperla sp.	N	-	-	-	2	-	-	8	2
F. Pteronarcidae									
Pteronarcella sp.	N	-	-	-	-	1	-	-	-
F. Perlodidae									
Isogenus sp.	N	-	-	-	-	-	-	-	4
COLEOPTERA									
F. Elmidae									
Narpus sp.	L	-	-	-	3	2	-	-	-
ODONATA									
S.O. Anisoptera									
F. Gomphidae									
Ophiogomphus sp.	N	-	-	-	2	-	-	-	-
GROUP 2 ORGANISMS									
DIPTERA									
F. Chironomidae									
S.F. Tanypodinae									
Procladius sp.	L	-	-	-	-	2	-	1	-
S.F. Chironominae									
Micropsectra sp.	L	1	1	2	14	75	13	1	-
Chironomus sp.	L	-	-	-	-	-	-	2	-

TABLE 14 CONT'D: Benthic Macro-Invertebrates - Detailed Identification, June 1977

TAXA	LIFE STAGE*	STATION NO. 1	2	3	4	5	6	7	8
GROUP 2 ORGANISMS Cont'd.									
DIPTERA cont'd.									
F. Chironomidae cont'd.									
S.F. Orthocladiinae									
Cricotopus sp.	L	1	-	6	-	-	-	-	-
Orthocladius sp.	L	-	-	6	-	1	37	7	-
Cardiocladius sp.	L	-	-	-	-	9	38	8	-
Chironomidae sp. indet.	P	-	-	-	-	-	-	-	1
F. Tipulidae									
Hexatoma sp.	L	1	3	3	5	-	-	1	-
Antocha sp.	L	-	-	-	-	-	2	6	2
Antocha sp.	L	-	-	-	-	-	-	2	-
F. Tanyderidae									
Protoplasa sp.	L	-	1	-	-	-	-	-	-
F. Rhagionidae									
Atherix sp.	L	-	-	5	1	-	-	1	-
F. Simuliidae									
Simulium sp.	L	-	-	-	1	-	-	-	1
Simulium sp.	P	-	-	-	-	-	-	-	3
F. Ceratopogonidae									
Ceratopogonidae sp. indet.	L	-	-	1	3	3	-	2	-
F. Empididae									
Empididae sp. indet.	L	-	-	1	-	3	2	-	-
F. Psychodidae									
Pericoma sp.	L	-	-	-	-	-	-	1	-
HYDRACARINA									
F. Sperchonidae									
Sperchon sp.	A	-	-	-	1	-	-	-	-

TABLE 14 CONT'D: Benthic Macro-Invertebrates - Detailed Identification, June 1977

TAXA	LIFE STAGE*	1	2	3	4	5	6	7	8
		STATION NO.							
GROUP 2 ORGANISMS Cont'd.									
TURBELLARIA									
O. Neorhabdocoela									
sp. indet.	A	-	-	-	-	-	-	2	7
GASTROPODA									
F. Bulimidae									
Bulimidae sp. indet.	A	1	-	-	-	-	-	-	-
BIVALVIA									
F. Sphaeriidae									
Pisidium sp.	A	-	1	-	-	-	-	-	-
NEMATODA									
Nematoda sp. indet.	A	-	-	-	-	-	-	-	1
GROUP 1 ORGANISMS									
OLIGOCHAETA									
F. Naididae	A	-	-	-	1	2	38	-	-
F. Lumbricidae	A	-	-	-	-	-	-	1	12
TOTAL NO. OF ORGANISMS		101	27	107	104	165	157	101	104
TOTAL NO. OF TAXA		11	7	13	17	17	12	24	13

* N = nymph　A = adult
L = larvae　EI = early instar
P = pupae

TABLE 14 CONT'D: Benthic Macro-Invertebrates - Detailed Identification, June 1977

TAXA	LIFE STAGE*	STATION NO. 10	11	13	14	15
GROUP 3 ORGANISMS						
EPHEMEROPTERA						
F. Heptageniidae						
Rhithrogena sp.	N	7	-	-	5	-
Ironopsis sp.	N	8	5	31	34	1
Cinygmula sp.	N	11	-	37	7	1
F. Baetidae						
Baetis sp.	N	35	-	49	29	-
Ephemerella sp. 1	N	2	-	4	2	-
Ameletus sp.	N	-	-	15	-	-
TRICHOPTERA						
F. Hydropsychidae						
Hydropsyche sp.	L	1	1	-	2	-
Hydropsyche sp.	P	-	-	-	1	-
F. Brachycentridae						
Brachycentrus sp.	L	1	-	-	1	-
F. Limnephilidae						
Limnephilidae sp. indet.	L	-	1	-	-	3
F. Glossosomatidae						
Agapetus sp.	L	-	-	1	-	-
F. Rhyacophilidae						
Rhyacophila sp.	L	3	6	1	4	-
PLECOPTERA						
F. Perlidae						
Claassenia sp.	N	5	7	-	-	-
F. Chloroperlidae						
Hastaperla sp.	N	5	1	3	1	22

TABLE 14 CONT'D: Benthic Macro-Invertebrates - Detailed Identification, June 1977

TAXA	LIFE STAGE*	STATION NO. 10	11	13	14	15
GROUP 3 ORGANISMS Cont'd.						
PLECOPTERA cont'd.						
F. Perlodidae						
Isogenus sp.	N	-	-	2	-	-
F. Nemouridae						
Nemoura sp.	N	-	-	-	1	-
COLEOPTERA						
F. Elmidae						
Narpus sp.	L	1	-	-	-	-
Zaitzevia sp.	L	-	10	-	-	-
GROUP 2 ORGANISMS						
DIPTERA						
F. Chironomidae						
S.F. Chironominae						
Micropsectra sp.	L	1	4	2	5	-
S.F. Orthocladiinae						
Cardiocladius sp.	L	14	41	-	16	23
Cardiocladius sp.	P	2	-	-	-	1
Orthocladius sp.	L	5	-	-	1	1
F. Tipulidae						
Antocha sp.	L	1	2	-	1	-
Tipulidae sp. indet.	L	-	-	1	-	-
F. Simuliidae						
Simulium sp.	L	-	2	1	1	20
F. Ceratopogonidae						
Leptoconops sp.	L	1	-	-	-	-

TABLE 14 CONT'D: Benthic Macro-Invertebrates - Detailed Identification, June 1977

TAXA	LIFE STAGE*	STATION NO. 10	11	13	14	15
GROUP 2 ORGANISMS Cont'd.						
DIPTERA cont'd.						
F. Psychodidae						
Pericoma sp.	L	1	-	-	-	-
TURBELLARIA						
O. Neorhabdocoela sp. Indet.	A	-	27	9	2	59
BIVALVIA						
F. Sphaeriidae						
Pisidium sp.	A	-	-	-	1	-
NEMATODA						
Nematoda sp. Indet.	A	-	2	-	-	-
GROUP 1 ORGANISMS						
OLIGOCHAETA						
F. Naididae	A	-	49	1	-	-
F. Lumbricidae	A	1	18	1	2	2
TOTAL NO. OF ORGANISMS		105	176	158	116	133
TOTAL NO. OF TAXA		18	15	15	18	9

* N = nymph
L = larvae
P = pupae
A = adult

AUGUST 1977

TABLE 1: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 1 - Bonaparte River (Surber Sampler)

TAXA	Sample Number 1	2	3	4	5	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	20	35	19	42	20	58	32.3
Trichoptera	8	11	23	29	36	34	23.5
Plecoptera	-	2	-	1	8	7	3.0
Coleoptera	3	-	1	1	-	1	1.0
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	3	22	2	11	9	14	10.2
Other Diptera	2	4	8	12	5	3	5.7
Nematoda	1	1	-	-	-	-	0.3
GROUP 1 ORGANISMS							
Oligochaeta	3	5	1	.2	4	3	3.0
TOTAL NO. OF ORGANISMS	40	80	54	98	82	120	79
TOTAL NO. OF TAXA	7	7	6	7	6	7	7

Other Organisms in Samples: Coleoptera adults - 2

Laboratory Sample Residue: plant debris, sand, wood pieces, fine plant debris, gravel

* Sample selected for detailed identification

TABLE 2: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 2 - Bonaparte River (Surber Sampler)

TAXA	Sample Number 1	2	3*	4*	5	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	5	41	7	55	9	15	22.0
Trichoptera	5	3	-	1	1	1	1.8
Plecoptera	1	3	1	6	-	2	2.2
Coleoptera	-	-	-	1	-	-	0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	1	4	-	8	1	1	2.5
Other Diptera	-	8	-	1	1	3	2.2
TOTAL NO. OF ORGANISMS	12	59	8	72	12	22	31
TOTAL NO. OF TAXA	4	5	2	6	4	5	4

