WATER QUALITY
AND
RECREATIONAL USAGE ISSUES
IN SHUSWAP LAKE, BRITISH COLUMBIA

D.R. KEARNEY

MARCH, 1991

PREPARED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF
THE M.E.DES. DEGREE IN THE FACULTY OF ENVIRONMENTAL DESIGN,
THE UNIVERSITY OF CALGARY

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The undersigned certify that they have read, and recommend to the Faculty of Environmental Design for acceptance, a Master's Degree Project entitled "Water Quality and Recreational Usage Issues in Shuswap Lake, British Columbia" submitted by Daniel Kearney in partial fulfillment of the requirements for the degree of Master of Environmental Design

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ABSTRACT

Water Quality and Recreational Usage Issues in Shuswap Lake, British Columbia
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March, 1991

Prepared in partial fulfillment of the requirements of the M.E.Des. degree in the Faculty of Environmental Design, The University of Calgary

A complaint of potential water quality degradation by waste water from pleasure boats was investigated between May and October 1988, and it was determined that the waters of the upper Seymour Arm of Shuswap Lake were oligotrophic (TP = 4.5 ug/L, TN = 127 ug/L, chlorophyll "a" = 0.8 ug/L), and had changed little since sampling began in 1971. Results bettered recreational water quality guidelines. Analyses from the water sampling regime established a chemical data base for the Arm. Other potential contaminant sources were documented at Seymour Arm. Documented sources throughout the basin were updated.

Literature reviews demonstrated that grey water is excluded from current legislation, and it is microbiologically and chemically comparable to black water. Grey water release contributes BOD, solids and potentially pathogenic bacteria to littoral waters during periods of peak recreational usage. TP loadings were estimated to be small from houseboat grey water, compared to TP loadings from municipal sewage effluent and agricultural runoff to major river basins.

A public lake user survey profiled attitudes about water quality, multiple usage of the resource, and shorezone development. Results showed preference for maintenance of current water quality, retention of grey water which could degrade water quality, sanitary station construction, curtailment of some houseboating and logging practices. A parallel survey profiled attitudes and waste practices of rental boat operators.

It is recommended that a sanitary pumpout station be constructed near Seymour Arm, that devices for off-loading waste water from watercraft be prohibited, and that consideration be given to the retention of grey water aboard pleasure craft, especially in slow flushing and popular embayments such as Bughouse Bay.

key words

Shuswap Lake, water quality, grey water, user survey, recreational impacts, houseboating

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Appendix G : Pleasure Boats in the Shuswap (4 pp.)

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GLOSSARY OF TERMS

Black water Domestic waste water from toilet wastes (including human feces and urine).

BOD Biochemical oxygen demand. A 5 day test (BOD_5) measures the presence of aerobic organisms in a water sample.

Chlorophyll "a" A measurement of the green pigment chlorophyll found in phytoplankton such as blue-green algae.

Cl^- The chloride ion (not to be confused with Cl_2 which is chlorine).

Conductivity Electrical conductance (in uS/cm or the equivalent umhos/cm of water). The reciprocal of resistance. A measure of the flow of electrons through water. Distilled water is about 0-10 uS/cm. The Atlantic Ocean is about 30,000 uS/cm.

DO Dissolved oxygen (as O_2) content.

DP (or DRP or RP) Dissolved phosphorus (also called dissolved reactive P or reactive P). This form of P is available to plants.

Epilimnion The warm, upper (lake) water layer above the thermocline.

Eutrophication The process of becoming eutrophic from mesotrophic or oligotrophic states, via enrichment from nutrients such as P, or N.

Eutrophic A "mature" nutrient-rich lake with high biological productivity.

Freshet The peak of spring runoff (of snowmelt waters) in watercourses.

Grey water Domestic waste water exclusive of toilet wastes.

Hypolimnion The deep, bottom (lake) water layer below the thermocline.

Littoral Zone The well lit, coarse sediment peripheral shallows of a lake where aquatic macrophytes are rooted.

Metalimnion The mass of water between the epilimnion and hypolimnion which contains the thermocline.

Mesotrophic A lake with characteristics of both eutrophic lakes and oligotrophic lakes (see Table 4-1).

mg/L, ug/L Milligrams, and micrograms per litre of sample (parts per million and parts per billion, respectively).

Na^+ The sodium ion

NH_3 Ammonia (as N), may be indicative of recent waste waters or fertilizers.

NO_2^- Nitrite (as N), an unstable intermediary between NH_3 and NO_3^-.

NO_3^- Nitrate (as N), may be indicative of aged sewage or natural decomposition.

NTA Nitrilotriacetic acid, a nitrogen compound used as a builder in detergents.

Oligotrophic A "young" nutrient-poor lake with low biological productivity.

P The element phosphorus.

Phototrophic Zone The zone of maximum light penetration which supports phytoplankton. Usually located exclusively above the thermocline, and usually 2.0 to 2.8 times the Secchi disc reading.

Profundal Zone The low light, fine sediment, cold deep zone of a lake where currents and oxygen are minimal.

Secchi disc A white or white and black disc 20 cm in diameter, used to measure water clarity and to approximate the phototrophic zone.

Shorezone The zone where terrestial and marine ecosystems meet (marine or fresh water).

SS Suspended solids in water as opposed to total dissolved solids (TDS).

STS Septic tank system, a subterranean waste water treatment and disposal system for grey water, black water or both. Consists of a tank for solids retention and a system of tile or perforated piping for liquid effluent dispersal.

Thermocline The metalimnion, where the maximum temperature gradient occurs in the water column.

TKN Total Kjeldahl N (TON + NH_3).

TN Total nitrogen (TKN + NO_2^-+ NO_3^-).

TP Total phosphorus. A measure of all three forms of phosphorus - organic, orthophosphate and polyphosphates.

TON Total organic N (TKN - NH_3).

Trophic State The level of productivity of a lake based mainly on nutrients.

TS Total solids (suspended and dissolved).

1.0 INTRODUCTION

1.1 Nature and Scope of the Investigation

Growth in the Canadian tourism industry has increased the level of recreational activity, user demands and potential impacts on the natural environment including water resources (Williams, 1987).

Shuswap Lake in southeastern British Columbia (Figure 1) is an increasingly popular recreational water body, catering to people mainly from southern B.C., and southern Alberta where recreational quality lakes are uncommon. The Shuswap Lake business community has developed a booming rental houseboat industry, centred in the lakeside settlement of Sicamous, B.C. Sicamous uses the motto the "houseboat capital of Canada". Along with tourism and its related service sector, the economy of the Shuswap is based in fruit and dairy agriculture and in forestry related industry. A dozen expanding communities including one city are located adjacent to the lake, as well as the country's main railway and highway transportation corridors.

Shuswap Lake borders mountainous terrain and the majority of its shoreland is steeply sloping. There are few shallow water zones near shore, resulting in boat and user congestion and in user conflicts. Grey water, which is waste water excluding toilet wastes, is legally released into Shuswap Lake from pleasure craft, as it is in all Canadian jurisdictions at present. Individuals and groups of Shuswap Lake users have been concerned about this practice (B.C. Ministry of Lands, Parks and Housing 1987), because pleasure craft with overnight accommodation are frequently moored together in groups at sheltered harbours and beaches.

There was concern by residents about the potential for eutrophication from watercraft waste water at Seymour Arm. The concern was expressed to the Faculty of Environmental Design, The University of Calgary, and this study was mounted in response.

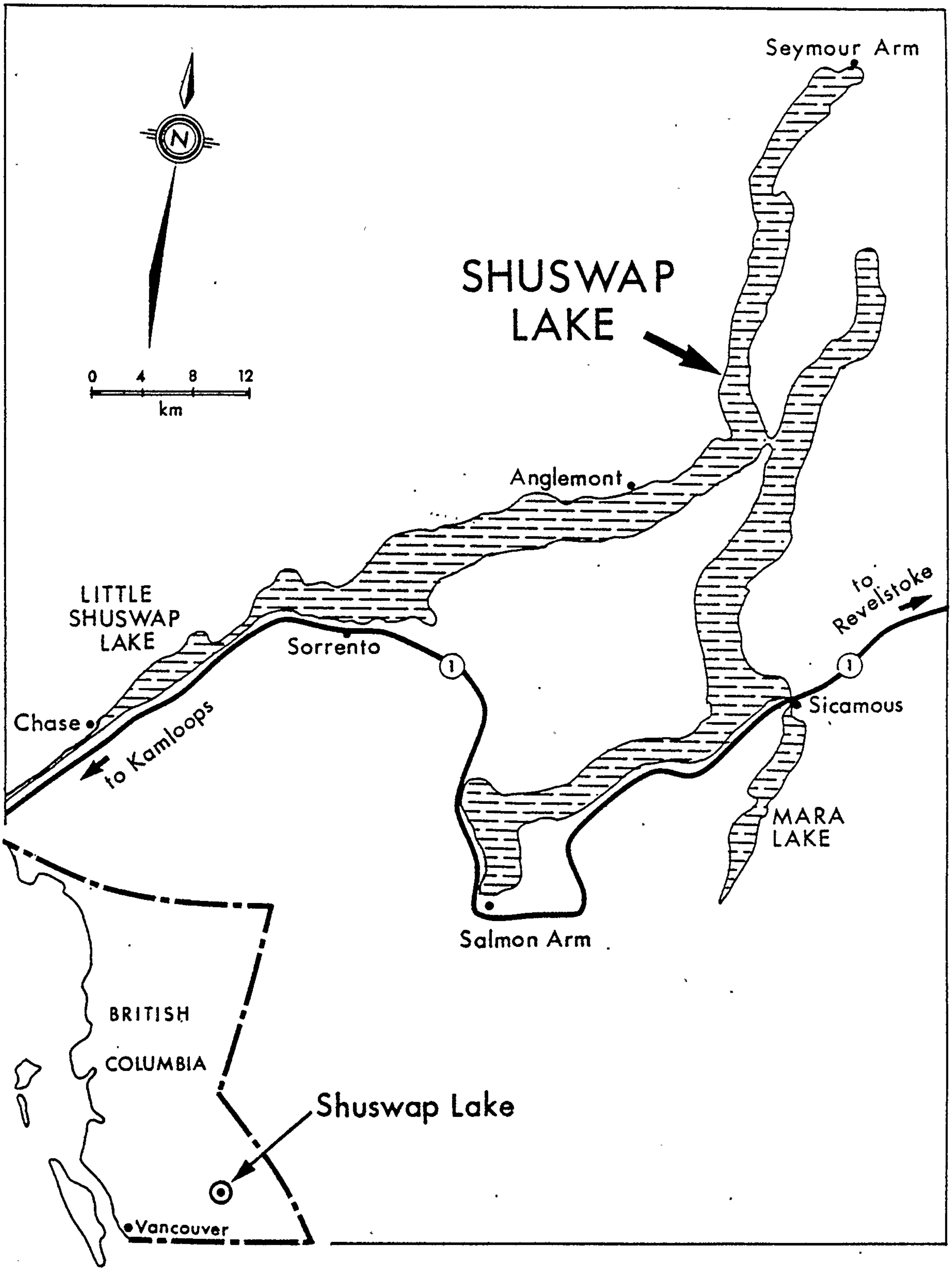

Figure 1: Location Map

Since conflicts over lake usage had been previously established (B.C. Ministry of Lands, Parks and Housing 1987, B.C. Ministry of Environment 1988), it was decided at the outset to augment study design with interviews of representatives of the principal lake user groups. Communications with Shuswap Lake residents, officials of the British Columbia Ministry of Environment and Faculty staff resulted in a final proposed study design in March, 1988.

Two major objectives of this study were to establish a water quality data base in upper Seymour Arm of Shuswap Lake, and to investigate land and water-based activities and events that may have detrimental or eutrophying effects on water quality at Seymour Arm specifically and at Shuswap Lake as a whole. The third major objective was to determine the opinions and attitudes of recreational and commercial lake users. A secondary objective of the study was to assimilate new and previous information in a comprehensive fashion that would support or dispell public and private perceptions about the lake and its usage.

Study design involved three separate methods of research to accomplish these objectives:

1. Literature searches which included Shuswap water quality, recreational water usage, waste water characteristics, lake processes.

2. Investigation of water quality through a water sampling and measurement regime augmented by shorezone inspections of potential contaminant pathways.

3. Collection of opinions and concerns of lake users through interviews using specifically designed questionnaires.

These methods were supported by communications with various experts, as required. Methods number two and three above were undertaken during the summer of 1988. Method number one covered the period from early 1988 to late 1990. This report summarizes the findings of the study.

1.2 Organization of the Report

The report is organized in sections, each beginning with a brief outline. Major subsections such as 4.1, 4.2 and 4.3 end with a summary of the most pertinent information. A description of each section and appendix is presented below.

Section 2.0 consists of background geographic information on the Shuswap and on Seymour Arm. It outlines the general and specific setting of the study and places the objectives described above in context.

Section 3.0 details what, how and why work was done. The section describes specific procedures used for data collection under the three methodological approaches (literature reviews, water quality work, questionnaires), in such a way that the collection of data could be reproduced if necessary.

In Section 4.0 the data collected in the field are presented and discussed. The section is divided into three subsections, each one of which deals with a particular phase of the study and incorporates into the collected information relevant findings from other studies found in the literature. The subsections are water quality based upon observed potential contaminant pathways to the lake water, water quality based upon measurements and upon past and present chemical analyses of water samples, and water quality as described and as perceived by the two major user groups (recreational and commercial) of Shuswap Lake.

Section 5.0 summarizes the findings of the study as presented in Section 4.0, relative to the study objectives. In this section documented and perceived water quality concerns and lake usage issues are discussed in the context of present and possible future conditions. This section refers to the appendices regularly. If the reader has not done so previously, he or she should read the appendices (especially F, H and I) at this point.

In Section 6.0, the conclusions of the study are presented, along with recommendations for future usage of the lake resource.

Materials which are referenced directly appear in the alphabetically arranged references section.

Relevant supporting information appears in the appendices. Appendices A, B, C(1) through C(6), D and E are descriptions of specific aspects of study methodology or findings. In order, they cover these topics: perenniel tributaries of Shuswap Lake, sampling stations chosen for the study, chemical analyses (results and error definition), the questionnaire used for interviewing members of the lake using public and the questionnaire used for interviewing members of the boat rental industry.

Appendices F, G, H and I are short essays on particular topics which are relevant to the work as supporting material. They are findings based on literature reviews, not on field work. These topics are referred to throughout the text, where appropriate. They include: lake types, volume replacement time and eutrophication (Appendix F), numbers and types of pleasure boats in the Shuswap (Appendix G), characteristics of grey water and other waste waters (Appendix H), and the legislation and regulations concerning recreational waste water releases (Appendix I). Tables and figures within an appendix are sequenced relative to that appendix, independent of the body of the text.

2.0 DESCRIPTION OF THE STUDY AREA

This section introduces work done in this study by describing the study area and supplying background information on history, geography and watershed characteristics. Some readers may wish to bypass this background information, while others less familiar with the Shuswap Lake watershed will find it relevant and introductory to the issues discussed throughout.

2.1 Background Information on the Shuswap

2.1.1 History

Thousands of people from across North America flocked to Big Bend on the Columbia River following the discovery of gold in 1865. Though the gold rush lasted only several years and few people made fortunes, it had a big impact on Shuswap Lake in general and on Seymour Arm (then Seymour City), in particular (Shuswap Sun Newspaper, 1988). The popular route to the gold fields was via ferry to the head of Seymour Arm, where the would-be miners then continued northwards over land. When the gold rush ended abruptly, so did Seymour City, and little now remains of the busy supply town.

British Columbia was physically connected with the Dominion with the completion of the trans-continental railway in 1885. By that time timber, mining, agriculture and the coastal fishery were established economic mainstays (Putnam and Putman, 1970).

It was a century between the gold rush and increasing tourism interests for the economy of the Shuswap. In 1972 it was estimated that tourism-related employment was 62% of the Shuswap-Okanagan labour force and that this number would increase to 72% by the year 2020 (O'Riordan and O'Riordan, 1972). Tourism services play a major role in the economy of urban centres in the Columbia Shuswap Regional District. Tourists are lured to the area because of its natural beauty and climate, and because of its water

(O'Riordan and O'Riordan 1972, McIntosh and Goeldner 1986, Shuswap Sun Newspaper 1988). Camping and boating are the prime expressions of this attraction.

The shortage of warm recreational quality water in neighbouring Alberta makes the Shuswap a viable source of water-based recreation for Calgarians and Edmontonians - the first and fifth largest markets for the area, respectively. Vancouver, the local region, and southern B.C. are the second, third and fourth largest markets, respectively (B.C. Ministry of Lands, Parks and Housing, 1987).