Laboratory Sample Residue: sand, wood pieces, gravel, fine plant debris, stones

* Samples selected for detailed identification

TABLE 3: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 3 - Bonaparte River (Surber Sampler)

TAXA	Sample Number 1	2	3	4*	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	102	37	54	39	12	61	50.8
Trichoptera	8	46	45	9	23	12	23.8
Plecoptera	8	2	3	2	-	2	2.8
Coleoptera	6	2	2	8	2	2	3.7
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	35	5	9	40	7	32	21.3
Other Diptera	28	19	10	11	6	22	16.0
GROUP 1 ORGANISMS							
Oligochaeta	5	2	5	1	-	-	2.2
TOTAL NO. OF ORGANISMS	192	113	128	110	50	131	121
TOTAL NO. OF TAXA	7	7	7	7	5	6	7

Laboratory Sample Residue: wood pieces, plant debris, gravel, stones, sand, fine plant debris

* Sample selected for detailed identification

TABLE 4: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 4 - Bonaparte River (Surber Sampler)

TAXA	Sample Number 1	2*	3	4	5	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	19	64	52	27	49	19	38.3
Trichoptera	7	-	9	43	3	-	10.3
Plecoptera	-	2	18	16	2	3	6.8
Coleoptera	1	4	1	-	5	-	1.8
Odonata	-	-	-	-	1	-	0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	3	5	-	2	3	1	2.3
Other Diptera	5	2	12	8	6	3	6.0
Nematoda	-	1	-	-	-	-	0.2
TOTAL NO. OF ORGANISMS	35	78	92	96	69	26	66
TOTAL NO. OF TAXA	5	6	5	5	7	4	5

Other Organisms in Samples: Coleoptera adult - 1

Laboratory Sample Residue: wood pieces, sand, fine plant debris, algae, stones

* Samples selected for detailed identification

TABLE 5: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 5 - Hat Creek (Surber Sampler)

TAXA	Sample Number 1	2	3	4*	5	6	Av./Sample
GROUP 3 ORGANISMS							
Ephemeroptera	29	33	36	45	47	85	45.8
Trichoptera	21	10	8	2	5	20	11.0
Plecoptera	17	36	20	10	12	4	16.5
Coleoptera	10	3	8	12	12	9	9.0
Odonata	1	-	-	-	-	-	0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	24	19	65	18	40	36	33.7
Other Diptera	11	5	4	17	3	-	6.7
GROUP 1 ORGANISMS							
Oligochaeta	-	-	6	1	10	2	3.2
TOTAL NO. OF ORGANISMS	113	106	147	105	129	156	126
TOTAL NO. OF TAXA	7	6	7	7	7	6	7

Other Organisms in Samples: Coleoptera adults - 2

Laboratory Sample Residue: fine plant debris, wood pieces, sand, fine organic debris

* Sample selected for detailed identification

TABLE 6: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 6 - Hat Creek (Surber Sampler)

TAXA	Sample Number 1	2	3*	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	92	79	55	61	46	114	74.5
Trichoptera	26	17	21	16	2	15	16.2
Plecoptera	5	8	7	8	3	4	5.8
Coleoptera	1	-	3	1	-	-	0.8
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	7	3	2	15	1	17	7.5
Other Diptera	38	14	13	35	16	36	25.3
GROUP 1 ORGANISMS							
Oligochaeta	1	2	1	2	-	2	1.3
TOTAL NO. OF ORGANISMS	170	123	102	138	68	188	131
TOTAL NO. OF TAXA	7	6	7	7	5	6	6

Laboratory Sample Residue: sand, stones, fine organic debris, wood pieces, gravel

* Sample selected for detailed identification

TABLE 7: Benthic Macroinvertebrates - First Order Identificatior
August 1977

STATION: 7 - Hat Creek (Surber Sampler)

TAXA	Sample Number 1*	2	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	64	89	96	97	103	82	88.5
Trichoptera	27	26	51	4	27	26	26.8
Plecoptera	10	16	17	9	3	9	10.7
Coleoptera	1	-	-	-	-	-	0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	5	25	19	23	27	33	22.0
Other Diptera	4	7	1	-	4	11	4.5
Turbellaria	1	-	-	-	-	1	0.3
Hydracarina	-	-	-	-	1	-	0.2
GROUP 1 ORGANISMS							
Oligochaeta	1	-	8	3	-	8	3.3
TOTAL NO. OF ORGANISMS	113	163	192	136	165	170	157
TOTAL NO. OF TAXA	8	5	6	5	6	7	6

Laboratory Sample Residue: wood pieces, fine plant debris, gravel, sand

* Sample selected for detailed identification

TABLE 8: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 8 - Small Creek (Surber Sampler)

TAXA	Sample Number 1	2*	3	4	5	6*	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	42	23	52	14	11	12	25.7
Trichoptera	4	4	6	1	1	9	4.2
Plecoptera	32	30	42	25	17	22	28.0
Coleoptera	-	-	-	-	-	1	0.2
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	1	5	-	-	-	-	1.0
Other Diptera	3	-	-	-	1	-	0.7
GROUP 1 ORGANISMS							
Oligochaeta	2	1	-	3	1	-	1.2
TOTAL NO. OF ORGANISMS	84	63	100	43	31	44	61
TOTAL NO. OF TAXA	6	5	3	4	5	4	5

Other Organisms in Samples: Coleoptera adult - 1

Laboratory Sample Residue: sand, wood pieces, fine plant debris, gravel, stones

* Samples selected for detailed identification

TABLE 9: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 10 - Hat Creek (Surber Sampler)

TAXA	Sample Number 1	2*	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	52	57	51	63	68	79	61.7
Trichoptera	8	18	13	24	8	15	14.3
Plecoptera	5	15	8	21	21	19	14.8
Coleoptera	1	2	1	-	2	3	1.5
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	21	8	33	13	13	15	17.2
Other Diptera	1	3	5	2	2	7	3.3
Turbellaria	-	-	-	-	5	-	0.8
GROUP 1 ORGANISMS							
Oligochaeta	1	1	-	-	-	1	0.5
TOTAL NO. OF ORGANISMS	89	104	111	123	119	139	114
TOTAL NO. OF TAXA	7	7	6	5	7	7	7

Laboratory Sample Residue: plant debris, sand, wood pieces, rocks, stones

* Sample selected for detailed identification

TABLE 10: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 11 - Medicine Creek (Surber Sampler)

TAXA	Sample Number 1*	2	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	94	174	230	182	140	197	169.5
Trichoptera	-	2	-	-	5	5	2.0
Plecoptera	44	66	38	59	81	234	87.0
Coleoptera	-	7	10	9	3	4	5.5
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	38	40	56	36	35	57	43.7
Other Diptera	2	2	1	2	3	8	3.0
Turbellaria	1	1	16	3	5	7	5.5
GROUP 1 ORGANISMS							
Oligochaeta	2	5	10	5	5	13	6.7
TOTAL NO. OF ORGANISMS	181	297	361	296	277	525	323
TOTAL NO. OF TAXA	6	8	7	7	8	8	7

Other Organisms in Samples: Coleoptera adults - 4

Laboratory Sample Residue: plant debris, sand, gravel, wood pieces, fine organic debris

* Sample selected for detailed identification

TABLE 11: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 13 - Anderson Creek (Surber Sampler)

TAXA	Sample Number 1*	2	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	56	117	115	36	94	40	76.3
Trichoptera	15	4	6	2	4	2	5.5
Plecoptera	30	72	116	21	48	36	53.7
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	1	-	7	8	3	-	3.2
Amphipoda	2	3	1	4	1	3	2.3
Turbellaria	-	2	2	-	-	-	0.7
GROUP 1 ORGANISMS							
Oligochaeta	5	5	-	4	3	-	2.8
TOTAL NO. OF ORGANISMS	109	203	247	75	153	80	145
TOTAL NO. OF TAXA	6	6	6	6	6	4	6

Laboratory Sample Residue: wood pieces, fine plant debris, sand

* Sample selected for detailed identification

TABLE 12: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 14 - Hat Creek (Surber Sampler)

TAXA	Sample Number 1*	2	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	58	90	83	56	52	57	66.0
Trichoptera	13	4	4	10	3	3	6.2
Plecoptera	29	16	23	13	20	33	22.3
Coleoptera	1	-	1	2	-	-	0.7
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	24	49	32	25	29	36	32.5
Other Diptera	13	17	1	6	-	2	6.5
GROUP 1 ORGANISMS							
Oligochaeta	-	11	13	3	3	8	6.3
TOTAL NO. OF ORGANISMS	138	187	157	115	107	139	141
TOTAL NO. OF TAXA	6	6	7	7	5	6	6

Laboratory Sample Residue: wood pieces, plant debris, sand, stones, gravel

* Sample selected for detailed identification

TABLE 13: Benthic Macroinvertebrates - First Order Identification
August 1977

STATION: 15 - Hat Creek (Surber Sampler)