Figure 2 illustrates population centres in the Mara-Shuswap area. The largest urban centre is the District of Salmon Arm with a population of approximately 12,000 people. Other nearby centres include Sicamous (pop. 1,200), Sorrento (pop. 2,050), and the Village of Chase (pop. 2,800). The total permanent population near the shorezone is 18,360. The number of permanent households near the shorezone is 6,877. These data are based on 1986 provincial census data for the following communities: Sorrento, Blind Bay, Eagle Bay, Tappen, Sunnybrae, Anglemont, Magna Bay, Celista, Seymour Arm, Sicamous and the District of Salmon Arm (Holmes 1990). The total number of (privately owned) residential properties in or near the shorezone of Shuswap Lake is 4,200, consisting of 1,651 vacant lots and 2,549 lots with either permanent or seasonal dwellings (Holmes, 1990). The nearest major urban centre is the City of Kamloops (pop. 68,000) which is located 107 km west of the District of Salmon Arm.

2.1.2 Geology, Climate, Vegetation and Wildlife

The Shuswap lies in the Columbian Highlands physiographic unit, between the Monashee Mountains to the east and the Interior Plateau to the west. The Monashee Mountain Range extends along the eastern side of Seymour Arm (Long Ridge) and Sicamous Arm. Land surface elevations decrease in a westerly direction across the lake basin. At Chase, Little Shuswap Lake outlets to the South Thompson River at the eastern edge of the Interior Plateau. The bedrock geology in Shuswap basin consists primarily of Canadian Shield granitic and metamorphosed granitic rocks, with localized intrusions of

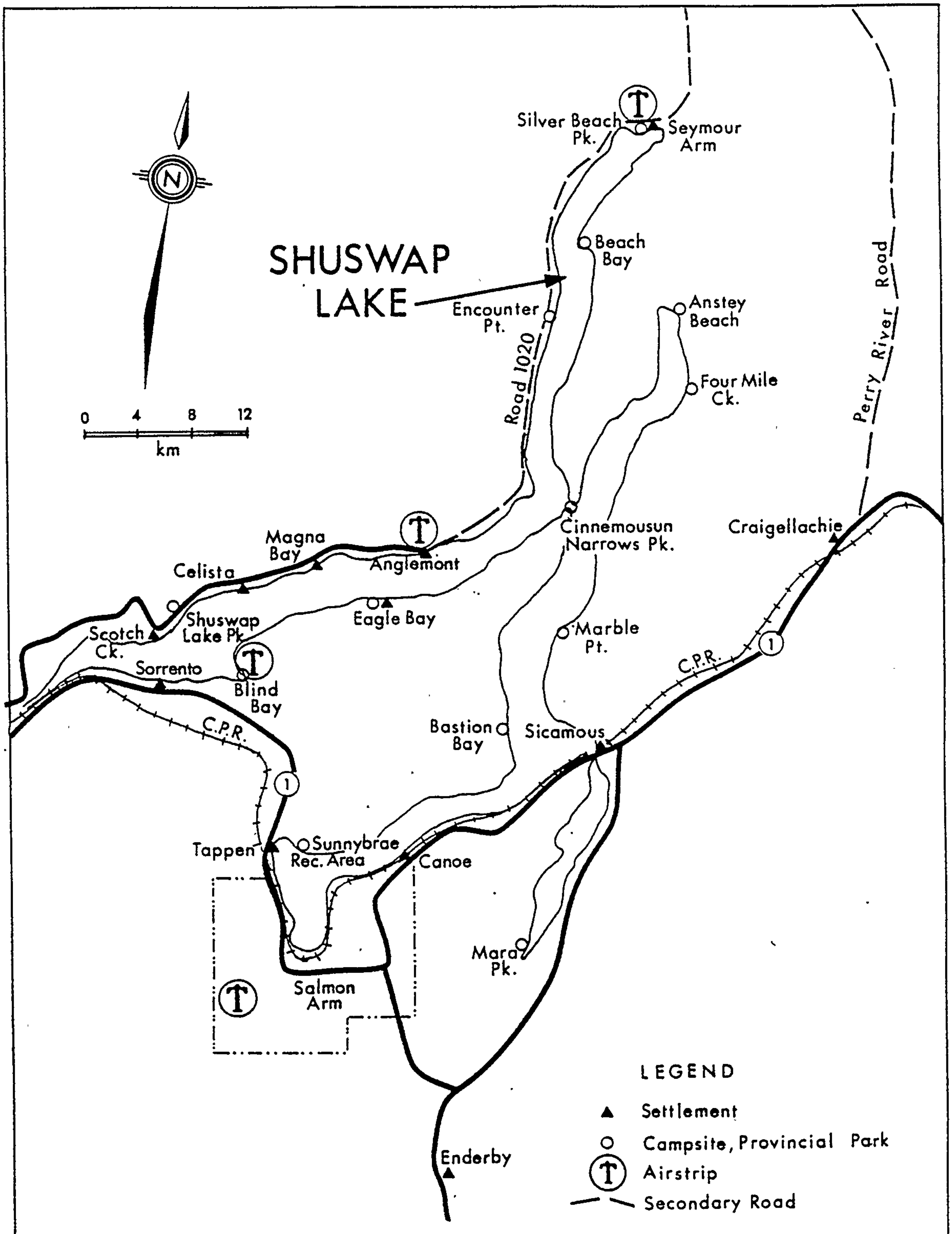

Figure 2: Map of the Shuswap Area

Jurassic-aged granitic rocks, and several deposits of Ordivician-aged sedimentary bedrock (Campbell, 1971).

The mineral apatite occurs extensively throughout the basin of the Salmon River, which flows from the south into the Salmon Arm. Water dissolves phosphorus from the apatite, which allows increased growth of algae and aquatic weeds in the lake water. The natural occurrence is relevant to this study since phosphorus is a plant nutrient which is limited in the Shuswap watershed (Ross, 1984), as discussed in Appendix F.

British Columbian climatic regions are dependent upon regional topographic characteristics, latitude and distance from the Pacific Ocean. The Shuswap lies in a region classified as "Semi-Arid Continental" climate (Ross 1984, Putnam and Putnam 1970), between the "Maritime West Coast" to the west and the "Mountain and Valley Continental" to the east. Meteorological statistics (Environment Canada, 1982) for the region are presented for reference, below. Data except wind and sunshine hours are mainly 30-year averages (1951 to 1980) from British Columbia weather station "Salmon Arm 2". Sunshine hours are from station "Salmon Arm". Wind data (1955 to 1980) are from station "Kamloops" (Environment Canada, 1983).

Temperatures (^{o}C)			
January			-5.1
July			19.5
Year			7.6
Extreme max. (70 yr. data)			41.1
Extreme min. (70 yr. data)			-35.0
Total precipitation (mm)			534
Rainfall			358
Snowfall			176
Days with Precipitation			122
Days with Rainfall			89
Total Sunshine hours			1,632
Prevailing Wind (average speed 12.0 km/h)			
Direction	Percentage	Season	
various	29	all year	
calm	26	all year	
E	18	winter	
ESE	15	fall, spring	
W	12	summer	
Frost-free days (Putnam & Putnam, 1970)			160
Degree-days above $5^{o}C$			3,800

Table 1: Meteorological Data for the Shuswap Lake, B.C. Area

The vegetation types in the province include those from boreal, desert, alpine and Maritime climates. The Shuswap is in the Columbia Forest vegetation region (Putnam and Putnam, 1970).

It is a heterogeneous mix of conifers including western red cedar and hemlock, Ponderosa pine, Douglas fir and western white pine. The coniferous canopy has a dense undergrowth similar to but less luxuriant than the Coastal Forest region. Deciduous tree species in the region include aspen, poplar and birch. Logging of mainly coniferous species is an economically important industry in the Shuswap watershed, as in many regions of British Columbia.

Shuswap Lake is an important staging and breeding area for shorebirds and waterfowl. The alluvial fans of the river mouths are important habitats for migratory birds (B.C. Ministry of Environment, 1988). Ungulate population capability is classed as being moderately high for deer, moose and bighorn sheep. The lake system has a stable sport fishery based on spawning resident populations of trout (rainbow), char (lake trout, dolly varden) and salmon (chinook, coho, sockeye). Along with open water trolling and near-shore angling by tourists, the Adams River sockeye salmon run (in four-year cycles) is a major source of tourist interest and economic benefit. Currently, the fishery is healthy and few spawning or escapement areas are threatened by development (B.C. Ministry of Environment, 1988).

2.1.3 Nomenclature Describing the Area and the Arms of Shuswap Lake

The common term "the Shuswap" will be used to describe the whole watershed or a portion of the watershed, as indicated by context.

When looking at a map of the Shuswap (Figure 3) there are at least seven obvious bodies of water, including Anstey Arm, Seymour Arm, the arm west from Cinnemousun Narrows, Adams Lake, Little Shuswap Lake, Mara Lake, and Salmon Arm from the District of Salmon Arm to Cinnemousun Narrows. For the purposes of this study, Adams Lake which drains via the Adams River into

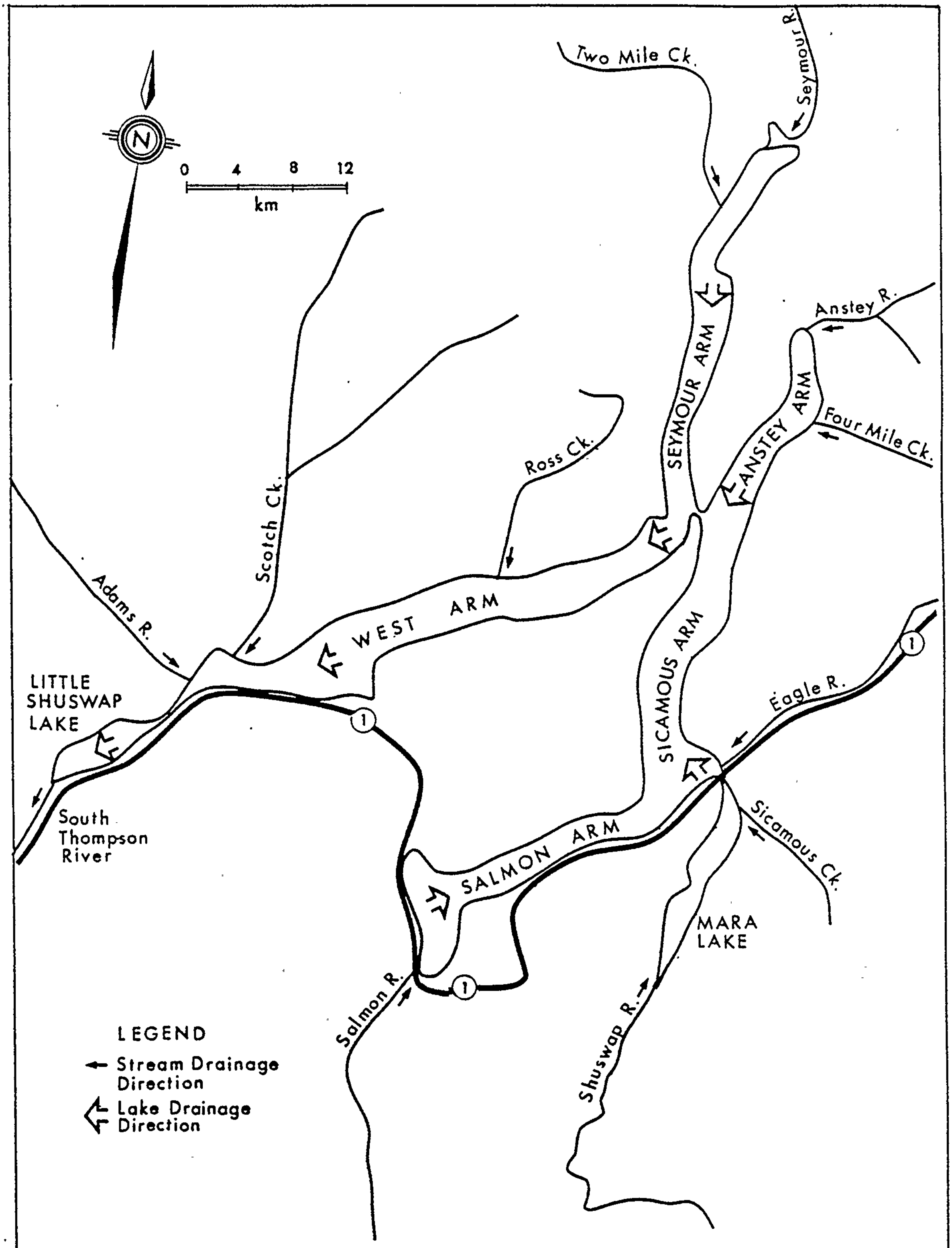

Figure 3: Nomenclature and Drainage in Shuswap Lake

the western arm, and Little Shuswap Lake which lies between Shuswap Lake and the South Thompson River will not be discussed. The criterion applied is easy accessibility by all watercraft types.

It is confusing that the large western arm is traditionally called "Shuswap Arm", "Main Arm" and even "Shuswap Lake". The whole lake system is Shuswap Lake. There is a physical division between the western half of the Salmon Arm (from Salmon Arm to Sicamous) and the northern half (from Sicamous to the Cinnemousun Narrows). Subsequently, for reasons of clarity and consistency with the basin description used by B.C. Ministry of Environment (Holmes, 1987), the western arm will be called West Arm, the western half of Salmon Arm will remain as Salmon Arm, and the northern half of Salmon Arm will be called Sicamous Arm. Shuswap Lake is therefore considered to consist of five arms of open water: Salmon Arm, Sicamous Arm, Anstey Arm, Seymour Arm and West Arm (as depicted in Figure 3).

2.1.4 The Watershed and Monitoring History

The Shuswap Lake watershed (Figure 4) encompasses an area of 15,600 square kilometres from Revelstoke in the Monashee Mountains westward to Kamloops in the Interior Plateau (Ross, 1984). The watershed is over 200 kilometres from north to south, and includes the following major inlets: the Adams River, the Seymour River, the Anstey River, the Eagle River, the Shuswap River and the Salmon River. Drainage into the lake system is accomplished by these six major rivers and over two dozen constantly flowing creeks as outlined in Appendix A. The Shuswap watershed is drained by the westerly-flowing South Thompson River. The mean elevation of the lake is 347 ± 2 metres above sea level.

Much of the following information is based on two studies of Shuswap Lake. The first is by Ross (1984), based on work done in 1978 and 1979. The second is a summation of data on the lake by Holmes (1987). Detailed morphometric information on the lake is not reproduced here, and may be obtained through these sources.

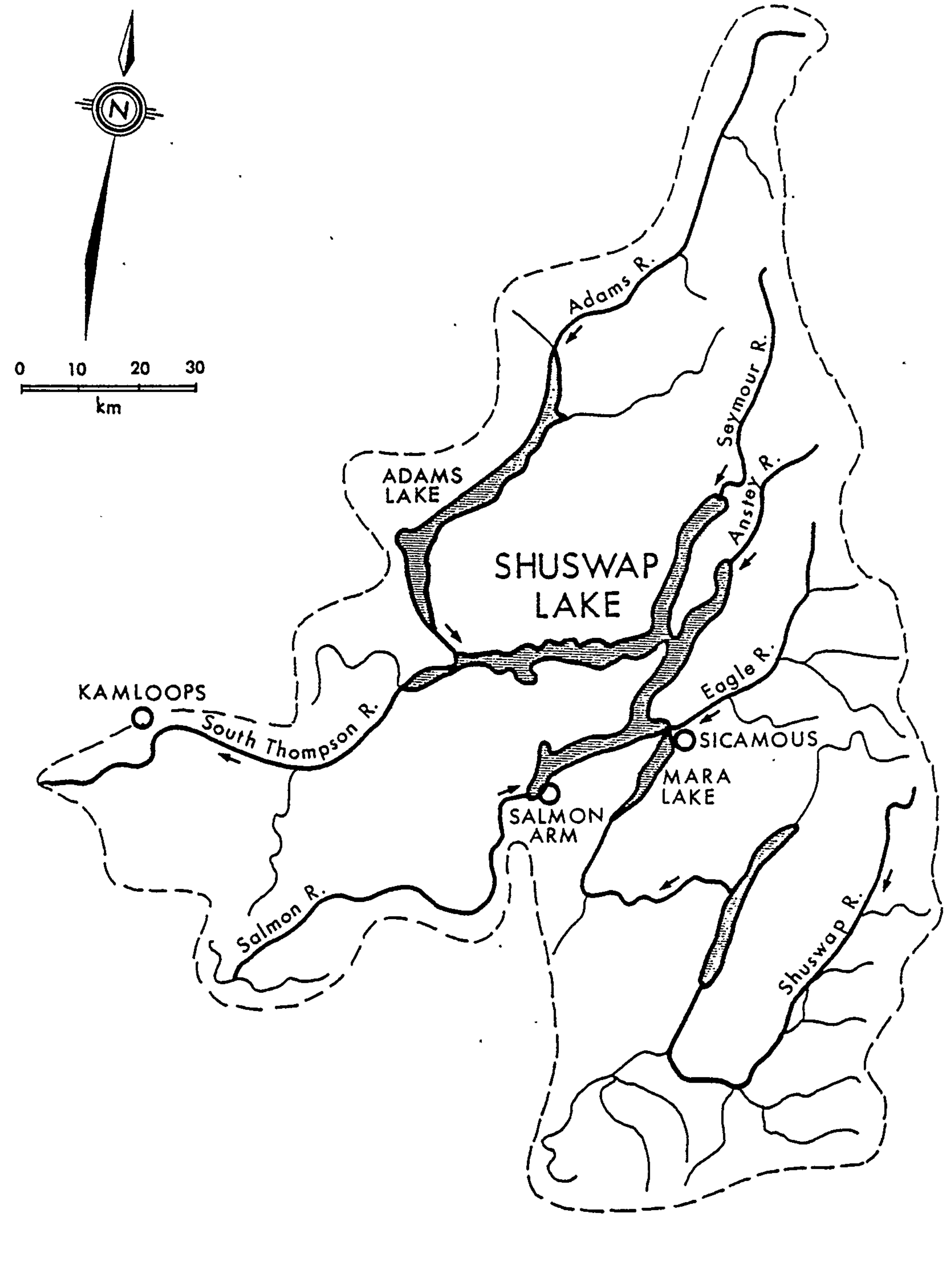

Figure 4: The Shuswap Lake Watershed

source: ROSS, 1984

The five designated arms of Shuswap Lake (excluding Mara Lake) have a combined total surface area of approximately 301 square kilometres. The total shoreline length is 312 kilometres. The irregularity of the shoreline is apparent from a glance at the lake outline. The mean depth of the lake is 62 metres. The maximum depth is 162 metres, measured at a mid-channel location to the south of Encounter Point on the Seymour Arm. The steep sloping walls of the lake basin create low potential for littoral community development along the majority of shoreline length (Ross, 1984). Other factors such as nutrient supply contribute to the low trophic level of the lake, as discussed more fully in Appendix F.