TAXA	Sample Number 1*	2	3	4	5	6	Av./ Sample
GROUP 3 ORGANISMS							
Ephemeroptera	25	37	16	6	28	21	22.2
Trichoptera	-	3	-	1	1	1	1.0
Plecoptera	57	15	79	52	15	47	44.2
Coleoptera	1	-	1	1	-	-	0.5
GROUP 2 ORGANISMS							
Diptera							
Chironomidae	101	162	103	105	246	157	145.7
Other Diptera	2	6	-	7	22	8	7.5
Turbellaria	-	3	2	8	6	3	3.7
GROUP 1 ORGANISMS							
Oligochaeta	-	4	6	22	-	-	5.3
TOTAL NO. OF ORGANISMS	186	230	207	202	318	237	230
TOTAL NO. TAXA	5	7	6	8	6	6	6

Other Organisms in Samples: Hemiptera - F. Corixidae - 1

Laboratory Sample Residue: fine organic debris, wood pieces, stones, gravel

* Sample selected for detailed identification

TABLE 14: Benthic Macroinvertebrates - Detailed Identification, August 1977

TAXA	LIFE STAGE*	Station No. 1	2	3	4	5	6	7
GROUP 3 ORGANISMS								
EPHEMEROPTERA								
F. Heptageniidae								
Rhithrogena sp.	N	2	25	-	26	-	-	-
Ironopsis sp.	N	-	-	-	1	-	-	1
Cinygmula sp.	N	-	-	-	1	6	-	-
F. Baetidae								
Baetis sp.	N	43	33	7	15	27	40	41
Baetis sp.	E	1	-	-	-	-	-	-
Ephemerella sp. 1	N	9	13	7	28	1	3	10
Ephemerella sp. 2	N	-	-	-	-	11	10	10
Paraleptophlebia sp.	N	-	1	-	-	-	-	1
Caenis sp.	N	3	5	25	12	-	-	-
Ameletus sp.	N	-	-	-	-	-	2	1
TRICHOPTERA								
F. Hydropsychidae								
Hydropsyche sp.	L	27	1	3	-	-	18	20
Hydropsyche sp.	P	1	-	-	-	-	-	-
F. Brachycentridae								
Brachycentrus sp.	L	4	-	3	-	-	-	-
F. Hydroptilidae								
Hydroptilidae sp. indet.	EI	1	-	-	-	2	-	-
F. Limnephilidae								
Limnephilidae sp. indet.	L	-	-	-	-	-	2	-
Limnephilidae sp. indet.	P	-	-	-	-	-	1	-

TABLE 14 Cont'd: Benthic Macroinvertebrates - Detailed Identification, August 1977

TAXA	LIFE STAGE*	Station No. 1	2	3	4	5	6	7
TRICHOPTERA Cont'd.								
F. Rhyacophilidae								
Rhyacophila sp.	L	1	-	-	-	-	-	-
F. Glossosomatidae								
Agapetus sp.	L	-	1	3	-	-	-	6
F. Psychomyiidae								
Neureclipsis sp.	L	-	-	-	-	-	-	1
PLECOPTERA								
F. Perlidae								
Claassenia sp.	N	-	1	-	1	7	6	5
F. Chloroperlidae								
Hastaperla sp.	N	1	1	-	1	1	1	4
F. Pteronarcidae								
Pteronarcella sp.	N	3	5	-	2	2	-	-
F. Perlodidae								
Isogenus sp.	N	3	2	2	1	-	-	1
COLEOPTERA								
F. Elmidae								
Narpus sp.	L	1	1	7	4	11	-	1
Zaitzevia sp.	L	-	-	1	-	1	3	-
GROUP 2 ORGANISMS								
DIPTERA								
F. Chironomidae								
S.F. Tanypodinae								
Procladius sp.	L	-	-	-	-	1	-	-
Procladius sp.	P	-	-	-	-	1	-	-

TABLE 14 Cont'd: Benthic Macroinvertebrates - Detailed Identification, August 1977

TAXA	LIFE STAGE*	Station No. 1	2	3	4	5	6	7
DIPTERA Cont'd.								
S.F. Chironominae								
Micropsectra sp.	L	2	3	30	2	10	1	2
S.F. Orthocladiinae								
Cricotopus sp.	L	9	-	2	4	6	-	-
Orthocladius sp.	L	3	6	8	-	-	1	-
Cardiocladius sp.	L	-	-	-	-	-	-	3
F. Tipulidae								
Hexatoma sp.	L	1	4	1	2	-	-	-
Antocha sp.	L	-	-	6	-	15	12	-
Antocha sp.	P	-	-	1	-	-	-	-
Tipulidae sp. indet.	L	-	-	-	-	1	-	1
F. Rhagionidae								
Atherix sp.	L	2	-	-	3	-	-	-
F. Empididae								
Empididae sp. indet.	L	-	-	1	-	1	-	2
Empididae sp. indet.	P	-	-	2	-	-	1	-
F. Ceratopogonidae								
Leptoconops sp.	L	-	-	-	-	-	-	1
TURBELLARIA								
O. Neorhabdocoela sp. indet.	A	-	-	-	-	-	-	1
NEMATODA								
Nematoda sp. indet.	A	-	-	-	1	-	-	-

beak

TABLE 14 Cont'd: Benthic Macroinvertebrates - Detailed Identification, August 1977

TAXA	LIFE STAGE*	Station No. 1	2	3	4	5	6	7
GROUP 1 ORGANISMS								
OLIGOCHAETA								
F. Naididae	A	3	-	1	-	-	1	-
F. Lumbricidae	A	-	-	-	-	1	-	1
TOTAL NUMBER OF ORGANISMS		120	102	110	104	105	102	113
TOTAL NUMBER OF TAXA		18	15	16	16	17	14	20

* N = nymph
E = emergent
L = larvae
P = pupae
A = adult
EI = early instar

TABLE 14 Cont'd: Benthic Macroinvertebrates - Detailed Identification, August 1977

TAXA	LIFE STAGE*	Station No. 8	10	11	13	14	15
GROUP 3 ORGANISMS							
EPHEMEROPTERA							
F. Heptageniidae							
Rhithrogena sp.	N	-	10	-	2	2	-
Ironopsis sp.	N	-	-	-	-	8	-
Cinygmula sp.	N	-	-	-	13	1	-
F. Baetidae							
Baetis sp.	N	18	30	54	4	26	-
Ephemerella sp. 1	N	4	13	19	-	19	8
Ephemerella sp. 2	N	-	-	3	-	-	-
Ephemerella sp. 3	N	-	-	-	1	-	-
Paraleptophlebia sp.	N	-	-	-	17	-	-
Ameletus sp.	N	13	4	18	19	2	17
TRICHOPTERA							
F. Hydropsychidae							
Hydropsyche sp.	L	-	16	-	-	-	-
F. Brachycentridae							
Brachycentrus sp.	L	-	-	-	3	2	-
F. Limnephilidae							
Limnephilidae sp. indet.	L	-	-	-	1	1	-
Limnephilidae sp. indet.	P	-	-	-	8	-	-
F. Glossosomatidae							
Agapetus sp.	L	8	1	-	-	1	-
F. Rhyacophilidae							
Rhyacophila sp.	L	3	-	-	-	1	-
F. Psychomyiidae							
Neureclipsis sp.	L	2	1	-	3	8	-

beak

TABLE 14 Cont'd: Benthic Macroinvertebrates - Detailed Identification, August 1977

TAXA	LIFE STAGE*	Station No. 8	10	11	13	14	15
PLECOPTERA							
F. Perlidae							
Claassenia sp.	N	-	6	2	5	10	11
F. Chloroperlidae							
Hastaperla sp.	N	5	8	-	20	14	43
Hastaperla sp.	E	-	-	-	-	-	1
F. Perlodidae							
Isogenus sp.	N	13	-	-	-	-	-
F. Nemouridae							
Nemoura sp.	N	34	1	42	5	5	2
COLEOPTERA							
F. Elmidae							
Narpus sp.	L	-	1	-	-	1	-
Zaitzevia sp.	L	-	1	-	-	-	-
F. Chrysopetalidae							
Galerucella sp.	L	1	-	-	-	-	1
GROUP 2 ORGANISMS							
DIPTERA							
F. Chironomidae							
S.F. Tanypodinae							
Procladius sp.	L	2	-	-	-	-	2
S.F. Chironominae							
Micropsectra sp.	L	2	4	4	1	1	4

beak

TABLE 14 Cont'd: Benthic Macroinvertebrates - Detailed Identification, August 1977

TAXA	LIFE STAGE*	Station No. 8	10	11	13	14	15
DIPTERA Cont'd.							
S.F. Orthocladiinae							
Cricotopus sp.	L	1	-	1	-	-	-
Orthocladius sp.	L	-	-	8	-	-	8
Cardiocladius sp.	L	-	4	25	-	23	79
Orthocladiinae sp. indet.	L	-	-	-	-	-	8
F. Tipulidae							
Tipula sp.	L	-	-	1	-	-	-
F. Rhagionidae							
Atherix sp.	L	-	-	-	-	1	2
F. Empididae							
Empididae sp. indet.	P	-	1	-	-	-	-
F. Ceratopogonidae							
Leptoconops sp.	L	-	1	-	-	-	-
F. Simuliidae							
Simulium sp.	L	-	1	1	-	12	-
AMPHIPODA							
F. Gammaridae							
Crangonyx sp.	A	-	-	-	2	-	-
TURBELLARIA							
O. Rhabdocoela sp. indet.	A	-	-	1	-	-	-
GROUP 1 ORGANISMS							
OLIGOCHEATE							
F. Lumbricidae	A	1	1	2	5	-	-

TABLE 14 Cont'd: Benthic Macroinvertebrates - Detailed Identification, August 1977

TAXA	LIFE STAGE*	Station No. 8	10	11	13	14	15
TOTAL NUMBER OF ORGANISMS		107	104	181	109	138	186
TOTAL NUMBER OF TAXA		14	18	14	15	19	12

* N = nymph
E = emergent
L = larvae
P = pupae
A = adult

APPENDIX F

Computer Program Output for Stomach Content Analysis

SITE: BONAPARTE RIVER STATION 1
DATE: SEPTEMBER 30, 1976
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 5
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	26.32	*****	.10
EPHEMEROPTERA (N)	60.00	14.89	10.53	7	.04
TRICHOPTERA (L)	60.00	31.91	21.05	15	.08
DIPTERA (L)	40.00	10.64	7.89	5	.03
DIPTERA (P)	40.00	4.26	5.26	2	.02
HEMIPTERA (A)	40.00	8.51	7.89	4	.03
NEMATODA	40.00	4.26	5.26	2	.02
DIPTERA (E)	20.00	6.38	2.63	3	.01
HYMENOPTERA	20.00	2.13	2.63	1	.01
COLEOPTERA (L)	20.00	2.13	2.63	1	.01
INSECTA	20.00	12.77	5.26	6	.02
PLECOPTERA (N)	20.00	2.13	2.63	1	.01
TOTAL-				47	.38

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 5
DATE: SEPTEMBER 29, 1976
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 10
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	40.00	*****	.14
EPHEMEROPTERA (N)	40.00	31.58	17.14	12	.06
DIPTERA (E)	20.00	13.16	5.71	5	.02
NEMATODA	20.00	13.16	5.71	5	.02
INSECTA	20.00	10.53	5.71	4	.02
PLECOPTERA (N)	20.00	7.89	8.57	3	.03
DIPTERA (L)	10.00	2.63	2.86	1	.01
HYMENOPTERA	10.00	2.63	2.86	1	.01
DIPTERA (A)	10.00	15.79	5.71	6	.02
LEPIDOPTERA (A)	10.00	2.63	5.71	1	.02
TOTAL-				38	.35

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: SEPTEMBER 29, 1976
LENGTH CATEGORY: 0-50 MM
SAMPLE SIZE: 1
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	0.	50.00	*****	.01
DETRITUS	100.00	0.	50.00	*****	.01
TOTAL-				0	.02

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: SEPTEMBER 29, 1976
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 9
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	56.52	*****	.13
EPHEMEROPTERA (N)	44.44	55.00	21.74	11	.05
NEMATODA	22.22	10.00	8.70	2	.02
HYMENOPTERA	11.11	5.00	4.35	1	.01
INSECTA	11.11	25.00	4.35	5	.01
PLECOPTERA (N)	11.11	5.00	4.35	1	.01
TOTAL-				20	.23

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: SEPTEMBER 29, 1976
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	50.00	*****	.02
EPHEMEROPTERA (N)	50.00	50.00	25.00	1	.01
TRICHOPTERA (L)	50.00	50.00	25.00	1	.01
TOTAL-				2	.04

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: SEPTEMBER 28, 1976
LENGTH CATEGORY: 0-50 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	80.00	40.00	4	.02
UNIDENTIFIED ANIMAL	100.00	******	40.00	*****	.02
DIPTERA (P)	50.00	20.00	20.00	1	.01
TOTAL-				5	.05

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: SEPTEMBER 28, 1976
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 5
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	53.85	*****	.07
OSTRACODA	40.00	28.57	15.38	2	.02
TRICHOPTERA (L)	20.00	14.29	7.69	1	.01
INSECTA	20.00	14.29	7.69	1	.01
DIPTERA (A)	20.00	28.57	7.69	2	.01
EPHEMEROPTERA (E)	20.00	14.29	7.69	1	.01
TOTAL-				7	.13

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: SEPTEMBER 28, 1976
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 9
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	77.78	******	39.68	*****	.25
NEMATODA	44.44	28.57	6.35	6	.04
INSECTA	33.33	19.05	4.76	4	.03
MINERAL	33.33	******	15.87	*****	.10
EPHEMEROPTERA (N)	22.22	14.29	4.76	3	.03
DIPTERA (L)	22.22	9.52	3.17	2	.02
HEMIPTERA (A)	22.22	14.29	3.17	3	.02
DETRITUS	22.22	******	17.46	*****	.11
TRICHOPTERA (L)	11.11	4.76	3.17	1	.02
HYMENOPTERA	11.11	9.52	1.59	2	.01
TOTAL-				21	.63

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: SEPTEMBER 28, 1976
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 1
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	76.92	*****	.10
TRICHOPTERA (L)	100.00	40.00	7.69	2	.01
HYMENOPTERA	100.00	40.00	7.69	2	.01
NEMATODA	100.00	20.00	7.69	1	.01
TOTAL-				5	.13

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: SEPTEMBER 28, 1976
LENGTH CATEGORY: 0-50 MM
SAMPLE SIZE: 1
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	100.00	100.00	3	.03
TOTAL-				3	.03

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: SEPTEMBER 28, 1976
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 11
NO. OF EMPTY STOMACHS: 1

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	72.73	******	53.45	*****	.31
EPHEMEROPTERA (N)	54.55	51.16	20.69	22	.12
TRICHOPTERA (L)	27.27	9.30	5.17	4	.03
DIPTERA (L)	27.27	16.28	6.90	7	.04
PLECOPTERA (N)	27.27	9.30	5.17	4	.03
NEMATODA	9.09	4.65	1.72	2	.01
INSECTA	9.09	4.65	1.72	2	.01
DIPTERA (A)	9.09	2.33	1.72	1	.01
DETRITUS	9.09	******	1.72	*****	.01
OSTRACODA	9.09	2.33	1.72	1	.01
TOTAL-				43	.58

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: SEPTEMBER 28, 1976
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 7
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	57.14	******	26.09	*****	.18
DIPTERA (L)	57.14	18.18	5.80	4	.04
MINERAL	42.86	******	44.93	*****	.31
HEMIPTERA (A)	28.57	27.27	4.35	6	.03
NEMATODA	28.57	13.64	2.90	3	.02
TRICHOPTERA (L)	14.29	9.09	1.45	2	.01
INSECTA	14.29	13.64	2.90	3	.02
PLECOPTERA (N)	14.29	4.55	1.45	1	.01
DIPTERA (A)	14.29	9.09	1.45	2	.01
DETRITUS	14.29	******	7.25	*****	.05
COLEOPTERA (A)	14.29	4.55	1.45	1	.01
TOTAL-				22	.69

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: SEPTEMBER 28, 1976
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 3
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	72.00	*****	.54
DIPTERA (A)	66.67	47.06	14.67	8	.11
MINERAL	66.67	******	4.00	*****	.03
EPHEMEROPTERA (N)	33.33	5.88	1.33	1	.01
HEMIPTERA (A)	33.33	11.76	1.33	2	.01
COLEOPTERA (L)	33.33	17.65	1.33	3	.01
INSECTA	33.33	5.88	4.00	1	.03
COLEOPTERA (A)	33.33	11.76	1.33	2	.01
TOTAL-				17	.75

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: SEPTEMBER 28, 1976
LENGTH CATEGORY: GREATER THAN 200 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	42.33	*****	.80
TRICHOPTERA (L)	50.00	19.40	1.06	13	.02
DIPTERA (L)	50.00	1.49	.53	1	.01
HEMIPTERA (A)	50.00	7.46	1.06	5	.02
HYMENOPTERA	50.00	1.49	.53	1	.01
NEMATODA	50.00	5.97	.53	4	.01
INSECTA	50.00	4.48	1.06	3	.02
DIPTERA (A)	50.00	59.70	26.46	40	.50
MINERAL	50.00	******	26.46	*****	.50
TOTAL-				67	1.89