Volume replacement time, or "flushing time", can be calculated by dividing the lake's equivalent water volume by the outlet discharge. The Shuswap Lake volume has been calculated by several authors including Ross (1984) using 1949 bathemetric data from the International Pacific Salmon Fisheries Commission to be 1.91×10^{10} m^3. Holmes (1987) used updated bottom mapping and computer assistance to calculate a volume of 1.57×10^{10} m^3. Therefore, the lake's volume replacement time is somewhere between 2.1 years (based on the larger volume and the 69-year average South Thompson River discharge of 288 m^3/s), and 1.7 years (based on the smaller volume and the 69-year average outlet discharge of 288 m^3/s). Volume replacement time is discussed in Section 4.3 and in Appendix F.

Water quality monitoring in the Shuswap watershed began with a zooplankton study by F.J. Ward in 1957 (Nordin, 1986). Previous to Ward's work, research in Shuswap Lake was entirely biological in nature and included studies related to the fishery such as those of W.A. Clemens of the Provincial Fisheries Department in 1934 and 1938. In 1960, F.J. Andrew of the International Pacific Salmon Fisheries Commission undertook a study on Sockeye salmon smolts on the lake. L.S. Roberts included Shuswap Lake in a 1963 study of the zooplankter Cyclopoida. In 1968 J.S. Nelson published a paper on Kokanee salmon in B.C. lakes including Shuswap Lake. No water quality monitoring occurred during the 1960's.

It was during the early 1970's that concern for the lake generated substantial scientific activity (O'Riordan and O'Riordan, 1972). This included work by the provincial Pollution Control Branch, several branches of the federal Inland Waters Directorate, the International Pacific Salmon Fisheries Commission, the Okanagan Study Committee and several university theses (O'Riordan and O'Riordan 1972, Nordin 1986). It was during the period 1971 to 1975 that many of the current Shuswap Lake water sampling stations were established by the B.C. Ministry of Environment (Nordin, 1986).

2.1.5 Constraints to Development

Certain areas throughout the lake are popular with tourists in general and boaters in particular. Reasons for popularity with boaters usually include moorage, beach, some degree of services, scenic appeal, and frequently a navigational constraint such as the constriction or end of a channel. The shape of the Shuswap Lake basin, as reflected in its depth of water and height of valley walls, has resulted in few natural harbours and beaches. Shoreline shape therefore dictates that little development (including access road construction) can occur without costly shoreline modifications.

This morphological fact supports the lakeshore's scenic appeal, but causes congestion and potential conflict at the limited number of shoreline locations which are developable and usable for water-based recreation (B.C. Environment, 1988).

2.1.6 Moorages and Services

There are few overnight moorage sites on Mara Lake. The land at the north and south ends of the lake, and much of the east shore is privately owned (Columbia-Shuswap Regional District, 1987). Most of the fairly steep west shore is crown land. Mara Park at the lake's southeastern corner is well equipped but does not offer overnight moorage. Sani-station services do not exist on Mara Lake but are available on a commercial basis in the Sicamous Narrows.

The Sicamous Narrows drains south to north connecting Mara Lake to Shuswap Lake. "Sicamous" is derived from a Shuswap Indian word meaning "in the middle" (Shuswap Sun Newspaper, 1988). Its limited width allows for bridging by the Canadian Pacific Railway main line and the Trans-Canada Highway. As a result of the natural harbour conditions, the marine facilities in the adjacent village of Sicamous, and proximity to the Trans-Canada Highway, the Narrows have become headquarters to most of the rental houseboat industry. The Narrows' marina facilities and the service industry in the Village of Sicamous provide moorage and servicing of the Shuswap's barge service, privately owned boats, most of the houseboat industry and pontoon aircraft. The densest concentration of boat traffic on Shuswap Lake is at the Sicamous Narrows (Mackie 1989, Prystai 1989).

Salmon Arm runs west to east 22 km from the municipalities of the District of Salmon Arm and Tappen to Sicamous, and is the most visible part of Shuswap Lake from the Trans-Canada Highway and the CPR mainline. Moorage is available at Sunnybrae Recreation Area, Paradise Point and at government wharves in Salmon Arm and Canoe. Shoreland from Canoe around Tappen Bay to Herald Park is almost exclusively in private ownership.

East of Herald Park, the north shore is approximately 50% crown land. East of Canoe, the south shore is approximately 80% crown land, with little development because of the steepness of the rocky shore. The single sani-station at Salmon Arm was not functional during the May to October 1988 study period.

Sicamous Arm is a 19 km-long body of water which connects Salmon Arm and Mara Lake to the Cinnemousun Narrows. Three provincial parks offer boat moorage - Hungry Cove and Marble Point on the east shore, and Hermit Bay on the (mid) west shore. Near to Hermit Bay, marine gasoline and supplies are available at Bastion Bay. Marble Point is also a popular campsite. Approximately 60% of shoreline on Sicamous Arm is crown land. The moorage, sani-stations for rental houseboats, fuel and servicing offered at the Sicamous Narrows lessen the need for moorage and services in Sicamous Arm.

The Cinnemoussun Narrows is the most popular site on the Shuswap with boaters (B.C. Ministry of Lands, Parks and Housing, 1987). All boaters travelling from either northern arm to any southern arm must pass through centrally located Cinnemousun. A small seasonal service industry has developed at the Narrows including a floating restaurant, a sani-station, a general store, beach and mooring facilities. Camping and park facilities are also available at the Cinnemousun Narrows Park. The sani-station facility at the Cinnemousun Narrows Park was the only such facility which was operational during the study period in 1988.

Anstey Arm is crown land with the exception of several stretches of privately-owned land between and across from Anstey View and Twin Bays. Moorage is available at the north end of Anstey Arm at Four Mile Creek and Anstey Beach Provincial Parks. The park has limited services and facilities. Four Mile Creek and Anstey Beach are the third and fourth most frequented moorages (B.C. Ministry of Lands, Parks and Housing, 1987).

There is little private or leased land on either steep, rocky shore of the Seymour Arm. At the head of the Seymour Arm, near Silver Beach Park and the settlement of Seymour Arm (the study area), there is considerable private land. The area offers a number of services including an airstrip, marina, moorage, a campsite, hotel rooms and rental cabins, groceries and liquor sales and two restaurants. The services offered and the scenic appeal of the area make Seymour Arm the second-most popular boating destination on the Shuswap (B.C. Ministry of Lands, Parks and Housing, 1987).

West Arm is the longest and widest arm, extending from the Cinnemousun Narrows to the lake outlet. It is also the most developed and contains the most privately-owned land (approximately 90%). There are airstrips, marinas, boat moorage and grocery supplies at both Anglemont and Blind Bay. Public moorage sites include Cinnemousun Narrows Park, Horseshoe Bay, Magna Bay, Eagle Bay, and the Roderick Haig-Brown Conservation Area at the Adams River mouth. The sani-stations at Anglemont and at Blind Bay were inoperative in 1988.

2.2 Background Information on Seymour Arm

Topographically, the study area is the bottom of the high-walled, north-south striking Seymour River Valley. Relief in the immediate area of concern - the Seymour Arm townsite near to shore - is less than 30 m. Maximum relief in the area is 1478 m, measured from the peak of Long Ridge to the east of the study area, to mean lake level (347 ± 2 m).

The Seymour River discharges to lake level through extensive deltaic deposits of medium to coarse sands and gravels. The Arm itself is the flooded, glacially-scoured extension of the Seymour River Valley. Sediments are granular in elevations near present lake level. At higher elevations, surficial materials are low permeability clay deposits. Unsorted clay till deposits exist north of the settlement at the local landfill site.

The Seymour River originates approximately 72 river kilometres north of its mouth near Gordon Horne Peak glacier. The river water is cold, clear and low in dissolved solids. The short distance from source to mouth, and the non-calcareous nature of regional surficial and bedrock geology are responsible for the high quality of the water.

Flow in the upper Seymour Arm is controlled by discharge from the mouth of the Seymour River, located between Bughouse Bay to the east and Dasniers Bay to the west. Despite the river's meandering course it enters the lake with sufficient force as to isolate the two bays from one another. Average monthly flow rates, as recorded by a federal flow gauge during the course of the field study, ranged from 17.3 m^3/s in September 1988 to 102 m^3/s during freshet in June, 1988 (Environment Canada, 1989).

There are areas of low energy water in the study area. These include the shallow bay east of the Seymour River mouth, the northwestern shore and the southwestern shore of Bughouse Bay. The quiescent waters are a result of protection from the prevailing westerly (summer) wind, shore profile and minimal input from creeks.

Provincial aerial photographs taken during peak freshet in 1974 and 1976 demonstrate clearly that the river's discharge heads south directly down the Arm. During May 1988, considerable logging debris was observed in a large arc stretching from north of Gilmans Bay to east of Shemar Lands. The arc was centred on the river mouth. No debris was seen near to Bughouse Bay or near to Dasniers Bay. The configuration of the debris clearly illustrated the southern flow direction of the river discharge.

The settlement of Seymour Arm is located at the head of the Seymour Arm, east of the Seymour River mouth (Figure 5). The permanent population consists of 150 residents. The seasonal population is about 400 persons.

Access to Seymour Arm is accomplished by air, by water or over land. Small aircraft can land at the local grass airfield during snow free months, or on the water if equipped with floats. The ferryboat Phoebe Ann out of Sicamous can usually access Seymour Arm all twelve months of the year (Mackie, 1989). Dependent upon ice conditions, most power boats can also access Seymour Arm year-round. The 35 km long Road 1020 allows vehicular access from Anglemont on the west shore of the Arm. The 70 km long Perry Road allows access from the east, originating on the Trans Canada Highway near Craigellachie. Roads in the settlement include the Abbott Road, the Quaft Road (which intersects with Road 1020) and the Seymour Arm Bay Road (which runs north and east of Bughouse Bay).

There are approximately 140 privately owned vacant lots and 200 improved (private, with dwelling) lots, in or near the shorezone at the settlement (Grace, 1990). The community has an elected council and a town hall. It is serviced with a reliable gravity-fed water distribution system. There are no communal electricity, telephone, sewer, garbage or police services. There is an administrator for the water supply and distribution system. Recently, a full-time teacher was hired.

For the purpose of this study, the area depicted on Figure 5 will be called Seymour Arm. Note that Silver Beach Provincial Park is located at Seymour Arm, and both are at the north end of the lake arm designated "Seymour".

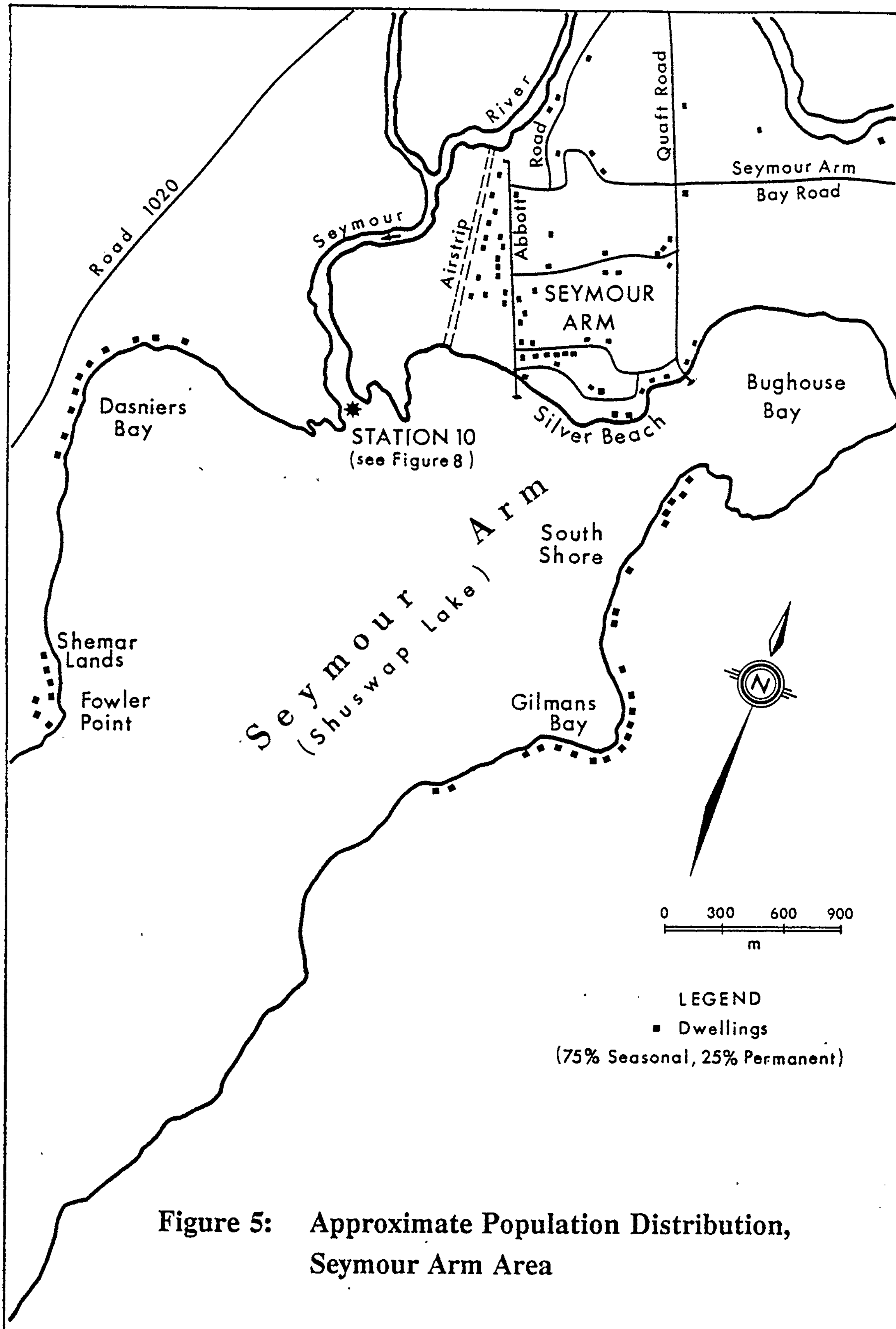

Figure 5: Approximate Population Distribution, Seymour Arm Area

3.0 METHODOLOGY

3.1 Overview

Methodologies employed in collecting and analyzing data are detailed in the following section. Three separate approaches to data collection were used.

1. literature searches and reviews;
2. water quality sampling and measurements using standard limnological equipment and techniques;
3. questionnaire completion to collect attitudinal and physical information pertaining to the use of Shuswap Lake.