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

beak

SITE: HAT CREEK STATION 10
DATE: SEPTEMBER 28, 1976
LENGTH CATEGORY: GREATER THAN 200 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	42.33	*****	.80
TRICHOPTERA (L)	50.00	19.40	1.06	13	.02
DIPTERA (L)	50.00	1.49	.53	1	.01
HEMIPTERA (A)	50.00	7.46	1.06	5	.02
HYMENOPTERA	50.00	1.49	.53	1	.01
NEMATODA	50.00	5.97	.53	4	.01
INSECTA	50.00	4.48	1.06	3	.02
DIPTERA (A)	50.00	59.70	26.46	40	.50
MINERAL	50.00	******	26.46	*****	.50
TOTAL-				67	1.89

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: SEPTEMBER 29, 1976
LENGTH CATEGORY: 0-50 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	44.44	*****	.04
EPHEMEROPTERA (N)	50.00	40.00	11.11	2	.01
TRICHOPTERA (L)	50.00	20.00	11.11	1	.01
DIPTERA (L)	50.00	20.00	11.11	1	.01
OSTRACODA	50.00	20.00	11.11	1	.01
MINERAL	50.00	******	11.11	*****	.01
TOTAL-				5	.09

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: SEPTEMBER 29, 1976
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 8
NO. OF EMPTY STOMACHS: 1

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	75.00	******	57.45	*****	.27
EPHEMEROPTERA (N)	50.00	73.68	19.15	28	.09
TRICHOPTERA (L)	25.00	5.26	4.26	2	.02
INSECTA	25.00	5.26	4.26	2	.02
DIPTERA (L)	12.50	2.63	2.13	1	.01
DIPTERA (P)	12.50	2.63	2.13	1	.01
NEMATODA	12.50	2.63	2.13	1	.01
COLEOPTERA (L)	12.50	2.63	2.13	1	.01
OSTRACODA	12.50	2.63	2.13	1	.01
EPHEMEROPTERA (E)	12.50	2.63	4.26	1	.02
TOTAL-				38	.47

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: SEPTEMBER 29, 1976
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 5
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	62.96	*****	.34
EPHEMEROPTERA (N)	60.00	67.24	11.11	39	.06
COLEOPTERA (L)	60.00	13.79	5.56	8	.03
DIPTERA (L)	40.00	3.45	3.70	2	.02
HYMENOPTERA	40.00	6.90	7.41	4	.04
NEMATODA	40.00	3.45	3.70	2	.02
TRICHOPTERA (L)	20.00	1.72	1.85	1	.01
PLECOPTERA (N)	20.00	1.72	1.85	1	.01
COLEOPTERA (A)	20.00	1.72	1.85	1	.01
TOTAL-				58	.54

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: SEPTEMBER 29, 1976
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 6
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	71.04	*****	1.30
DIPTERA (L)	100.00	19.49	5.46	23	.10
EPHEMEROPTERA (N)	83.33	8.47	2.73	10	.05
DIPTERA (P)	66.67	22.88	2.73	27	.05
COLEOPTERA (L)	66.67	22.88	3.28	27	.06
HYMENOPTERA	50.00	17.80	3.28	21	.06
HEMIPTERA (A)	33.33	1.69	1.09	2	.02
PLECOPTERA (N)	33.33	2.54	1.09	3	.02
OSTRACODA	33.33	1.69	1.09	2	.02
TRICHOPTERA (L)	16.67	.85	.55	1	.01
NEMATODA	16.67	.85	.55	1	.01
DETRITUS	16.67	******	.55	*****	.01
MINERAL	16.67	******	5.46	*****	.10
ARACHNOIDEA	16.67	.85	1.09	1	.02
TOTAL-				118	1.83

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: SEPTEMBER 29, 1976
LENGTH CATEGORY: GREATER THAN 200 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	78.31	*****	1.30
HEMIPTERA (A)	100.00	14.58	6.63	7	.11
COLEOPTERA (L)	100.00	6.25	1.81	3	.03
TRICHOPTERA (L)	50.00	2.08	.60	1	.01
DIPTERA (L)	50.00	4.17	1.20	2	.02
DIPTERA (P)	50.00	47.92	1.20	23	.02
HYMENOPTERA	50.00	4.17	1.20	2	.02
NEMATODA	50.00	10.42	.60	5	.01
INSECTA	50.00	4.17	.60	2	.01
PLECOPTERA (N)	50.00	2.08	.60	1	.01
MINERAL	50.00	******	6.02	*****	.10
COLEOPTERA (A)	50.00	2.08	.60	1	.01
BIVALVIA	50.00	2.08	.60	1	.01
TOTAL-				48	1.66

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

JUNE 1977

SITE: BONAPARTE RIVER STATION 1
DATE: JUNE 14, 1977
LENGTH CATEGORY: 0-50 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	22.22	*****	.02
EPHEMEROPTERA (N)	100.00	75.00	44.44	9	.04
DIPTERA (L)	100.00	16.67	22.22	2	.02
TRICHOPTERA (L)	50.00	8.33	11.11	1	.01
TOTAL-				12	.09

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: BONAPARTE RIVER STATION 1
DATE: JUNE 14, 1977
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	15.38	*****	.02
EPHEMEROPTERA (N)	100.00	85.00	69.23	17	.09
PLECOPTERA (N)	50.00	15.00	15.38	3	.02
TOTAL-				20	.13

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: BONAPARTE RIVER STATION 3
DATE: JUNE 14, 1977
LENGTH CATEGORY: 0-50 MM
SAMPLE SIZE: 3
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	21.43	*****	.03
EPHEMEROPTERA (N)	100.00	87.50	64.29	14	.09
TRICHOPTERA (L)	33.33	6.25	7.14	1	.01
DIPTERA (L)	33.33	6.25	7.14	1	.01
TOTAL-				16	.14

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 5
DATE: JUNE 14, 1977
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 8
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	21.54	*****	.14
EPHEMEROPTERA (N)	75.00	44.09	46.15	41	.30
TRICHOPTERA (L)	37.50	8.60	9.23	8	.06
DIPTERA (L)	37.50	37.63	12.31	35	.08
NEMATODA	37.50	5.38	4.62	5	.03
EPHEMEROPTERA (E)	12.50	3.23	4.62	3	.03
INSECTA	12.50	1.08	1.54	1	.01
TOTAL-				93	.65

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 5
DATE: JUNE 14, 1977
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 5
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	28.50	*****	1.20
DIPTERA (L)	100.00	27.69	3.56	36	.15
TRICHOPTERA (L)	80.00	8.46	2.14	11	.09
EPHEMEROPTERA (N)	60.00	44.62	61.52	58	2.59
NEMATODA	60.00	8.46	.71	11	.03
PLECOPTERA (N)	40.00	3.85	.95	5	.04
COLEOPTERA (L)	40.00	3.08	1.19	4	.05
HYMENOPTERA	20.00	.77	.24	1	.01
ANNELIDA	20.00	.77	.71	1	.03
ARACHNOIDEA	20.00	.77	.24	1	.01
DIPTERA (P)	20.00	1.54	.24	2	.01
TOTAL-				130	4.21

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: JUNE 16, 1977
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 10
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	33.33	*****	.18
EPHEMEROPTERA (N)	90.00	56.90	33.33	33	.18
DIPTERA (L)	50.00	13.79	11.11	8	.06
TRICHOPTERA (L)	40.00	15.52	12.96	9	.07
NEMATODA	20.00	3.45	3.70	2	.02
PLECOPTERA (N)	10.00	3.45	1.85	2	.01
INSECTA	10.00	1.72	1.85	1	.01
DIPTERA (E)	10.00	5.17	1.85	3	.01
TOTAL-				58	.54

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: JUNE 16, 1977
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 5
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	35.09	*****	.20
TRICHOPTERA (L)	100.00	34.21	24.56	13	.14
DIPTERA (L)	80.00	36.84	15.79	14	.09
EPHEMEROPTERA (N)	60.00	15.79	10.53	6	.06
PLECOPTERA (N)	20.00	2.63	5.26	1	.03
NEMATODA	20.00	2.63	1.75	1	.01
DIPTERA (E)	20.00	5.26	1.75	2	.01
MINERAL	20.00	******	3.51	*****	.02
COLEOPTERA (A)	20.00	2.63	1.75	1	.01
TOTAL-				38	.57

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: JUNE 16, 1977
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 3
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	36.00	*****	.18
TRICHOPTERA (L)	66.67	54.84	36.00	17	.18
PLECOPTERA (N)	66.67	9.68	8.00	3	.04
EPHEMEROPTERA (N)	33.33	12.90	6.00	4	.03
DIPTERA (L)	33.33	3.23	2.00	1	.01
NEMATODA	33.33	6.45	2.00	2	.01
INSECTA	33.33	3.23	2.00	1	.01
HYMENOPTERA	33.33	6.45	4.00	2	.02
ARACHNOIDEA	33.33	3.23	4.00	1	.02
TOTAL-				31	.50