These three research approaches were augmented with inspections in the prime study area (the settlement of Seymour Arm) to identify potential land-based sources of contamination of the lake water, observations of usage of the shorezone and of lake users, and personal communications regarding lake usage from individuals, organizations, businesses and government officials. Analyses of the physical data (lake water samples) and the descriptive and social data (results of the questionnaires) are explained in following sub-sections.

3.2 Literature Searches and Reviews

Literature reviews were undertaken in February 1988, June and November, 1989 and January, 1990 in order to determine the relevance of previous works to this study. The first, third and fourth literature searches were performed through The University of Calgary's IBM mainframe library system, featuring the Dobis and Nomads on-line catalogues. The second search was undertaken through the Conference Board of Canada computer database. Search topics included: lake eutrophication and trophic systems; limnological techniques; water law; Canadian water quality legislation, regulations and guidelines; Shuswap Lake and Seymour Arm; common resource ownership; lake water contaminants; waste waters; water recreation and houseboating. Two reports commissioned by the Ontario government (MacLaren

Engineers 1987, Beak Consultants Limited, 1988) on grey water and pleasure craft were found and permission to use them granted. Neither have appeared in the literature to date.

3.3 Inspection of Land-Based Potential Sources of Lake Water Contamination in the Study Area

Inspection of properties within 250 m of the lake shore was undertaken in mid May and late July, 1988, to assess potential sources of contamination to the lake via direct discharge, overland flow and potential groundwater migration. This inspection covered properties in Shemar Lands, Dasniers Bay, Silver Beach Park, Seymour Arm, Bughouse Bay, the South Shore and Gilmans Bay.

Three main criteria were used to guide field inspections of potential contaminants entering the lake water from shorezone sewage disposal systems including grey water disposal, shorezone petroleum product storage and distribution, agricultural runoff or seepage, and others as observed. These criteria are based upon the Province of British Columbia's Sewage Disposal Regulations (B.C. Reg. 199/86, The Health Act), regarding the siting and construction of underground sewage disposal systems (The British Columbia Gazette - Part II, 1986).

The first criterion is distance - no portion of a sewage disposal system may lie within 30 m of the high water mark of a surface water body or water course. Potential sewage disposal systems in the shorezone were measured to present water line and estimated high water line using a 100 foot (30 m) tape measure. The second criterion is slope of the land surface - no sewage system may be constructed on land which slopes in excess of 30%. In the field, slope was estimated from elevations and measured distances (rise over run = 1/3.3 or approximately 30%). The third criterion involves site specific geologic conditions - no sewage disposal system may be constructed in soil less than 1.2 m above an impervious layer of soil, above bedrock or above the water table. The 1.2 m depth of soil must not be disturbed (as in fill material), and must represent the natural land surface. This criterion was checked by observations of surficial materials and grades, observations of bedrock outcrops, discussions with local residents who were heavy equipment operators, and the completion by lake residents of detailed descriptions of their sewage disposal systems.

Local pathways of potential contamination to the lake from domestic, commercial, agricultural and industrial sources are presented and discussed in Section 4.1.1. Similarly, pathways of potential contamination from these types of sources throughout the lake basin are presented and discussed in Section 4.1.2.

3.4 Documentation of Water Quality and Quantity

In order to document present water quality at Seymour Arm, and potential threats to or changes in quality, a water sampling and measurement regime was established and undertaken according to a predetermined schedule designed (a) to make the most practical use of time, equipment and analytical resources, (b) to coincide with the tourism cycle peak in late July, and (c), to observe and measure lake and stream characteristics over spring, summer and fall seasons.

Dates of water sampling and measurements at lake water stations were May 9, May 19, July 26, August 2 and October 3, 1988. Discussion herein involves conditions in and around the lake up to and including October 3, 1988.

3.4.1 Water Samples

Ten water sampling and measurement stations were selected for localized representativity and repeatability. They are located from the mouth of the Seymour River eastwards to the head of Bughouse Bay (as illustrated in Figure 8 and detailed in Appendix B). Stations were not established in Dasniers Bay or Gilmans Bay because water from both bays flows away from the Silver Beach Park area.

Seven stations (numbers 2, 3, 5, 6, 7, 8, 10) were located near to shore, designed to reflect potential nutrient input from land-based sources or from boating activities in the shallow water of the foreshore. Stations number 1, 4 and 9 were deep water stations designed to represent typical water quality at the head of Bughouse Bay (#1), at the centre of the mouth of the Bay (#4), and at a point downstream from Silver Beach and the Bay (#9). These three stations could be used to represent background full column water quality, and be comparable to previous deep water sampling data on Shuswap Lake (Ross, 1984).

Composite water samples from the deep water stations were taken from different depths within that portion of the water column designated as the phototrophic zone. Following accepted limnological technique (Cole, 1975), a standard Secchi disc was lowered into the water column on bright days between 1000 and 1400 hours, and its point of disappearance ($\pm$0.1 m) noted. The recorded depth was doubled. This depth is considered to be a conservative approximation of the phototrophic zone (Lind 1974, Cole 1975).

Duplicate samples for analyses of chlorophyll "a" and for analyses of selected water chemistry parameters were composited from samplings of each quarter of this depth using a standard model Van Dorn sampler (Lind, 1974). The loaded sampler was lowered through the water column to the desired maximum depth as indicated by the affixed graduated line and was actuated by dropping the messenger weight along this line. As the loaded sampler always rinsed itself with ambient water, no cross-contamination (depth-to-depth or station-to-station) could occur. Some of the captured five litres of water sample was used to rinse two new one-litre sample bottles. Two hundred and fifty millilitres of the water was used to fill the rinsed bottles to one quarter volume. Except for the rinsing, the process was repeated three more times at desired depths to obtain 1000 mL of sample.

Typical sampling depths below water surface for the deep-water composited samples were thirteen, nine, five and one metre.

The remaining seven stations were too shallow for double Secchi depth composite samples. Subsequently stations 2, 3, 5, 6, 7, 8 and 10 were sampled by the grab method - hand dipping a locally-rinsed bottle into the water column and taking the one-litre sample at a consistent 0.5 m below the surface.

Sample bottles used in the study were new, one-litre polyethylene vessels. The rectangular sample bottles are the standard for non-bacteriological water samples in the province of British Columbia. The two bottles used for sampling each station (one for chemistry, one for chlorophyll "a") were first rinsed on location with water from 0.5 m depth for grab samples and maximum sample depth for composite samples. Once filled, bottles were sealed, labelled and stored in a cooler, as per standard procedure followed by the B.C. Ministry of Environment (Holmes, 1987).

Water samples were delivered for analyses in the following fashion. At a pre-arranged time B.C. Environment officials would arrive over land or by boat to take delivery of the 20 labelled cooler-stored samples for sample runs one through four. For run number five on October 3, 1988, the fresh samples were driven to a prearranged rendezvous with a B.C. Ministry of Environment staff member. In all cases, water samples were delivered to an overnight courier service in Kamloops later in the day that they were obtained. Samples arrived at the provincial laboratory in Vancouver the following day. This procedure was adequate for the analyses of the selected chemical parameters (which were not very perishable) and in accordance with procedures recommended by regional B.C. Environment staff.

Analytical techniques in Vancouver were in strict accordance with A Laboratory Manual for the Chemical Analysis of Water, Waste Waters and Biological Tissues, Second Edition (B.C. Department of Environment, Vancouver, 1976) and subjected to in-house quality controls including supervision, bench sheets, blank samples, standards and ion balance by computer (Grace, 1989). The selection of parameters and each individual parameter tested (mainly nutrients N and P) are discussed in Section 4.2.2. The specific tests performed on water samples follow. The accuracy and precision, range and minimum detection concentration for each test are presented together in Appendix C(6).

Parameter	Units	Analytical Technique
Conductivity	uS/cm	meter (Siebold)
pH	pH units (logarithmic)	meter (Fisher)
Na	mg/L	auto analyzer (flame emission)
Cl	mg/L	auto analyzer (mercuric thiocyan)
N-total, total organic	mg/L	mathematically calculated
NH_3, TKN, NO_3	mg/L	(block digital, Bertholot, cadmium reduction)
DP, TP	mg/L	auto analyzer (ascorbic acid)

Table 2: Analytical Methods for Water Sample Analyses

3.4.2 Measurements Taken at Lake Sampling Stations

Secchi disc readings were taken at the four stations that were in water deep enough to accommodate the readings, stations 1, 3, 4 and 9. Station 3 had sufficient depth for a Secchi disc reading, but insufficient depth for composite samples over a depth of twice the reading.

Three types of measurements were taken in order to gauge in the field whether any sources of ions, oxygen demand or heat existed at the stations at the time of sampling, and to guide further investigation or sampling if warranted by such findings. Electrical conductivity readings were taken at 0.5 m below surface at all stations using a Hanna Instruments Model 8033 portable conductivity meter. These readings were compared to laboratory conductivity readings for water samples taken at the same time and location as the readings. Measurements of dissolved oxygen (DO) taken 0.5 m below water surface at all stations were performed using a Yellow Springs Instruments (YSI) Model 54 dissolved oxygen meter.

The meter was used also to record water temperature at the 0.5 m depth per station. Water temperature readings from the YSI were then checked against a field thermometer to ensure agreement within 0.5°C. The three measurements were taken at the same depth below the water surface as the shallow water samples to maintain consistency of methodology and to avoid influences such as increased oxygen from the atmosphere and water interface and an elevated surface temperature from solar radiation.

Along with these measurements, observations were made of field conditions at the time of sampling - water level, turbidity, aquatic macrophyte growth, water usage and weather. The aquatic macrophyte Potamogeton richardsonii was identified in the field using descriptions of the common submergent plant and an illustration found in Cole (1975).

3.4.3 Measurements Taken at Inlet Streams

Measurements and observations of five continuously flowing streams in the study area (Seymour River, creeks designated A, B, C, D) were undertaken in mid May, in late July and early August, and in early October, 1988. These included field calculations of flow rate, and measurements of electrical conductivity and water temperature. These measurements were to quantify potential contributions of contaminants from the inlet stream water to the lake water of the study area. As with the lake samples, electrical conductivity was used as an indicator of the presence of major ions.

Temperature readings were taken using a field thermometer and checked against the thermometer on the YSI DO meter, as described above. Conductivity measurements were taken by facing the meter's probe downstream at mid-stream in mid-column, in order to obtain a constant reading and to protect the electrodes from suspended material in the rushing water.

Measurements of water velocity and channel cross-sectional area were taken over the course of the study to determine instantaneous estimations of flow. Often referred to as the "bobber method", the stream's average velocity is multiplied by cross-sectional area (averaged stream depth h times width w). For example, on a 3 m-wide stream, measurements for depth could be taken at 0.5 m intervals. The estimation of velocity is an average of three measurements of time in seconds for a buoyant object floating on the water surface to cover a known distance (length l). This measures surface velocity and does not consider frictional forces from the stream bed and banks (Cole, 1975). Averaged measurements yield an estimation of flow calculated as a volume (l x w x h) per unit time (s), or m^3/s.

Creeks A, B and C crossed under the (Bughouse Bay) East Road via culverts of readily measurable length and average stream depth. Creek D was most appropriately measured near its mouth. Estimations of flow for the Seymour River were taken at the bridge on Quaft Road (Station E). Station E field calculations are compared in Section 4.2.1 to same day readings from the Environment Canada gauge located 2.25 km further downstream.

3.5 Gathering Information from Shuswap Lake Users

Two questionnaires were developed. Procedures were established to conduct personal interviews based upon the questionnaires. The procedures were subject to approval by the Conjoint Areas Research Ethics Committee, of The University of Calgary. Approval was granted by the Committee in April, 1988 to conduct interviews in which the respondent remained anonymous and in which no coersion was employed.

3.5.1 Questionnaire #1 - Residents of and Visitors to the Seymour Arm Area, Shuswap Lake

A questionnaire (Q1) was developed for all users of Shuswap Lake. Its use was centred on Seymour Arm, but was designed for permanent and seasonal residents of, and return visitors to Shuswap Lake. Q1 was designed to collect opinions on lake usage issues applicable to the Shuswap and on lake usage issues specific to Seymour Arm. Questions were based on information gathered during consultations with the complainants, officials of the British Columbia Ministry of Environment and Parks, the author's supervisory committee, and staff of the Faculty of Environmental Design at The

The University of Calgary. Comments were encouraged to ensure that respondents could express all of their concerns. The questionnaire sought opinions on water quality, possible land-based sources of contaminants, recreational usages, lake discharges such as grey water, planning and multiple use of the lake, houseboating, regulatory agency presence and personal waste water practices. The questionnaire also gathered information on solid and liquid waste disposal practices of respondents independent of their user group (eg. camper, resident). Q1 is reproduced in Appendix D.

Between July 23 and August 7, 1988, 175 lake users were interviewed at Seymour Arm. Four interviews were conducted on July 30, 1988, at Sicamous. Respondents were required to have experience of at least two prior visits to the Shuswap, including one to Seymour Arm. This was based on the premise that those with no lake experience had no comparative basis for their opinions on water quality and lake usage. Ten test questionnaires were completed which verified the premise, and were then destroyed. The test interviews resulted in vague answers, frequent "no response" or "don't know" answers and few comments.

The three main random sampling methods require a compiled list of the sample universe. It is implied in each random selection method (simple or systematic, stratified and cluster) that a listing of the units in the universe is at least finite and at best manageable. In this case, lists existed for some lake users such as residents, but not for others such as day users, campers, houseboat rentors and visitors of residents. In quota sampling, a quota is established based on known characteristics of the universe, such as prior knowledge of the lake. "There are times when using a quota is the only reasonable way to select a sample. This is particularly true when it is extremely difficult, if not impossible, to list and identify all of the potential elements in the universe" (Cannon, 1987, p.104). Edbon (1985) stated this in another way: "For some purely descriptive purposes, samples which are not random may be most useful" (p. 36).

A quota of 175 to 200 respondents was established as a reasonable number of lake users to be interviewed. Respondents to Q1 were selected in this fashion. All groups of prospective respondents (who had prior experience of the lake and who had not been approached before) were asked if one of their number would agree to an interview on lake usage. The group members were asked if they would select one member whom they considered to be representative. Children under the apparent age of 16, persons who appeared to be intoxicated, and persons who seemed doubtful were excluded from the interview process, if they happened to be selected by their group.

A total of 77 repeat visitors to the Shuswap were interviewed. Five owners of pleasure boats with overnight accommodation from outside the Shuswap, from an estimated population of 75 $\pm$ 25, completed Q1 (5% - 10%). Twenty two renters (group representatives) of the 327 $\pm$ 5 available houseboats for rent on Shuswap Lake, completed Q1 (6.7%). Nine persons renting rooms or visiting Seymour Arm residents completed Q1, or about 4.6 % of the 15 available rental units (x 3 persons/unit), plus three visitors each at an arbitrarily chosen 50 of the 200 private dwellings at Seymour Arm. Out of an estimated 200,000 overnight Shuswap Lake park visitors per annum (B.C. Ministry of Lands, Parks and Housing, 1987), 37 representative campers completed Q1 (0.02%). Four runabout boat owners from outside the Shuswap watershed completed Q1. There are no statistics available on the number of launched runabouts which originated outside the Shuswap (Table G-1).

A total of 102 residents (seasonal and permanent) were interviewed. Eighteen representatives of the total population of 150 individual permanent Seymour Arm residents completed Q1 (12%). Sixty two of the estimated 400 seasonal Seymour Arm residents completed Q1 (15.5%). The ratio of the 12 permanent Shuswap residents who completed Q1 to their total number of 18,360 is less than 0.1%. The ratio of the ten seasonal Shuswap residents who completed Q1 to their total number of 3825 (estimated 1275 seasonal dwellings x 3 persons/dwelling) is less than 0.3%.

To bring campers, permanent Shuswap residents and seasonal Shuswap residents up to the 3.5% to 15.5% range of representation of other groups would have required hundreds more interviews. Also, this proportionment would not have been representative of the study area demography during the sampling period. More importantly, the fact that no list of potential campers exists precluded the use of random selection techniques (Cannon, 1987).

The questionnaire contained 27 questions. It was most frequently filled out verbatim by the interviewer as directed by the single interviewee. It became apparent one simultaneous interview with a small group of respondents would be a more efficient method of collecting information, providing that a group could retain the integrity and anonymity of individual respondents. Subsequently, two experimental interviews were conducted with two test groups of two persons each. Careful review of test responses indicated that the apparent quality of responses did not seem different from the apparent quality of responses from one-on-one interviews. This was a judgement by the author made in response to field conditions and based on three criteria: the number of questions answered, the number of clarifications required and the comments offered by respondents.