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: JUNE 16, 1977
LENGTH CATEGORY: GREATER THAN 200 MM
SAMPLE SIZE: 1
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	43.48	*****	.10
TRICHOPTERA (L)	100.00	28.57	13.04	2	.03
EPHEMEROPTERA (N)	100.00	14.29	8.70	1	.02
PLECOPTERA (N)	100.00	14.29	21.74	1	.05
HYMENOPTERA	100.00	14.29	4.35	1	.01
COLEOPTERA (A)	100.00	28.57	8.70	2	.02
TOTAL-				7	.23

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: JUNE 15, 1977
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 10
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	90.00	******	27.27	*****	.12
EPHEMEROPTERA (N)	90.00	70.91	34.09	39	.15
DIPTERA (L)	30.00	9.09	11.36	5	.05
NEMATODA	30.00	7.27	6.82	4	.03
TRICHOPTERA (L)	20.00	3.64	6.82	2	.03
PLECOPTERA (N)	20.00	3.64	4.55	2	.02
INSECTA	20.00	3.64	4.55	2	.02
DIPTERA (P)	10.00	1.82	2.27	1	.01
MINERAL	10.00	******	2.27	*****	.01
TOTAL-				55	.44

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

beak

SITE: HAT CREEK STATION 7
DATE: JUNE 15, 1977
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 7
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	49.47	*****	.47
TRICHOPTERA (L)	57.14	14.04	7.37	8	.07
PLECOPTERA (N)	57.14	15.79	8.42	9	.08
EPHEMEROPTERA (N)	42.86	33.33	8.42	19	.08
DIPTERA (L)	42.86	5.26	3.16	3	.03
HYMENOPTERA	42.86	10.53	4.21	6	.04
DIPTERA (P)	42.86	8.77	3.16	5	.03
EPHEMEROPTERA (E)	28.57	8.77	10.53	5	.10
ANNELIDA	14.29	1.75	2.11	1	.02
ARACHNOIDEA	14.29	1.75	1.05	1	.01
DETRITUS	14.29	******	2.11	*****	.02
TOTAL-				57	.95

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: JUNE 15, 1977
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 3
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	48.87	*****	1.08
TRICHOPTERA (L)	66.67	17.24	2.26	5	.05
EPHEMEROPTERA (N)	33.33	3.45	.45	1	.01
DIPTERA (L)	33.33	17.24	1.36	5	.03
NEMATODA	33.33	20.69	.45	6	.01
EPHEMEROPTERA (E)	33.33	34.48	45.25	10	1.00
HYMENOPTERA	33.33	3.45	.45	1	.01
MINERAL	33.33	******	.45	*****	.01
COLEOPTERA (A)	33.33	3.45	.45	1	.01
TOTAL-				29	2.21

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: JUNE 15, 1977
LENGTH CATEGORY: GREATER THAN 200 MM
SAMPLE SIZE: 1
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	15.11	*****	1.00
TRICHOPTERA (L)	100.00	63.64	60.42	28	4.00
EPHEMEROPTERA (N)	100.00	36.36	24.47	16	1.62
TOTAL-				44	6.62

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

beak

SITE: HAT CREEK STATION 10
DATE: JUNE 16, 1977
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 4
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
DIPTERA (L)	100.00	75.00	37.50	33	.09
UNIDENTIFIED ANIMAL	75.00	******	29.17	*****	.07
EPHEMEROPTERA (N)	75.00	9.09	12.50	4	.03
TRICHOPTERA (L)	50.00	4.55	8.33	2	.02
INSECTA	50.00	9.09	8.33	4	.02
NEMATODA	25.00	2.27	4.17	1	.01
TOTAL-				44	.24

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: JUNE 16, 1977
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 7
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	25.95	*****	2.53
DIPTERA (L)	100.00	47.65	2.26	81	.22
TRICHOPTERA (L)	85.71	7.06	1.13	12	.11
EPHEMEROPTERA (N)	85.71	17.06	1.44	29	.14
DIPTERA (P)	57.14	4.71	.41	8	.04
PLECOPTERA (N)	42.86	2.94	.51	5	.05
INSECTA	28.57	5.29	.31	9	.03
HYMENOPTERA	28.57	2.35	.31	4	.03
ANNELIDA	28.57	7.65	65.64	13	6.40
COLEOPTERA (L)	28.57	2.35	.41	4	.04
MINERAL	28.57	******	1.23	*****	.12
COLEOPTERA (A)	28.57	1.18	.21	2	.02
ODONATA (N)	14.29	.59	.10	1	.01
HEMIPTERA (A)	14.29	1.18	.10	2	.01
TOTAL-				170	9.75

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: JUNE 16, 1977
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 3
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	17.95	*****	1.70
DIPTERA (L)	100.00	43.06	1.27	31	.12
EPHEMEROPTERA (N)	66.67	6.94	3.38	5	.32
HYMENOPTERA	66.67	2.78	.21	2	.02
TRICHOPTERA (L)	33.33	8.33	.32	6	.03
PLECOPTERA (N)	33.33	4.17	2.22	3	.21
NEMATODA	33.33	1.39	.11	1	.01
INSECTA	33.33	1.39	.11	1	.01
ANNELIDA	33.33	25.00	73.92	18	7.00
DIPTERA (P)	33.33	2.78	.11	2	.01
MINERAL	33.33	1.39	.21	1	.02
COLEOPTERA (A)	33.33	1.39	.11	1	.01
DIPTERA (A)	33.33	1.39	.11	1	.01
TOTAL-				72	9.47

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: JUNE 16, 1977
LENGTH CATEGORY: GREATER THAN 200 MM
SAMPLE SIZE: 5
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	8.65	*****	1.97
EPHEMEROPTERA (N)	60.00	6.59	.26	6	.06
PLECOPTERA (N)	60.00	3.30	1.36	3	.31
NEMATODA	60.00	16.48	.18	15	.04
COLEOPTERA (L)	60.00	3.30	.79	3	.18
TRICHOPTERA (L)	40.00	2.20	.09	2	.02
DIPTERA (L)	40.00	8.79	.26	8	.06
INSECTA	40.00	3.30	.13	3	.03
ANNELIDA	40.00	49.45	87.80	45	20.00
DIPTERA (P)	20.00	5.49	.04	5	.01
COLEOPTERA (A)	20.00	1.10	.44	1	.10
TOTAL-				91	22.78

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: JUNE 15, 1977
LENGTH CATEGORY: 0-50 MM
SAMPLE SIZE: 1
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	50.00	*****	.01
EPHEMEROPTERA (N)	100.00	100.00	50.00	2	.01
TOTAL-				2	.02

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: JUNE 15, 1977
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 6
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	11.76	18.87	14	.10
UNIDENTIFIED ANIMAL	83.33	******	20.75	*****	.11
DIPTERA (L)	83.33	76.47	41.51	91	.22
INSECTA	50.00	7.56	9.43	9	.05
PLECOPTERA (N)	33.33	1.68	3.77	2	.02
HYMENOPTERA	33.33	1.68	3.77	2	.02
DIPTERA (P)	16.67	.84	1.89	1	.01
TOTAL-				119	.53

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: JUNE 15, 1977
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 4
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	20.00	*****	.12
TRICHOPTERA (L)	100.00	3.23	6.67	5	.04
EPHEMEROPTERA (N)	100.00	9.68	15.00	15	.09
DIPTERA (L)	100.00	74.84	36.67	116	.22
INSECTA	75.00	6.45	6.67	10	.04
PLECOPTERA (N)	25.00	3.23	3.33	5	.02
NEMATODA	25.00	.65	1.67	1	.01
HYMENOPTERA	25.00	.65	1.67	1	.01
ARACHNOIDEA	25.00	.65	1.67	1	.01
DIPTERA (P)	25.00	.65	1.67	1	.01
DETRITUS	25.00	******	5.00	*****	.03
TOTAL-				155	.60

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: JUNE 15, 1977
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 3
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	16.43	*****	.23
DIPTERA (L)	100.00	34.09	6.43	45	.09
TRICHOPTERA (L)	66.67	1.52	4.29	2	.06
EPHEMEROPTERA (N)	66.67	3.79	2.14	5	.03
HYMENOPTERA	66.67	43.94	30.71	58	.43
MINERAL	66.67	******	2.86	*****	.04
PLECOPTERA (E)	66.67	6.06	30.00	8	.42
PLECOPTERA (N)	33.33	1.52	.71	2	.01
NEMATODA	33.33	.76	.71	1	.01
INSECTA	33.33	3.03	1.43	4	.02
COLEOPTERA (A)	33.33	4.55	1.43	6	.02
DETRITUS	33.33	******	2.14	*****	.03
AMPHIPODA	33.33	.76	.71	1	.01
TOTAL-				132	1.40