With these criteria in mind, it was believed that conducting small group interviews was legitimate and could proceed. The format used in one-on-one situations (where the interviewer completed Q1), was duplicated in the group situations (where the respondent completed Q1). This included the interviewer reading the question for the respondent, a slow pace, and insistance that the respondent answer in isolation exactly as he or she pleased. Also as with one-on-one interviews, anonymity of participation was guaranteed. On seven occasions small groups ranging from two to 18 persons and averaging six persons, were interviewed together. Questions directed at the interviewer regarding intent of a question were accepted, but not questions regarding answers. Respondents were instructed to use response spaces provided (for analytical purposes), and to augment responses with comments as desired.

Independent variables such as age, sex, occupation and income level were not incorporated into the questionnaires and subsequently no correlations (regression analysis) were attempted. The rationale employed was that the study was focussed on what people thought about water quality and lake usage issues within the context of their experience, not why they might think so or whether their perceptions were influenced by external factors such as the variables mentioned above. This decision was made in the study design phase, under advice. Also, statistical treatment of quota samples which exclude random selection methods are not considered to be reliable

(Cannon, 1987, p.104) or even valid (Ebdon, 1985, p.15). Parkes (1973) incorporated such independent variables into cluster samples of water-based recreationists and subjected the data to regression analysis, with mixed results. One result was that the correlations seemed to be very site specific, as discussed in Section 4.3. Site specific responses were desired in this study, and only one site was used: Seymour Arm on Shuswap Lake.

To summarize, sample selection for the information survey was by quota method since lists of the units of all elements of the universe did not exist, and in the case of experienced campers, pleasure boat rentors and visitors of residents, lists could not exist. Also, beach-using Seymour Arm residents tended to avoid the crowded beach in mid summer, or to occupy the same space habitually. This undermined the use of sampling in proximity to regularly placed flags as per the methodology of Parkes (1973). Non-random selection was required in a temporal sense also: campers tended to stay for one to three weeks, and houseboaters tended to stay for less than two days. Both situations required searching for new respondents daily. Considering the vastness of some elements in the universe, and the descriptive nature of the information sought, quota sampling was the optimal methodology (Ebdon 1985, Cannon 1987).

An eligibility criterion imposed by the author was lake experience: in order to qualify, respondents needed at least two prior visits to Shuswap Lake including at least one prior visit to Seymour Arm. An important but less obvious criterion was representativeness. Each respondent was asked to be representative of his or her family or group. This usually led to a candidate selection process by the group, based upon various criteria. By this means, the (family, friend or cohort) group selected the candidate they felt represented them "best". This allowed representative respondents to be selected by their peers, not by the author. The demographic breakdown from this study was compared to that from a B.C. Ministry of Lands, Parks and Housing (1987) study of the boating public on Shuswap Lake. They are nearly identical (Section 4.3.1).

The percentage of responses (positive, negative and uncertain) was assessed using all 179 questionnaires. Results of the simple percentage analyses are presented and discussed in Section 4.3.1. Q1 contained 17 questions in which categorical responses were required, whether or not the response was augmented by further comment. The remaining 10 questions were opinion oriented. Q1 contained nine questions in common with Q2, the questionnaire designed for the operators or owners of commercial pleasure boat companies.

3.5.2 Questionnaire #2 - Owners of Rental Watercraft with Sleeping Accommodations

Questionnaire Q2 (Appendix E) was developed for the operators of firms in the Shuswap which rented boats with overnight accommodations. As no company rented sailing yachts or cabin cruisers on the Mara-Shuswap Lake system, this category pertained to the operators of all ten companies who rented houseboats. The operators were included in the study because they too were major recreational users of the lake, and because their craft were implicated in the user conflict which existed in the Shuswap when the study began. Principals of each company were interviewed. No one refused to participate. The respondents were male or female, owners and/or operators. Respondents were selected by asking for the highest ranking official from each company available at the time.

The 26 questions on Q2 contained nine questions in common with Q1. These nine questions are Q2 numbers 18 through 26, which correspond to Q1 numbers 6, 9, 10, 11, 18, 21, 23, 24 and 25. They dealt with water quality changes and importance, the economic importance and other concerns about houseboats, grey water releases and potential retention, and the compatibility of various uses of the lake resource. Seventeen questions on Q2 were specific to houseboat company owners and their respective businesses, and dealt with issues such as solid and liquid waste storage and disposal mechanisms, policies on waste water and plumbing design.

In the same manner as Q1 positive, negative and neutral responses were tabulated as percentages. The accuracy of the Q2 survey was as high as possible because the sample size (10) represented the entire target.

4.0 INVESTIGATION

4.1 Identification of Land-Based Potential Sources of Lake Water Contamination

It was determined from the outset that an investigation of water quality would be inappropriate without consideration of all potential pathways of contamination to the Seymour Arm study area, and to the Shuswap. To suggest abating one source of potential contamination when only one source had been considered in isolation would also be inappropriate.

Therefore, potential nutrient inputs were inspected including domestic, commercial and municipal wastes and effluents, agricultural runoff or leachate, logging or log milling practices, and petroleum losses. These sources are presented at the local level based upon direct observation and Q1 and Q2 results. The sources are presented at the watershed level based upon direct observation, personal communications, literature reviews and Q1 and Q2 results.

4.1.1 Sources in Seymour Arm, B.C.

Sources of potential lake water contamination which originated on land were identified by inspecting the study area shoreline as depicted in Figure 6, including Seymour Arm and Silver Beach, Bughouse Bay and the South Shore. Inspection was also carried out on inlet streams in the study area including the Seymour River. These inspections were supported by liquid waste disposal information from Question #13 of questionnaire Q1.

The potential sources of lake water contamination which were investigated included sewage disposal systems (using B.C. Health Act criteria as detailed in Section 3.3), agricultural practices, logging practices, petroleum handling practices, the local landfill site, and a small log milling operation. Few detrimental sources were anticipated because of the small industrial sector within the small population base. Sources with the greatest potential to contaminate the lake water were suspected to be large and/or located in the shorezone.

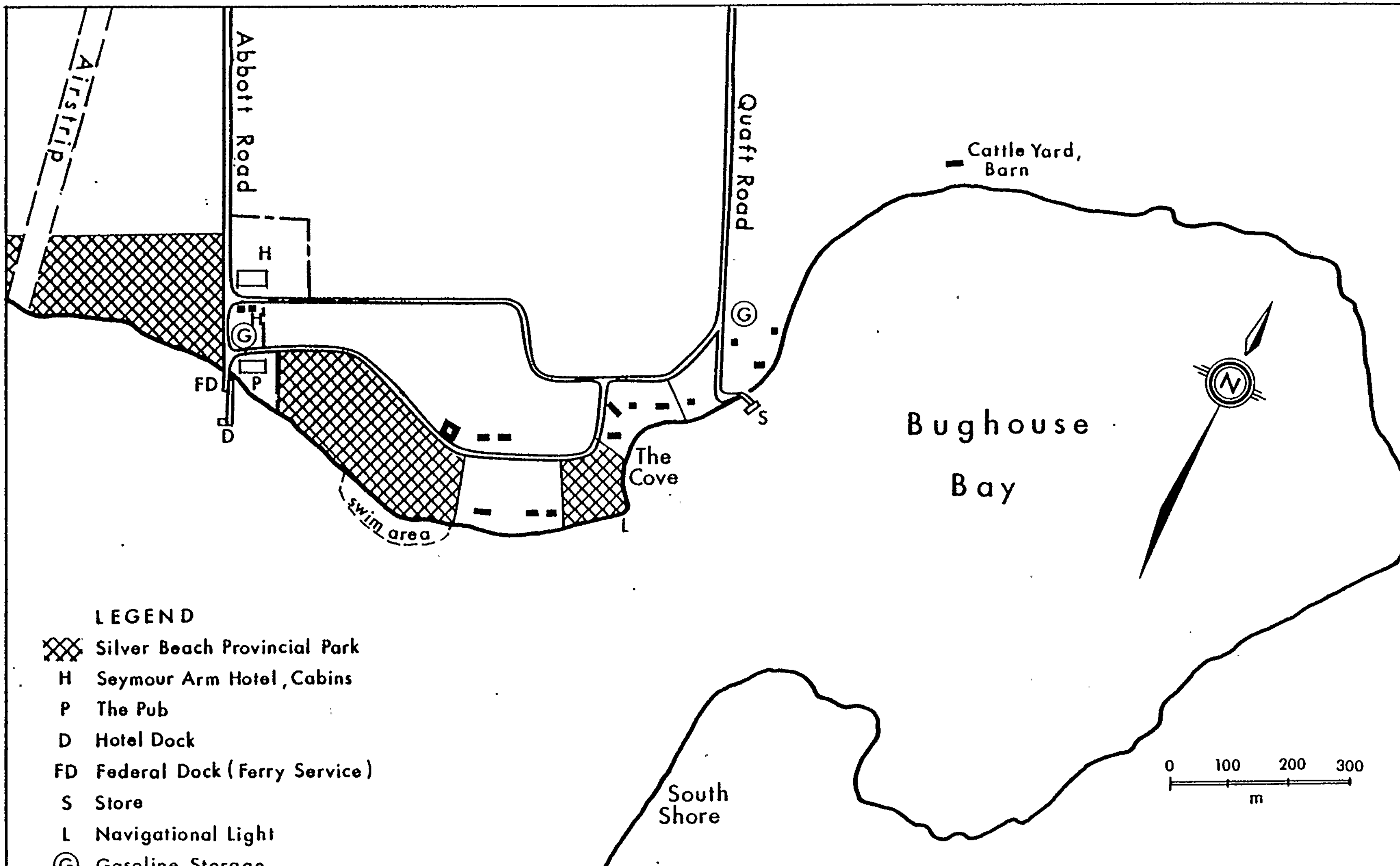

Figure 6: Seymour Arm Shoreline Showing Landmarks

Private and Commercial Sewage

As explained in Section 3.3, sewage (and grey water) disposal systems near the shorezone were inspected for design, distance from shoreline and slope to the land surface.

Some underground disposal systems included both black water and grey water, but most residents wasted grey water separately into buried "dry wells" or stilling pits. Five residents reported wasting grey water to the land surface where it percolated into the soil. Of the 62 seasonal residents in Seymour Arm area interviewed in Q1, 38 used a dry well for grey water and an outhouse (only) for sewage.

Many domestic sewage and grey water systems in the study area were used infrequently, as most seasonal residents reported using their cottages three to six times per year. Loadings to the septic tank system were therefore intermittent. Many sewage systems might therefore assimilate the infrequent loadings despite inadequacies of size or construction. The annual loading to an average seasonal resident sewage system (black water and grey water combined) might be roughly estimated in this fashion:

250 Lpcd x 4 persons x 20 days/yr. = 20,000 L/yr.

20,000 L/yr of effluent is not a high figure for a residence. Four permanent residents would generate 365,000 L/yr., based upon the same (rural) water consumption rate of 250 Lpcd or litres per capita daily (Hammer, 1977). This estimation indicates that waste water loading to the subsurface from a seasonal residence is about 1/18 of the loading from a permanent residence.

Eight disposal systems existed in the study area that had contamination potential based upon a 30 m proximity of the system to the shore. When year round usage was considered, these eight became lesser potential sources because all service seasonal residences. Groundwater monitoring studies would be required to establish sewage disposal systems which produced migrating leachate with the potential to discharge to the lake water. Such a degree of investigation was beyond the scope of this study.

The Pub is open at least twelve hours a day, six days a week, May through September. The sewage system for the local bar is located on the west side of the building. It accommodates waste water from one urinal, two toilets and three sinks. The system is likely the most heavily-used in the settlement, followed by the hotel septic tank system which is located 150 m to the north. (The hotel sewage system handles waste water from the kitchen and laundromat, and black water from four toilets). Other than the infrequently used town hall located 1 km north of the floating store, there are no other public buildings in Seymour Arm. Four local residents stated that The Pub does not have a proper system, but one constructed from wooden cribwork. Reportedly, there is no tile field. The owner of The Pub stated that the sewage system was installed before he took possession of the properties.

Aquatic weed growth was noted in the shallow water in front of The Pub. Many respondents to Q1 (local and seasonal residents and repeat campers and boaters) mentioned this particular weedy area and its increasing growth over time. A general increase in weeds in the lake was the second most common comment offered by questionnaire Q1 respondents.

The nine outhouses in Silver Beach Park contain wastes in wooden cribs (McLean, 1989), allowing effluent to leach to the surrounding sediments. This is the same design believed to be in use at The Pub. The pit toilets were observed to be heavily chlorinated. Several were noted to penetrate the nearby water table, which severely undermines the benefit of outhouses. That the outhouses were flooded was determined by looking through the seat hole, and by dropping a stone into the pit. A splashing sound confirmed the presence of water. As the design of the outhouses allowed for liquid effluent to seep out, the splash did not represent urine unable to seep out of the pit and down toward the water table under the force of gravity, but represented ground water coming in to the pit from the surrounding saturated formation. That is to say, since the vaults are not the sealed type, liquids would be free to leave, unless prevented from doing so by the saturated, permeable surrounding formation. That the water table is near to land surface is obvious in the sandy soil type observed throughout Silver Beach Park. The outhouses are less than three metres in elevation above the lake level whose shoreline is located no more than 75 metres distant.

Campers complained that there was no facility at Silver Beach Park for emptying the grey water tanks of their recreational vehicles. Subsequently, some campers reported draining the grey water tanks in the campsite parking lot or along nearby roadways.

There are four seasonal residents in the Cove where the slope to the land surface in the shorezone was estimated to be between 10° and 15°. Three cottages on the north side of the Cove have outhouses and grey water dry wells located on the north (upgradient) side. The cottage on the west shore wastes black water and grey water together in one subterranean system which is used less than 20 days annually. It is located on near level ground, more than 30 m from the high water mark. The floating store to the east of the Cove is busiest during the tourist season, but does not have a toilet or running water. If the seasonal residences in the Cove were permanent, it is likely that upgrading of sewage systems would be warranted due to the increase in loading from approximately 20,000 to 365,000 L/yr. as previously noted.

Unlike the shallow water in front of The Pub, aquatic macrophyte growth was not apparent in the littoral water of the steep-walled Cove.

Three seasonal residences were located between the Park proper and the small eastern (Cove) portion of the Park. Two were in use. One had a six year old septic tank and tile line system for black water only located 50 m from the highwater mark on flat land surface in sandy soil. The other residence had an outhouse. Grey water was wasted to subterranean stilling wells. The unused residence had no water or sewage system. Two permanent residents live in a house located within 20 m of the shoreline, between the store and the gasoline storage tanks. The residents have an outhouse and waste grey water to the land surface. They do not have a subterranean sewage disposal system.

In summary, sites were investigated in the Seymour Arm area where contaminant plumes from septic and grey water systems might be expected. Direct evidence of lake water degradation was lacking. Limited waste water loading from infrequent usage by seasonal residents has the potential to protect the lake water from migrating effluent as does sewage system design and distance from shore. No permanent residents had sewage systems located within 30 m of the shoreline. No sewage disposal systems were located on slopes >30%, or where bedrock was less than 1.2 m below the land surface. That is to say all were legal. Question 13 from Q1 determined that no residents had encountered bedrock in any excavations constructed on their properties. The only bedrock observed in the study area was an outcrop near the cattle barn located on the north shore of Bughouse Bay.

The sewage disposal system which was believed to be a potential source of contamination to the lake water was the heavily-used system at the local bar, The Pub. However, no evidence of lake water contamination was determined through chemical analyses of lake water samples taken (at station 8) in front of The Pub.

Agriculture

Excluding several permanent Seymour Arm residents who own less than six head of livestock, there are only two farming operations in the settlement. The largest operation is a 25 hectare farm which is located along Quaft Road, 1.2 km north of the lake shore. It consists of 60 head of Hereford cattle and of hay production. The owner stated on May 12, 1988 that both organic (manure) and chemical fertilizers were used on the pastures and the hay crop, and that pesticides were not used on the farm.

There is a smaller farming operation on a larger piece of land, which is also based on cattle and hay production. A 100 ha farm is located along the north shore of Bughouse Bay and extends northward to Seymour Arm Bay Road. The farmer raises 25 Charolais cattle and several dozen chickens. The barns and loafing yard are located along the shoreline 350 m northeast of the Store. The cattle roam freely, grazing and watering along the northern shorezone of Bughouse Bay. This resulted in considerable manure deposition, soil compaction and vegetation damage. The owner was interviewed regarding farming practices on May 11, 1988 and stated that chemical fertilizer was used to enhance hay crop productivity, and that no form of pesticide was used on the farm.