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

AUGUST 1977

SITE: BONAPARTE RIVER STATION 1
DATE: AUGUST 3, 1977
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	4.60	2.96	12	.09
UNIDENTIFIED ANIMAL	100.00	******	5.26	*****	.16
TRICHOPTERA (L)	100.00	87.74	79.28	229	2.41
MINERAL	50.00	******	6.58	*****	.20
HYMENOPTERA	50.00	1.53	1.32	4	.04
COLEOPTERA (A)	50.00	4.21	3.29	11	.10
NEMATODA	50.00	.77	.33	2	.01
ARACHNOIDEA	50.00	.38	.33	1	.01
DIPTERA (L)	50.00	.38	.33	1	.01
PLECOPTERA (N)	50.00	.38	.33	1	.01
TOTAL-				261	3.04

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: BONAPARTE RIVER STATION 3
DATE: AUGUST 3, 1977
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
HYMENOPTERA	100.00	55.88	29.41	76	.30
COLEOPTERA (A)	100.00	27.21	22.55	37	.23
UNIDENTIFIED ANIMAL	100.00	******	17.65	*****	.18
DIPTERA (L)	100.00	6.62	7.84	9	.08
EPHEMEROPTERA (N)	50.00	5.88	9.80	8	.10
NEMATODA	50.00	.74	.98	1	.01
TRICHOPTERA (L)	50.00	.74	.98	1	.01
INSECTA	50.00	2.21	5.88	3	.06
ODONATA (N)	50.00	.74	2.94	1	.03
UNIDENTIFIED PLANT	50.00	******	1.96	*****	.02
TOTAL-				136	1.02

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 5
DATE: AUGUST 3, 1977
LENGTH CATEGORY: 0-50 MM
SAMPLE SIZE: 1
NO. OF EMPTY STOMACHS: 1

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
TOTAL-				0	0.

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 5
DATE: AUGUST 3, 1977
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 1
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	50.00	37.50	5	.03
UNIDENTIFIED ANIMAL	100.00	******	25.00	*****	.02
DIPTERA (L)	100.00	40.00	25.00	4	.02
PLECOPTERA (N)	100.00	10.00	12.50	1	.01
TOTAL-				10	.08

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 5
DATE: AUGUST 3, 1977
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 4
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
NEMATODA	100.00	50.00	21.74	10	.05
UNIDENTIFIED ANIMAL	100.00	******	43.48	*****	.10
DIPTERA (L)	75.00	25.00	13.04	5	.03
EPHEMEROPTERA (N)	25.00	10.00	4.35	2	.01
HYMENOPTERA	25.00	10.00	8.70	2	.02
PLECOPTERA (N)	25.00	5.00	8.70	1	.02
TOTAL-				20	.23

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 5
DATE: AUGUST 3, 1977
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 1
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
HYMENOPTERA	100.00	33.33	15.79	7	.06
COLEOPTERA (A)	100.00	14.29	5.26	3	.02
UNIDENTIFIED ANIMAL	100.00	******	21.05	*****	.08
ARACHNOIDEA	100.00	4.76	15.79	1	.06
INSECTA	100.00	23.81	15.79	5	.06
ANNELIDA	100.00	4.76	15.79	1	.06
HEMIPTERA (A)	100.00	4.76	2.63	1	.01
COLEOPTERA (L)	100.00	14.29	7.89	3	.03
TOTAL-				21	.38

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: AUGUST 3, 1977
LENGTH CATEGORY: 0-50 MM
SAMPLE SIZE: 3
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	71.88	53.85	23	.07
UNIDENTIFIED ANIMAL	66.67	******	15.38	*****	.02
DIPTERA (L)	66.67	28.13	30.77	9	.04
TOTAL-				32	.13

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: AUGUST 3, 1977
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 4
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	33.33	21.43	10	.06
UNIDENTIFIED ANIMAL	100.00	******	25.00	*****	.07
DIPTERA (L)	75.00	33.33	17.86	10	.05
TRICHOPTERA (L)	75.00	13.33	14.29	4	.04
HYMENOPTERA	25.00	6.67	7.14	2	.02
NEMATODA	25.00	3.33	3.57	1	.01
ARACHNOIDEA	25.00	6.67	3.57	2	.01
INSECTA	25.00	3.33	7.14	1	.02
TOTAL-				30	.28

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: AUGUST 3, 1977
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 6
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	36.17	*****	.17
TRICHOPTERA (L)	100.00	27.03	21.28	10	.10
EPHEMEROPTERA (N)	66.67	21.62	8.51	8	.04
HYMENOPTERA	33.33	13.51	6.38	5	.03
INSECTA	33.33	8.11	8.51	3	.04
MINERAL	16.67	******	6.38	*****	.03
NEMATODA	16.67	2.70	2.13	1	.01
DIPTERA (L)	16.67	21.62	6.38	8	.03
PLECOPTERA (N)	16.67	2.70	2.13	1	.01
COLEOPTERA (L)	16.67	2.70	2.13	1	.01
TOTAL-				37	.47

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: AUGUST 3, 1977
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 4
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	25.93	*****	.28
INSECTA	100.00	36.73	24.07	36	.26
HYMENOPTERA	75.00	15.31	12.04	15	.13
COLEOPTERA (A)	75.00	19.39	12.96	19	.14
TRICHOPTERA (L)	75.00	12.24	10.19	12	.11
DIPTERA (L)	50.00	10.20	4.63	10	.05
EPHEMEROPTERA (N)	25.00	1.02	.93	1	.01
MINERAL	25.00	******	2.78	*****	.03
NEMATODA	25.00	1.02	.93	1	.01
PLECOPTERA (N)	25.00	3.06	4.63	3	.05
PLECOPTERA (E)	25.00	1.02	.93	1	.01
TOTAL-				98	1.08

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 6
DATE: AUGUST 3, 1977
LENGTH CATEGORY: GREATER THAN 200 MM
SAMPLE SIZE: 1
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
MINERAL	100.00	******	42.55	*****	.20
HYMENOPTERA	100.00	26.09	10.64	6	.05
NEMATODA	100.00	4.35	2.13	1	.01
UNIDENTIFIED ANIMAL	100.00	******	12.77	*****	.06
PLECOPTERA (N)	100.00	13.04	10.64	3	.05
INSECTA	100.00	56.52	21.28	13	.10
TOTAL-				23	.47

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: AUGUST 5, 1977
LENGTH CATEGORY: 0-50 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	69.23	50.00	9	.06
UNIDENTIFIED ANIMAL	100.00	******	41.67	*****	.05
DIPTERA (L)	50.00	30.77	8.33	4	.01
TOTAL-				13	.12

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: AUGUST 5, 1977
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 8
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	16.29	*****	.29
TRICHOPTERA (L)	100.00	36.69	32.02	91	.57
EPHEMEROPTERA (N)	87.50	44.35	36.52	110	.65
DIPTERA (L)	75.00	15.32	11.24	38	.20
PLECOPTERA (N)	37.50	1.21	2.25	3	.04
NEMATODA	25.00	1.21	1.12	3	.02
DIPTERA (P)	12.50	1.21	.56	3	.01
TOTAL-				248	1.78

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: AUGUST 5, 1977
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 6
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	42.48	57.41	96	1.55
TRICHOPTERA (L)	100.00	42.92	23.33	97	.63
UNIDENTIFIED ANIMAL	83.33	******	9.63	*****	.26
DIPTERA (L)	50.00	9.73	4.44	22	.12
NEMATODA	33.33	1.33	.74	3	.02
DIPTERA (P)	33.33	1.33	.74	3	.02
MINERAL	16.67	******	1.85	*****	.05
HYMENOPTERA	16.67	.44	.37	1	.01
COLEOPTERA (A)	16.67	.44	.37	1	.01
PLECOPTERA (N)	16.67	.44	.37	1	.01
INSECTA	16.67	.44	.37	1	.01
TRICHOPTERA (P)	16.67	.44	.37	1	.01
TOTAL-				226	2.70

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: AUGUST 5, 1977
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 4
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	5.95	9.31	47	.27
UNIDENTIFIED ANIMAL	100.00	******	9.31	*****	.27
TRICHOPTERA (L)	100.00	17.72	32.41	140	.94
HYMENOPTERA	75.00	2.66	4.48	21	.13
INSECTA	75.00	7.22	10.00	57	.29
MINERAL	50.00	******	1.38	*****	.04
NEMATODA	50.00	.25	.69	2	.02
DIPTERA (L)	50.00	5.19	5.86	41	.17
PLECOPTERA (N)	50.00	.51	2.41	4	.07
DIPTERA (P)	50.00	.63	1.03	5	.03
COLEOPTERA (A)	25.00	.25	.69	2	.02
HEMIPTERA (A)	25.00	.13	.34	1	.01
COLEOPTERA (L)	25.00	.25	1.03	2	.03
DETRITUS	25.00	******	.34	*****	.01
OSTRACODA	25.00	59.24	20.69	468	.60
TOTAL-				790	2.90