Landfill

The local sanitary landfill site for Seymour Arm and area is located to the north of the community (approximately 250 m north of the intersection of the Quaft Road and Road 1020). It was observed that the landfill was not maintained during the study period. The lack of maintenance resulted in widely-dispersed paper and plastic debris, strong organic odours, and constant scavenging by wildlife. The trench-and-fill system landfill was rarely burned, was never compacted and never backfilled with soil. The landfill site is located on a clay till hillside 350 m from the Seymour River. Swampland separated the site from the elevated bed for Road 1020. If contaminants from the site discharged to the river 350 m distant, effects were not observed in the field or detected using the water quality measurements at station E as described in Section 3.4.3.

Logging Operations

There is a small log milling operation located 250 m north of the government dock along Abbott Road. It is not considered to be a potential source of contamination to the lake, or even to local groundwater. The site is dry and local topography is flat. The mill operated infrequently, generating small volumes of coniferous chips and sawdust.

Federated Coop operates a logging mill and log dump on the west shore 6 km south of the Seymour River mouth. Logging further up the Seymour Valley was observed to be on the direct slopes to the river and its tributaries (Appendix A). Older clear-cuts extended to the partially-replanted river banks.

There were no logging operations near the shorezone within 2 km of Seymour Arm other than the 3.5 ha contract located on the East Road at Creek D. In July and early August, the steep creek banks were littered with logging debris and disturbed topsoil. There were no measurable impacts (appearance, temperature, flow, conductivity) upon the water quality of Creek D at that time. It was determined that high conductivity readings at station D_2 resulted from an iron bacteria-rich, humic groundwater seep 400 m upstream of station D_1, 600 m downstream of station D_2.

This seep likely flows intermittently. The 3.5 ha clear cut located up-gradient could increase its mineral-rich discharge to the lake (via Creek D) by accelerating runoff (Hare, 1984) and changing the rate of groundwater recharge (Shaw, 1986). Other such discharges of shallow groundwater were observed to the northeast near the outlets of Creeks B and C. These iron-rich groundwater seeps were common to the area according to three long-time residents.

Liquid Petroleum Hydrocarbons

Liquid petroleum product storage was identified. One underground storage tank and 26 above ground storage tanks - equal to or greater than 2,250 litres in volume - were located. Many permanent and some seasonal residents had smaller storage tanks (usually 900 L or 1,350 L) of furnace oil, diesel fuel or gasoline. A similar basis of assessment was applied for liquid petroleum product storage as for sewage disposal systems. This basis included proximity of the storage tank to the lake shore, slope to the land surface and quantity of stored material.

Smaller volume storage tanks in the topographically flat subdivision to the east of the airfield and sixteen drums of helicopter fuel located midway along the length of the airfield were not assessed as potential sources under the criteria described earlier in Section 3.3. Fuel tanks located on the South Shore along to Gilmans Bay and at Dasniers Bay were excluded for the reason that spillage might reach the lake only as a subterranean plume, but could not flow upstream to the Silver Beach study area. Also, the volumes of the private storage tanks were less than 2,200 L.

Two commercial enterprises, the hotel complex and the store complex employed the largest volume fuel tanks in the study area. These tanks and distribution systems were located in the shorezone and were in constant use supplying boats with gasoline. Subsequently they represented the greatest contamination potential from liquid petroleum hydrocarbons.

Located between the hotel and The Pub on the east side of Abbott Road was the 18,000 L underground storage tank used for fuelling boats by way of a single housed pump located near the end of the hotel pier. The galvanized pipeline which ran along the west side of the pier (above the water line) did not appear to leak at joints during the course of the study. The distribution pipeline was buried from the base of the pier due north 90 m to the buried tank. The tank was believed to be approximately 10 years old and had not been pressure tested. The distribution lines had not been pressure tested. It is unknown how much dock movement (as in a storm) would be required to separate the distribution line joints.

The floating store had a large fuel storage and distribution system. The following above ground storage tanks were located east of Seymour Arm Bay Road, 110 m north of and 15 m higher in elevation than the lake: one 54,000 L tank for marine gasoline, one 13,500 L tank for regular gasoline and one 9,000 L tank for diesel fuel. Located approximately 30 m and 35 m north of, 7 m and 8 m higher in elevation than the lake were two 2,250 L gasoline tanks. Located on the floating platform of the store 0.5 m above lake water level was one 4,500 L tank for marine gasoline. This tank was gravity-fed by the 54,000 L tank up the hillside through an assortment of pipe types, sizes and fittings. The store owner reported that these fittings included safety valves for loss prevention.

In summary, private petroleum storage was generally acceptable by the criteria adopted here but should be inspected regularly by shorezone residents. Stored quantities are small and tanks were located more than 30 m from shore.

The two commercial facilities were not well conceived. Safety mechanisms and distribution lines were questionnable. Clean up costs and penalties, lost business, and capital losses are cited as reasons for upgrading these commercial facilities. Tank or distribution line rupture at either marina, especially the store complex, could adversely affect water quality. This judgement is based upon the proximity of the products to the water and the volumes of products involved.

Discussion

Potential sources of contamination to the lake of anthropogenic origin were inspected as part of the overall approach to the study of water quality in Seymour Arm (Figure 7).

Newer cottages in Seymour Arm reportedly had properly-installed septic tank systems, consisting of a septic tank and tile field. Some older residences did not. Most residents disposed of black water and grey water in separate subterranean systems which decreased mounding of the water table by diffusing point source loadings. The low periodic loadings of seasonal residences, and the distance of most systems from the lakeshore (greater than 30 m) and the slope to the land surface (<30%), provided a measure of protection from subsurface contaminant migration (Ponce and Gary, 1979). Permanent residences in the shorezone generated constant hydraulic loadings to the water table and subsequently greater contamination potential. However, there was only one permanent residence in the shorezone in Seymour Arm. The two residents who lived there used an outhouse.

A concern of campers in Silver Beach Park - especially those with years of experience in the park - was that the Park provided no facility for the disposal of grey water. There was no evidence (e.g. water sample results, weed growth) of contaminant plume migration discharging into the lake. However, several outhouses in Silver Beach Provincial Park were observed to

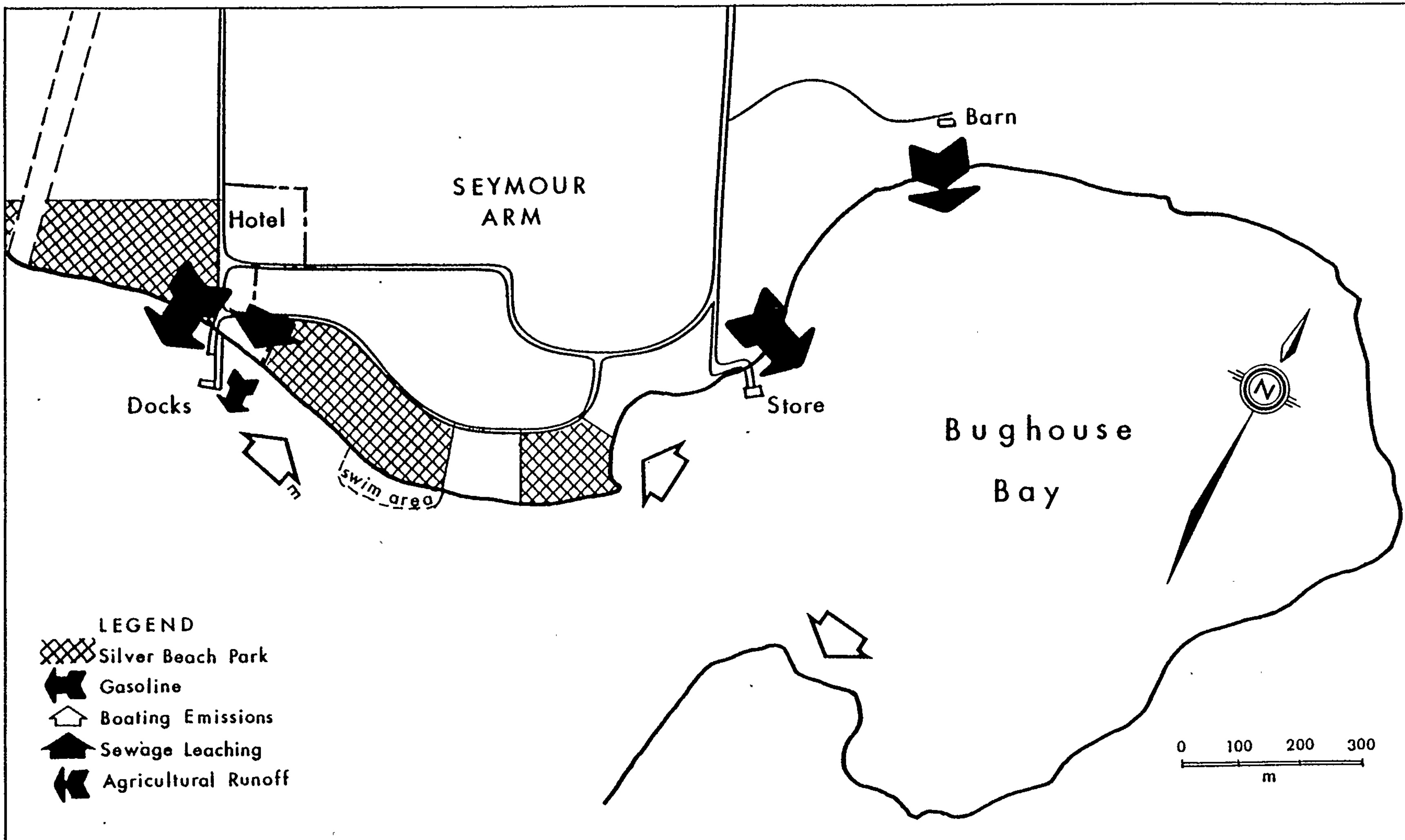

Figure 7: Possible Lake Water Contaminant Pathways

have intersected the water table (as described earlier), a situation that is potentially detrimental to the quality of nearby surface water (Vallentyne 1974, Ponce and Gary, 1979).

Vallentyne (1974) strongly supports the benefit of keeping fecal matter dry in the soil mantle and out of the water table. Vallentyne (1974) attributes the "conversion of wells and outhouses into water mains, flush toilets, and sewage drains" as the single factor which contributes the most to man-made eutrophication and increased water pollution (page 36). Observations in Seymour Arm indicated that more than half of the seasonal dwellings used outhouses or wasted grey water separate from black water.

Logging operations observed near Seymour Arm during the study were small-scale and removed from the lake shore. In the case of the small logging contract along the banks of Creek D, it is likely that the clear cut creek banks will erode, allowing increased nutrient loss to the atmosphere (Marlund and Rotty, 1985) and increased nutrient loading to the creek (Hare 1984, Shaw 1986). A pulp logging operation was located in a dry area along the north side of Road 1020, several kilometres west of the Quaft Road intersection, and 150 m north of the Seymour River. Undergrowth was starting to cover the cut in the summer of 1988. Abandoned large scale clear cuts further up the Seymour valley were observed to be less vegetated and thus more prone to erosion.

To summarize, the permanent population base of Seymour Arm is small, but the (mid summer) seasonal population is large. There are a half dozen commercial enterprises, two of which are in the shorezone. There is a busy campground adjacent to the shorezone. There is no major industrial or agricultural activity and none is anticipated by local residents. The sanitary landfill site is removed from the Seymour River by 350 m and was not observed to affect water quality. Residences have private sewerage, thus eliminating municipal effluent. Many residents use outhouses so that fecal matter degrades out of contact with the water table.

There are four land-based sources of potential contamination to the waters of the lake (or inlet streams) near the Seymour Arm study area. These are the most obvious, shorezone enterprises which handle large volumes of materials. These include: the floating store with its upgradient fuel storage tanks and gravity-fed distribution system; the cattle loafing yard and watering area along the north shore of Bughouse Bay; the suspected undersized sewage disposal system for The Pub; and the above ground-below ground gasoline storage and distribution system at the hotel dock.

Observed water-based (anthropogenic) sources in the study area included litter from lake users, grey water released from moored pleasure boats with overnight accommodation in late July and early August, and petroleum films on the water surface from outboard motors throughout the study period. These observations were supported by residents and visitors through conversation and questionnaire response.

4.1.2 Sources in the Shuswap Lake Watershed

Throughout the lake system, areas of concern to lake users included agricultural practices, industry (logging), private and municipal sewage, and shorezone commercial interests including marinas and transportation routes. These land-based potential sources of contamination throughout the lake were not specifically investigated. Main areas of concern were observed directly, discussed with officials knowledgeable about the lake (personal communications), obtained from the literature on the lake (O'Riordan and O'Riordan 1972, Ross 1984, Nordin 1986, Holmes 1987), and confirmed as concerns by questionnaire respondents (Q1 and Q2).

Agriculture

According to Ross (1984), Nordin (1986), Holmes (1987), B.C. Ministry of Environment (1988), Holmes (1990) and Grace (1990), the worst nutrient loading to Mara and Shuswap Lakes comes from farm applications of fertilizers which leach or flow overland into southern rivers from farms along the riverbanks. The river basins most affected are the Salmon and the Eagle. The Shuswap River is suspected of being contaminated by agricultural runoff, but sufficient and reliable water quality data do not exist.

Agricultural contamination along the Salmon River especially during freshet, is a major concern of many Shuswap residents and visitors, as observed through questionnaires Q1 and Q2. It was frequently mentioned as a concern in the Shuswap Lake water quality literature by O'Riordan and O'Riordan in 1972. Nordin (1986) felt that the Salmon River was the worst inlet, contributing significant quantities of nutrients, coliform bacteria and organic carbon to Tappen Bay from agricultural operations located adjacent to the riverbanks further up the Salmon River valley.

For many lakes including Shuswap Lake, the most detrimental agricultural waste is the nutrient phosphorus - especially in its soluble form when it is usable by aquatic plants for photosynthesis and growth (Appendix F).

Table 3 shows estimates of annual phosphorus loadings from three separate sources which affect Shuswap Lake: grey water from pleasure boats with overnight accommodation, the District of Salmon Arm sewage treatment plant effluent, and the waters of the Salmon and Eagle Rivers (reflecting agricultural and natural P loadings). The data originate from four separate sources as referenced and are mostly estimates, but the trend is clear - the rivers contribute nearly a thousand times more total phosphorus than pleasure boat grey water, and the District of Salmon Arm sewage plant effluent contributes about 90 times more TP than does pleasure boat grey water.

However, the comparison between the Eagle River loading and the loadings from pleasure boats with overnight accommodation is deceiving for three reasons. First, the TP in the Eagle River discharge is forced from the alluvial fan to the profundal waters of the steep walled Sicamous Arm (B.C. Ministry of Environment, 1988), and not physically available to algae and aquatic plants. Second, Eagle River water is less than 10% orthophosphorus, and so is chemically unusable by algae and plants (B.C. Ministry of Environment, 1988). Third, approximately 65% of the total TP loading occurred during freshet, approximated as May 22 to June 21, 1985 (B.C. Ministry of Environment, 1988). During freshet, the instantaneous volume replacement time of the lake as a whole is substantially shorter than the annual average replacement time of approximately two years. Nutrients which do not end up in the hypolimnion stand a good chance of being flushed out through the outlet during this period of peak discharge.

Source	Annual Loadings to Lake (kg)				
	TP	DP	TN	SS	BOD
grey water					
from pleasure boats(a)	32	28	270(b)	2800	2320
municipal effluent					
Salmon Arm (c)	2920	2040(d)	16425	16060	10220
agricultural, natural influent					
Salmon River (e)	13900	4700	n/d	n/d	n/d
Eagle River (e)	30400	2200	n/d	n/d	n/d

(a) from Table H-4 (Beak Consultants Limited, 1988), based upon an estimated 400 pleasure boats over a 100 day season
(b) calculated - TKN x 1.5, from Table H-2 (Hammer, 1977)
(c) from Table 4
(d) calculated - TP x 0.7, from Table H-2 (Hammer, 1977)
(e) from B.C. Ministry of Environment, 1988
n/d no data

Table 3: Comparison of Estimated Annual Chemical Loadings to Shuswap Lake From Various Sources

The ratio of TP loading during freshet (May 18 to June 18, 1985) to the annual TP loading for the Salmon River was a very similar 64%. It appears that nearly two thirds of the riverine phosphorus entering Shuswap Lake occurs in one month, and at river mouths. With grey water loadings, the time period is more than 3 months, at shallow locations such as harbours and beaches.

The argument that TP is unavailable to green plants does not apply to the Salmon River - one third of the TP is DP and is available to plant life. Its effect, combined with the effect of the District of Salmon Arm sewage treatment plant effluent is the eutrophication of Tappen Bay and the western part of the Salmon Arm (Ross 1984, Holmes 1987).

Data were not available for the Shuswap River mouth at southern Mara Lake. Data from the outlet of Mara Lake at Sicamous indicate that nutrients may have precipitated out of solution into the profundal zone of Mara Lake. The TN concentration at Sicamous Narrows is 200 ug/L and TP concentration is 5 - 12 ug/L (Grace, 1990). These compare to concentrations for the lake of 135 ug/L TN and <5 ug/L TP (Table 9).