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 7
DATE: AUGUST 5, 1977
LENGTH CATEGORY: GREATER THAN 200 MM
SAMPLE SIZE: 2
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	2.31	.63	4	.02
HYMENOPTERA	100.00	13.87	6.65	24	.21
COLEOPTERA (A)	100.00	1.73	.95	3	.03
NEMATODA	100.00	2.31	.95	4	.03
UNIDENTIFIED ANIMAL	100.00	******	7.28	*****	.23
TRICHOPTERA (L)	100.00	9.83	6.01	17	.19
PLECOPTERA (N)	100.00	3.47	4.11	6	.13
INSECTA	100.00	63.01	39.87	109	1.26
MINERAL	50.00	******	31.65	*****	1.00
DIPTERA (L)	50.00	.58	.32	1	.01
HEMIPTERA (A)	50.00	.58	.32	1	.01
COLEOPTERA (L)	50.00	1.16	.63	2	.02
PLECOPTERA (E)	50.00	.58	.32	1	.01
EPHEMEROPTERA (E)	50.00	.58	.32	1	.01
TOTAL-				173	3.16

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: AUGUST 5, 1977
LENGTH CATEGORY: 0-50 MM
SAMPLE SIZE: 1
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	66.67	40.00	4	.02
UNIDENTIFIED ANIMAL	100.00	******	20.00	*****	.01
DIPTERA (L)	100.00	16.67	20.00	1	.01
TRICHOPTERA (L)	100.00	16.67	20.00	1	.01
TOTAL-				6	.05

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: AUGUST 5, 1977
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 8
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	28.50	26.92	55	.35
UNIDENTIFIED ANIMAL	100.00	******	17.69	*****	.23
DIPTERA (L)	100.00	46.63	29.23	90	.38
COLEOPTERA (L)	62.50	8.81	12.31	17	.16
DIPTERA (P)	62.50	8.29	6.92	16	.09
TRICHOPTERA (L)	37.50	2.07	3.08	4	.04
PLECOPTERA (N)	25.00	1.55	2.31	3	.03
OSTRACODA	25.00	4.15	1.54	8	.02
TOTAL-				193	1.30

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: AUGUST 5, 1977
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 6
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	14.29	*****	.29
DIPTERA (L)	100.00	47.06	12.32	72	.25
EPHEMEROPTERA (N)	66.67	15.03	8.87	23	.18
TRICHOPTERA (L)	66.67	7.19	3.94	11	.08
OSTRACODA	50.00	9.80	2.96	15	.06
COLEOPTERA (A)	33.33	1.96	1.48	3	.03
PLECOPTERA (N)	33.33	1.96	1.48	3	.03
COLEOPTERA (L)	33.33	1.31	.99	2	.02
MINERAL	16.67	******	49.26	*****	1.00
HYMENOPTERA	16.67	.65	.49	1	.01
NEMATODA	16.67	2.61	.99	4	.02
INSECTA	16.67	.65	.49	1	.01
DIPTERA (P)	16.67	11.76	2.46	18	.05
TOTAL-				153	2.03

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: AUGUST 5, 1977
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 4
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
EPHEMEROPTERA (N)	100.00	44.72	10.16	55	.37
UNIDENTIFIED ANIMAL	100.00	******	4.95	*****	.18
DIPTERA (L)	100.00	17.07	3.02	21	.11
TRICHOPTERA (L)	100.00	10.57	3.30	13	.12
NEMATODA	75.00	2.44	.82	3	.03
PLECOPTERA (N)	75.00	4.88	5.22	6	.19
MINERAL	50.00	******	28.02	*****	1.02
OSTRACODA	50.00	8.94	1.10	11	.04
HYMENOPTERA	25.00	2.44	.55	3	.02
INSECTA	25.00	.81	.27	1	.01
COLEOPTERA (L)	25.00	.81	.27	1	.01
DIPTERA (P)	25.00	7.32	1.10	9	.04
DETRITUS	25.00	******	41.21	*****	1.50
TOTAL-				123	3.64

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 10
DATE: AUGUST 5, 1977
LENGTH CATEGORY: GREATER THAN 200 MM
SAMPLE SIZE: 3
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	100.00	******	17.86	*****	.05
DIPTERA (P)	100.00	28.57	10.71	6	.03
DIPTERA (L)	66.67	28.57	10.71	6	.03
EPHEMEROPTERA (N)	33.33	14.29	10.71	3	.03
HYMENOPTERA	33.33	4.76	3.57	1	.01
COLEOPTERA (A)	33.33	4.76	3.57	1	.01
NEMATODA	33.33	4.76	3.57	1	.01
TRICHOPTERA (L)	33.33	4.76	3.57	1	.01
INSECTA	33.33	9.52	7.14	2	.02
UNIDENTIFIED PLANT	33.33	******	28.57	*****	.08
TOTAL-				21	.28

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: AUGUST 4, 1977
LENGTH CATEGORY: GREATER THAN 200 MM
SAMPLE SIZE: 3
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
HYMENOPTERA	100.00	15.74	12.73	17	.14
UNIDENTIFIED ANIMAL	100.00	******	25.45	*****	.28
DIPTERA (L)	100.00	41.67	20.00	45	.22
INSECTA	100.00	31.48	20.00	34	.22
EPHEMEROPTERA (N)	66.67	1.85	1.82	2	.02
COLEOPTERA (L)	66.67	2.78	2.73	3	.03
DETRITUS	66.67	******	13.64	*****	.15
COLEOPTERA (A)	33.33	1.85	1.82	2	.02
ARACHNOIDEA	33.33	.93	.91	1	.01
DIPTERA (P)	33.33	3.70	.91	4	.01
TOTAL-				108	1.10

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: AUGUST 4, 1977
LENGTH CATEGORY: 101-150 MM
SAMPLE SIZE: 5
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
DIPTERA (L)	100.00	70.45	31.25	31	.15
UNIDENTIFIED ANIMAL	80.00	******	35.42	*****	.17
EPHEMEROPTERA (N)	40.00	11.36	6.25	5	.03
DIPTERA (P)	40.00	4.55	4.17	2	.02
MINERAL	20.00	******	10.42	*****	.05
HYMENOPTERA	20.00	9.09	8.33	4	.04
ARACHNOIDEA	20.00	2.27	2.08	1	.01
COLEOPTERA (L)	20.00	2.27	2.08	1	.01
TOTAL-				44	.48

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: AUGUST 4, 1977
LENGTH CATEGORY: 151-200 MM
SAMPLE SIZE: 6
NO. OF EMPTY STOMACHS: 0

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
HYMENOPTERA	83.33	14.00	4.80	21	.19
UNIDENTIFIED ANIMAL	83.33	******	7.58	*****	.30
DIPTERA (L)	83.33	54.00	13.64	81	.54
INSECTA	50.00	14.67	4.80	22	.19
COLEOPTERA (L)	50.00	5.33	26.52	8	1.05
EPHEMEROPTERA (N)	33.33	1.33	.51	2	.02
PLECOPTERA (N)	33.33	3.33	1.26	5	.05
DIPTERA (P)	33.33	3.33	.76	5	.03
MINERAL	16.67	******	.76	*****	.03
COLEOPTERA (A)	16.67	2.00	.76	3	.03
ARACHNOIDEA	16.67	.67	.25	1	.01
TRICHOPTERA (L)	16.67	.67	.25	1	.01
PLECOPTERA (E)	16.67	.67	.25	1	.01
DETRITUS	16.67	******	37.88	*****	1.50
TOTAL-				150	3.96

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE

SITE: HAT CREEK STATION 14
DATE: AUGUST 4, 1977
LENGTH CATEGORY: 51-100 MM
SAMPLE SIZE: 7
NO. OF EMPTY STOMACHS: 1

FOOD ITEM	FREQUENCY OCCURRENCE (%)	NUMERICAL (%)	VOLUMETRIC (%)	ACTUAL NUMBER	ACTUAL VOLUME
UNIDENTIFIED ANIMAL	85.71	******	22.41	*****	.13
DIPTERA (L)	57.14	86.81	60.34	79	.35
EPHEMEROPTERA (N)	42.86	9.89	12.07	9	.07
TRICHOPTERA (L)	14.29	1.10	1.72	1	.01
PLECOPTERA (N)	14.29	1.10	1.72	1	.01
CLADOCERA	14.29	1.10	1.72	1	.01
TOTAL-				91	.58

(A)- ADULT
(E)- EMERGENT
(N)- NYMPH
(P)- PUPAE
(L)- LARVAE
******- NOT APPLICABLE