The average annual P concentrations (based on 16 samples taken mainly in 1985) for the Eagle River were TP = 15 ug/L and DP = < 3 ug/L. For the Salmon River, the TP concentration was reported to be TP = 86 ug/L, based upon 12 samples by the B.C. Ministry of Environment (1988). It is estimated by B.C. Ministry of Environment that approximately 50% of Salmon River phosphorus originates from agricultural operations, and that White Creek and Canoe Creek add another 10% of the TP to the Salmon Arm. Also, the headwaters of the river are high in ortho P concentrations from the dissolution of the mineral apatite. Regarding the Eagle River, approximately 20% of the TP concentration in the river water is believed to be a direct result of agricultural contamination (Grace, 1990).

Table 3 also shows estimated loadings of suspended solids and BOD from grey water, compared to calculated loadings from the Salmon Arm plant effluent in 1989. The 60 to 90 fold differences between soluble nutrients from grey water and from municipal effluent, do not apply to the insoluble SS and BOD. The ratio of SS and BOD concentrations from grey water compared to those from the effluent is about 5 fold, because the grey water has not been treated. Water treatment has reduced SS and BOD in the effluent quite effectively.

Logging Operations

Changes in drainage basin hydrology, increased nutrient leaching (Marlund and Rotty, 1985) and loading to watercourses, wildlife habitat loss and aesthetic appearance are some of the main impacts from clear cut forestry practices (Hare 1984, Shaw 1986, Berner and Berner 1987). Many Q1 respondents stated that local logging practices were incompatible with other (more sensitive) uses of the lake, such as recreation. Local residents mentioned (through response to Q1 and Q2) the obvious increases over time in the amount of logging debris seen on the water surface throughout the lake during spring freshet.

The Federated Coop Mill at the settlement of Canoe does not release treated or cooling water effluent to the waters of Salmon Arm. The plant releases about 450 litres per day of calcium-rich blower backwash to its underground sewage disposal system (Grace, 1990), and releases vaprous emissions through its stacks. B.C. Environment officials are content with emissions from and operations at the mill (Holmes, 1990).

Municipal Sewage

The chemical quality of the District of Salmon Arm sewage treatment plant effluent in Tappen Bay has been a source of eutrophication of the upper reach of the Salmon Arm since the plant was constructed in 1974 (Ross 1984, Nordin 1986). Untreated sewage discharge, and the proposed treated effluent concerned local residents before plant construction (O'Riordan and O'Riordan, 1972). Treated effluent is still a prime concern of visitors and citizens of the Shuswap. The plant effluent has improved since the plant was refitted to tertiary level of treatment in mid-1988. It has not functioned consistently but has reduced nutrients, solids and biochemical oxygen demand (Table 4). The Ministry of Environment was scheduled to introduce chemical precipitation to plant operations to reduce phosphorus concentrations to 1 ug/L by January, 1990.

Ross (1984) estimated that the sewage treatment plant effluent augmented the supply of DP at times critical to phytoplankton, thus extending their growing season. She calculated that the sewage treatment plant contributed between 21% and 41% DP to the Bay at the time of her study.

Listed in Table 4 are the chemical data for the final effluent of the Salmon Arm STP from eight samplings between 85/07/31 and 88/02/02 (prior to plant modifications), and quarterly summaries from the first, second and fourth quarters of 1989 (after the modifications). The average daily effluent discharge during 1988 and 1989 was 2,400,000 litres.

Period	Total N	Total P	S.S.	BOD
	Parameters in mg/L			
(a) 1985-1988				
Range	5-353	1.9-12.5	n/d	11-173
Average	59.3	5.3	n/d	60.0
Geometric Mean	19.2	4.5	n/d	34.1
(b) Averages				
Jan.-Mar. 89	20.3	1.9	27.4	12.6
Apr.-June 89	18.7	2.9	8.0	9.9
Oct.-Dec. 89	17.1	5.0	19.3	12.9
Average loadings				
daily (1989)	45 kg	8 kg	44 kg	28 kg
annually (1989)	16425 kg	2920 kg	16060 kg	10220 kg

Table 4: Salmon Arm Sewage Treatment Plant Effluent, (a) Before and (b) After Modifications in mid-1988

The data presented in Table 4 indicate that the quality of the District of Salmon Arm sewage treatment plant effluent has improved since modifications in 1988. The secondary sewage treatment plant was updated to a tertiary level of sewage treatment (enhanced P, N, BOD and SS removal from precipitation by ferric chloride added to the final clarifier effluent) in the summer of 1988. During 1989, the sewage treatment plant contributed 16,425 kg TN, 2,920 kg TP, 16,060 kg SS, and 10,220 kg BOD to Tappen Bay.

Private Sewage and Nutrient Loadings

Private sewage control is a definite factor in lake water quality protection (Vallentyne 1974, Ponce and Gary 1979, Gosz 1982), and to the perception of protective action by lake users. Currently, there are 2,550 permanent and seasonal residences on private sewerage fronting on or very near to the shores of Shuswap Lake, and 1,650 undeveloped (private) lots. Like waste water releases from recreational activities, this source is readily corrected and brings nutrient control to a personal level. With their "own backyard" in order, landowners and groups can more effectively pursue other sources. Peer pressure can be effective for encouraging environmental common sense, such as upgrading private sewerage, maintaining a buffer of shoreline vegetation, and by simply reducing chemical fertilizer usage. Fertilizer usage is a major source of nutrient pollution of waterways (Vollenweider 1970, Vallentyne 1974, Schindler 1974, Gerking 1974, Lind 1974, Stoker and Seager 1976, Hare 1984, Berner and Berner 1985). Ammonia and nitrate fertilizers are a main contributor of nitrous oxide, a greenhouse gas that has increased 17-fold since 1950 (Marlund and Rotty, 1985).

Lake users were concerned about the settlement of Sicamous, where aging private sewage systems in the shorezone are believed to leach into the waters of the Sicamous Narrows, as previously noted by Ross (1984). Residents, visitors and individuals with considerable knowledge of the lake, expressed concern (through Q1, Q2 and personal communications) about the issue of shorezone sewage disposal systems throughout the Shuswap. The quantification of chemical loadings to the lake water from domestic septic leachate is difficult to estimate and was not attempted in this study.

Commercial Development

By their nature, commercial developments and development planning follow strips - along roadways on land and along the shorezone on water. Areas of greatest commercial development such as Sicamous Narrows, Blind Bay and Tappen Bay, have developed water quality problems such as weed and algal growth. There is a direct relationship between shoreline development and water quality degradation (Vallentyne 1974). Ponce and Gary (1979) found that poor shorezone roadway and cottage design contributed to degraded water quality. The strip development in the shorezone was similar to transportation route strip developments.

On a commercial level, a similar situation applies throughout the basin as in Seymour Arm. A potential source of lake water contamination comes from shorezone commercial enterprises catering to the boating public. These businesses - usually marinas - offer gasoline and other petroleum products, food supplies, toilet facilities and other amenities. The result of these convenient services located on or adjacent to the water was observed to include environmental emissions such as petroleum, grey water, refuse, smoke and noise.

Effluents - Wastes and Losses

Sources of lake water contamination which originate in water are mainly from inletting watercourses, and from emissions from boats plying Shuswap waters. Nutrient-contaminated streams relate back to a land-based source somewhere along the watercourse. The source of the chemical load could be natural (organic or geologic) in origin, or most likely anthropogenic. The major problem with inletting watercourses in the Shuswap watershed is contamination with nutrients from agriculture. Southern rivers and creeks are in flat valley bottoms or gently rolling highlands which allow for fruit growing, cattle rearing and crop production. Northern rivers and creeks including the Anstey, Seymour, Celista, Scotch and Adams originate in mountainous highlands where farms and settlements are few, and where logging is the only industry. At Cinnemousun Narrows, cleaner water from the northern arms dilutes the more nutrient-rich waters of the south.

Wastes entering the Shuswap are of two types: non-point sources and point sources. Non-point sources include farm or deforestation runoffs, which peak at freshet but build up nutrients in the sinks of the lake and are possible long term problems. Point sources include industrial, municipal or private effluent discharges. The non-point sources are more difficult to abate, and require changes in people's actions. The point sources are easier to abate, requiring modifications to technology or its regulation, or the enforcement of existing regulations. Despite the differences in origin and control, these sources affect the lake water from the land.

Of concern here are sources of contamination of lake water which originate in water. These include the natural recirculation of benthic nutrients (despite their origin), and emissions into the water from boat traffic and shorezone commerce.

Gasoline or diesel-powered watercraft emit liquid petroleum product, partially-combusted petroleum product, and partially or fully combusted gaseous petroleum by-products to the water and to the air at the interface. It is estimated that there are about 1800±300 gasoline-powered boats in the watershed at peak season (Appendix G), including about 400 pleasure boats with overnight accommodation. Many of these craft would report to one or more of the 16 marinas on the lake (Columbia Shuswap Regional District, 1987) regularly for fuel and supplies, and subsequently cause the release of concentrated emissions.

Releasing black water, grey water or the combination is aesthetically questionnable. Waste water release degrades water quality with oxygen demanding and potentially pathogenic bacteria, solids, and to a lesser extent nutrients, in concentrations comparable to raw municipal sewage (Appendix H). The release of waste waters to receiving water is most detrimental to lake users and to water quality in shallow bays, and in areas of boat congestion (International Joint Commission 1970, MacLaren Engineers 1987, Beak Consultants Limited 1988).

4.2 Water Monitoring Results

4.2.1 Lake Water Measurements and Sample Analyses

As detailed in Section 3.4.1, lake water samples were taken from ten stations (Figure 8 and Appendix B) around the Seymour Arm (settlement) shoreline, on these five dates in 1988: May 9, May 19, July 26, August 2 and October 3. In duplicate, the three composite and seven shallow water samples were delivered to the Vancouver Environmental Laboratory for chemical analyses within 48 hours of each sampling.

Chemical parameters chosen for analyses were discussed with appropriate personnel at the B.C. Ministry of Environment and The University of Calgary. In the report by the Inquiry on Federal Water Policy, Currents of Change, "conventional pollutants" are listed as BOD, solids, nutrients, microorganisms and ions such as sodium and carbonates (Pearse et al, 1985). With the exception of microorganisms, these are the chemical indicators of water quality chosen for this study. It was decided between B.C. Environment staff, Faculty staff and the author that expensive and laborious BOD tests were unwarranted, based upon the Ministry's experience with very low BOD_5 values from Shuswap Lake samples (Holmes, 1987).

Electrical conductivity (cond.) and pH were chosen as general water quality indicators (Pearse et al 1985, CCREM 1987). The major ions sodium (Na^+) and chloride (Cl^-) were chosen to indicate their percentage of total conductivity and by inference the approximate proportion of remaining major ions calcium (Ca^{++}), magnesium (Mg^{++}), carbonate ($CO_3^=$), nitrate (NO_3^-) and sulphate ($SO_4^=$). Na^+ and Cl^- can also be indicators of possible waste water presence (Cole, 1975). In a watershed where most geologic materials are granitic such as the Shuswap Lake Watershed, Na^+ and Cl^- are typically found in low concentrations in ground and surface waters.

The remaining seven analytical parameters were various species of the nutritive elements nitrogen and phosphorus. The purpose of these tests was to determine background concentrations of these water quality indicators

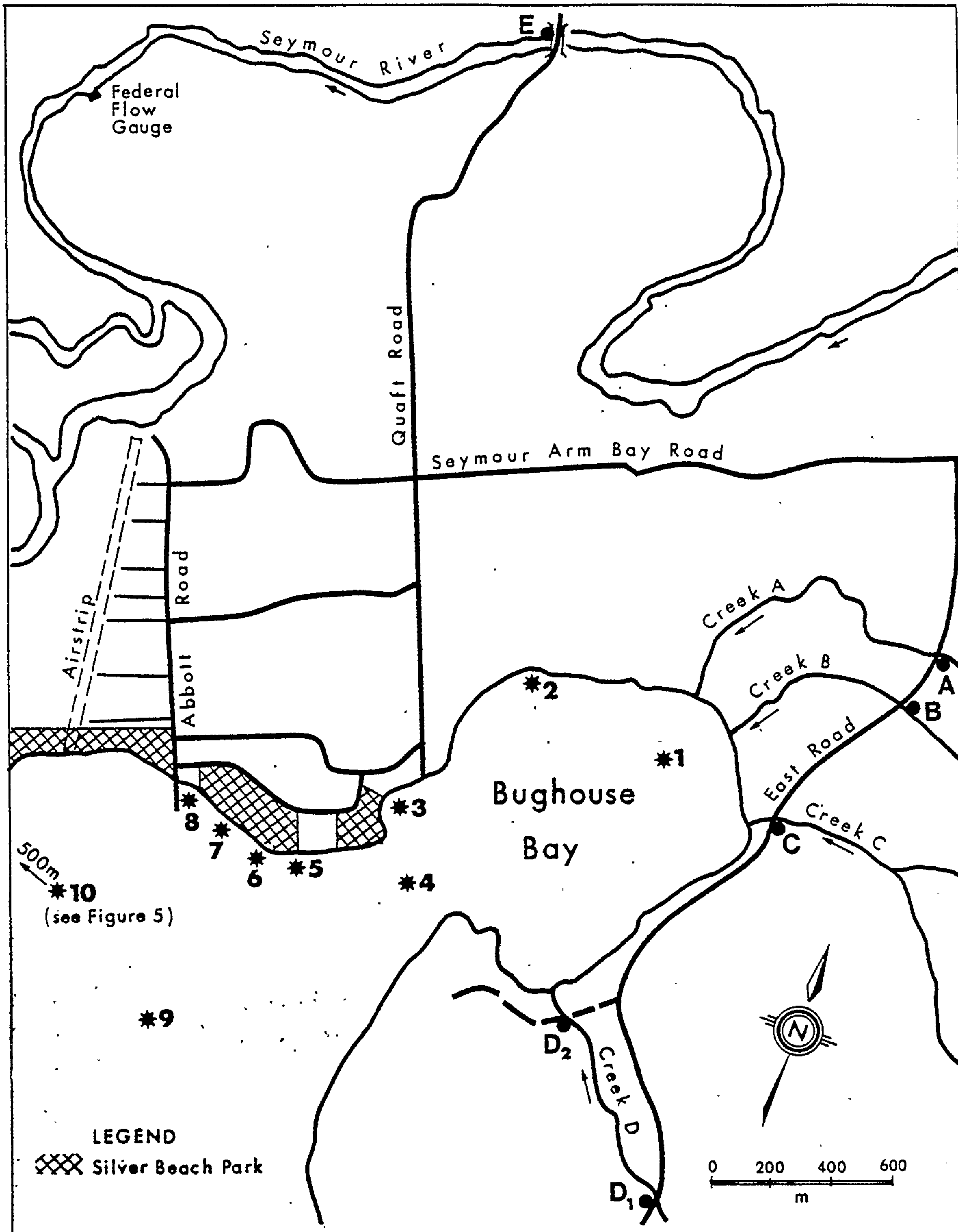

Figure 8: Central Study Area Showing Water Sampling, Measurement Stations (1-10) and Stream Measurement Stations (A-E)

and to attempt to discern any anthropogenic pathways from natural pathways of these nutrients to the lake water. Nitrogen parameters were: total nitrogen (TN), total organic nitrogen (TON), total Kjeldahl nitrogen (TKN), ammonia (NH_3), and nitrite plus nitrate (NO_2^- + NO_3^-). Phosphorus parameters were total phosphorus (TP), and dissolved or ortho phosphorus (DP).

Total phosphorus (TP) measures all forms of the element including phosphorus in solution (DP). The relationship between the various nitrogen forms (tests) is as follows: total nitrogen (TN) includes total Kjeldahl nitrogen plus nitrite and nitrate (TN = TKN + (NO_2^- + NO_3^-)); total Kjeldahl nitrogen includes total organic nitrogen plus ammonia (TKN = TON + NH_3), does not include NO_2^- + NO_3^-, and implies that TON = TKN - NH_3 (Brandes 1977, Ontario Ministry of Environment 1984). Organic nitrogen originates solely from organic matter (Hammer, 1977). TN and TON are not analytically derived but are mathematical calculations based on analyses (Table 2).

Ammonia is produced mainly by bacterial decomposition of organic matter (Hutchinson, 1957). It is a constituent of waste waters and fertilizers. It oxidizes directly to nitrite, a perishable intermediary between ammonia and nitrate in the nitrogen cycle. Nitrate is the most oxidized, stable form of nitrogen. It can indicate aged domestic contamination, or biological decomposition (Lind, 1974).

The pigment chlorophyll "a" was used as an indicator of biological productivity and trophic state (Lind 1974, Cole 1975).

Along with taking samples with a Van Dorn sampler or by dipping the sample bottle, measurements were taken for temperature, dissolved oxygen and electrical conductivity at 0.5 m below the water surface at each station. On July 26 and August 2, problems of needle drift were encountered with the YSI Ltd. dissolved oxygen meter, which were not believed to be electrical in nature, as the "zero" and "red line" settings on the meter were accurate and did not waiver. The problem therefore was with the probe or more specifically with the probe membrane. Changing the membrane and ensuring that no air bubbles appeared in the fluid did not alleviate the problem.

The resultant irregular data were suspect and are not presented. The reason for the suspicion was that in May the DO in the river water was supersaturated and higher by at least 3 ppm than other stations which had regular and similar readings in May (Table 5). On July 26 and August 2, the river water was less than 10 mg/L, and DO readings at the lake stations varied wildly by ± 4 ppm. Given the low ionic content of the river and lake water, and the similarity of measurements from one station to another, a slight problem with instrument readings could be critical.

Lake Water Measurements

Measurements for water clarity, dissolved oxygen, electrical conductivity and temperature were taken as described in Sections 3.3 and 4.2.1 on the five sampling runs and one extra run on May 15, 1988. Since the river water is substantially different from the lake water, these data have been presented separately.

The data from all stations are summarized in Table 5. The data presented are averaged lake water measurements (stations 1 to 9) and the Seymour River water (station 10). The river water was always more turbid in appearance, more oxygenated (by 2.5 to 4.8 ppm D.O.), cooler (by 6 to 11°C) and less ionized (by 58 to 64%) than the lake water.

The river mouth is station 10 of the lake runs; and the river at the Quaft Road bridge is station E of the inlet stream runs. The river data recorded on the six lake runs for station 10 compared favourably to the inlet streams data for station E. They were recorded within three days of each other on all occasions. Tables 5 and 8 indicate that the data for river mouth measurements versus measurements taken 5.3 km upstream at the Quaft Road bridge are within 2 degrees and 6 uS/cm.

Weed growth (identified as the submergent Potamogeton richardsonii or pond-weed) was observed at shallow water stations 2 (near the cattle barn) and 8 (at the hotel pier). It progressed from spring to summer, diminishing sharply by fall. No weed growth was observed at other lake stations - 7, 6, 5 (along Silver Beach), 10 (the river mouth), or 4 (the Cove).

Dissolved oxygen readings from the nine lake stations ranged from a minimum of 9.2 ppm to 14.6 ppm O_2. Dissolved oxygen averaged 12.9 ppm over the 36 recordings - 13.2 ppm for the three deep stations and 12.8 ppm for the six shallow stations. DO at the river mouth averaged 16.2 ppm, which is supersaturated. Ross (1984) reported DO saturated and supersaturated epilimnion water throughout the lake, corresponding with photosynthetic activity from June through August 1978 and 1979. These values indicate that the river water was supersaturated with oxygen in May and October (Cole, 1975) possibly from the mixing effect of the dozens of ripples and falls within 10 km of the river mouth. Apparent anomalies appeared at: station 8 on May 9, 9.4 ppm (low compared to mean of 12.5); stations 8 and 2 on May 15, both 13.0 ppm (low compared to mean of 14.0); station 7 on May 19, 13.2 ppm (low compared to mean of 14.1); and at station 2 on October 3, 9.2 ppm (low compared to mean of 11.0).

Date (1988)	Lake Station	Cond. (uS/cm)	Temp. (°C)	DO (mg/L)	Secchi[a] (m)
May 9 Run #1	lake[b] river[c]	60 22	14 6.0	12.5 17.0	6.2 N/A
May 15 Run #1a	lake river	61 22	12 6.5	14.0 16.5	4.5 N/A
May 19 Run #2	lake river	62 26	13 6.2	14.1 17.1	4.5 N/A
July 26 Run #3	lake river	63 24	23 13.8	n/d n/d	7.8 N/A
Aug. 2 Run #4	lake river	63 23	23 12.0	n/d n/d	7.7 N/A
Oct. 3 Run #5	lake river	55 23	16 9.5	11.0 14.2	9.0 N/A

a - average measurement from stations 1, 3, 4, 9
b - average measurement from lake water stations 1 through 9
c - river water measurements (station 10)
N/A - not applicable
n/d - no data

Table 5: Summary of Lake and River Water Measurements, Stations 1 to 10

Secchi readings were possible at deep water stations 1, 3, 4 and 9 (Figure 8 and Appendix B). Results of all 24 readings ranged from a minimum reading of 4.3 m (below the water surface) on May 15 to a maximum of 9.3 m on October 3, and averaged 6.7 metres. Increasing Secchi disc readings (the phototrophic zone) were also observed by Ross (1984) throughout the lake and at the lower portion of Seymour Arm. Secchi depth readings are presented in Table 6. The low readings for May 15 are most likely a result of observed algae blooms. In run #4, where distinct turbidity from algae was observed at stations 1 and 3, it was not apparent at nearby station 4 and distant station 9.

Run No. (Date)	Station Secchi Reading ($\pm$0.1m) 1	3	4	9
1 (May 9)	6.2	6.3	6.0	6.3
1(a) (May 15)	4.8	4.7	4.3	4.4
2 (May 19)	5.1	5.3	5.2	5.1
3 (July 26)	7.8	7.6	7.8	7.8
4 (Aug. 2)	6.5	6.8	8.3	8.2
5 (Oct. 3)	8.9	8.9	9.0	9.3
water depth ($\pm$0.2m)	15 m	9 m	17.5 m	28 m

Table 6: Secchi Disc Readings

Electrical conductivity readings ranged from 54 uS/cm at four stations on October 3, to 67 uS/cm at station 8 on July 26, and averaged 61 uS/cm. The river mouth (station 10) ranged from 22 to 26 uS/cm and averaged 23 uS/cm. The overall pattern was a small rise in conductivity from May to mid summer then decreasing in October (61 to 63 to 55 uS/cm). Ross (1984) reported the same pattern in epilimnion water in lower Seymour Arm from June to September 1978. The range was approximately 60 to 81 umhos/cm.

Several anomalies were noted. Station 8 had the highest field conductivity on May 9, May 15, May 19 and July 26, indicating a possible source of chemical input. There is no pattern to the lowest reading per run. Field conductivity measurements were slightly lower than laboratory conductivity measured at the Vancouver Environmental Laboratory within 48 h of sampling.

The Seymour River mouth (Station 10) temperature ranged from 6.0°C on May 9 to 13.8° in early August, averaging 9.0° during the study period. Lake station temperatures ranged from 11.5° at station 9 on May 15 to 23.5° at station 2 on August 2, and averaged 16.5°. Water temperatures varied little from lake station to lake station on the same run. Deep water stations were cooler than shorezone stations by an average of one half degree. Station 9 water temperature was coldest on three of the six runs.

Lake Water Sample Analyses

Appendix C (1) to (5) shows all water sample analyses for the eleven chemical parameters at the ten sampling stations over the five sampling runs. Ranges of results for each parameter are presented and discussed in the following section. Appendix C(6) details the instrument precision and test accuracy for each of the eleven parameters. Note that precision and accuracy decrease as detection limit is approached.

Most chemical parameters were low in concentration and range and were measured near the analytical minimum detection concentration (MDC), making data interpretation difficult. Some readings were below MDC (Appendix C (6)), and are reported as such. Plots of average chemical concentrations for nutrient parameters per run, are presented in Figure 9.

Laboratory conductivity of the lake water samples for stations 1 to 9 ranged from 62 to 74 and averaged 67 uS/cm. Conductivity of the composite samples tended to be lower than that of the shallow water samples. Seymour River water samples (station 10) ranged from 29 to 33 and averaged 31 uS/cm. The precision of conductivity at 66 uS/cm is 1.2%.

Values of pH varied only slightly during the study, ranging from 7.6 to 7.9. Ross (1984) reported lake pH values ranging from 7.3 to 8.1. The river water ranged from pH 7.4 to 7.6. For pH values between 2.1 and 12.1, the standard deviation is 0.1.

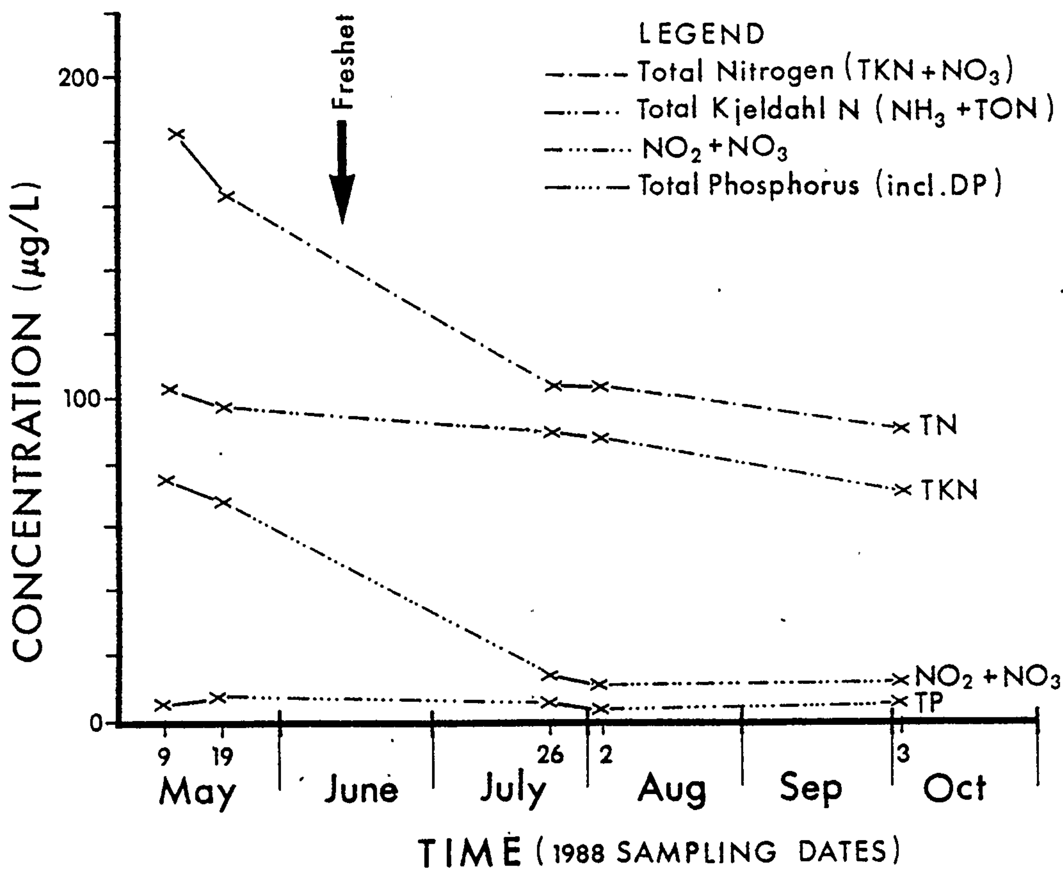

Figure 9: Lake Water Mean Values for Nutrient Parameters

Sodium concentrations in lake water ranged from 1.0 to 1.4 mg/L and averaged 1.2 mg/L, declining slightly with time (Appendix C). No other trends were apparent. Sodium concentration in the river did not exceed 0.6 mg/L. The precision of sodium measurements is 0.9% at 5.7 mg/L.

Chloride concentrations ranged from below MDC (0.5 mg/L) to 0.7 mg/L. On May 19 all lake stations contained a detectable 0.5 mg/L, except station 2 which had a chloride concentration of 0.7 mg/L. On July 26 all samples contained 0.6 mg/L except that from station 8 which contained 0.7 mg/L. Seymour River water contained less than the 0.5 mg/L MDC values in all samples taken during the study. The laboratory accuracy for average river water is $\pm$0.7% and the precision at 1.6 mg/L is 3.2%.

Total phosphorus ranged from the detection limit of 0.003 mg/L to 0.007 mg/L TP, and averaged 0.005 mg/L over the 45 lake water samples. In the May 9 and 19 runs the composite samples (stations 1, 4, 9) contained the highest concentrations of P. In the July run, the highest concentrations were found in samples from stations 8 and 7, respectively. Note the shape of plotted concentration vs. time in Figure 9, indicating a general decrease over time. This will be discussed in the following section. The Seymour River samples contained 0.011, 0.009, 0.003, 0.003 and 0.004 mg/L. Dissolved reactive phosphorus was below the MDC of 0.003 mg/L for all lake water and river water samples. This same finding was reported by Holmes (1987) in his overview study of Shuswap Lake.

Total nitrogen, calculated from the addition of total Kjeldahl nitrogen plus nitrite and nitrate, averaged 0.127 mg/L in lake stations, ranging from 0.06 to 0.20 mg/L. Concentrations of total nitrogen decreased over time as did total Kjeldahl and nitrate (Figure 9). Kjeldahl is total organic nitrogen plus ammonia (NH_3). Kjeldahl ranged from 0.04 to 0.13 mg/L, and averaged 0.09 mg/L for the nine lake stations. There was no discernable pattern to the data which might indicate potential sources of nitrogen. Seymour River Kjeldahl ranged from 0.11 mg/L in early May to 0.04 mg/L in early August. The accuracy for river water is $\pm$2%.

Total organic nitrogen (TON), Kjeldahl minus ammonia, ranged from 0.06 to 0.13 mg/L, averaging 0.09 mg/L over the 45 lake samples. Ammonia (NH_3) ranged from <0.005 mg/l (MDC) at many stations on each run to 0.019 mg/L at station 7 on May 19. At 0.018 mg/L the precision of the test is 5.1%. NH_3 in lake samples averaged less than 0.007 mg/L. The concentration of NH_3 in river samples averaged less than 0.006 mg/L. Nitrite (NO_2^-) is unstable in water and is usually much lower in concentration than nitrate (NO_3^-) (Cole, 1975). Nitrate values in the lake were low. They decreased over time from 0.8 and 0.7 mg/L in May to less than detection of 0.02 mg/L for all lake stations in July, August and October. Consistently during the study, nitrate values were lower in the lake water than in the river water. Precision decreases as concentration decreases.

Chlorophyll "a" measures the amount of chlorophyll detected from almost all photosynthetic organisms including blue-green algae, and subsequently the amount of primary production. All 45 lake water samples contained the very low concentrations of chlorophyll "a" of <2 ug/L, as seen in Table 7. The composite samples (1, 4, 9) had higher concentrations of chlorophyll "a", since they represented the phototrophic zone, not just the surface. Low mid-summer values compared to higher spring and fall values may indicate blooms of diatom algae common to oligotrophic waters (Table F-1), and freshet dilution.

Station (Figure 6)	Sample Type	Sample Run Date (1988) May 9	May 19	July 26	Aug. 2	Oct. 3	mean per station
1	composite	1.4	1.0	0.8	0.8	0.9	1.0
2	surface	0.9	0.6	0.6	0.5	0.7	0.7
3	surface	0.9	0.8	<0.5	0.5	0.8	0.7
4	composite	1.7	1.0	0.7	0.8	0.8	1.0
5	surface	1.0	0.8	0.6	0.8	1.2	0.9
6	surface	0.9	0.9	<0.5	0.7	1.0	0.8
7	surface	0.8	0.9	0.6	0.7	0.8	0.8
8	surface	1.0	0.9	0.5	0.6	0.7	0.7
9	composite	1.6	1.0	0.6	0.8	0.8	1.0
10	surface	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
mean per run		1.1	0.8	0.6	0.7	0.8	0.8

Table 7: Chlorophyll "a" Concentrations in ug/L

4.2.2 Inlet Stream Water Measurements

The five stream sampling stations labelled A through E are depicted in Figure 6 and located in detail in Appendix B. Measurements were made during each work period for temperature, electrical conductivity and estimated creek flow, and are presented in Table 8. Data showing field estimates of Seymour River flow rate and (same day) measured flow rate from the Water Survey of Canada staff gauge on the river are also shown in Table 8.

Measurements of water temperature, conductivity and flow in the four creeks which discharge to Bughouse Bay and the Seymour River at Quaft Road bridge (stations A, B, C, D_1 and D_2, E) were taken as described in Section 3.4.3. The conductivity and temperature of the Seymour River water at the Quaft Road bridge (Station E) are similar to measurements taken at the mouth (station #10). River conductivity ranged from 18 uS/cm in mid-May to 26 uS/cm in early August, and averaged 21 uS/cm. River temperature ranged from 5°C to 14°C, averaged 9°C. Inlet streams data appear in Table 8.

Estimates of flow were made on May 7, 12 and 18 at Station E and compared to the Water Survey of Canada flow gauge #08LE027, located approximately 2.25 km downstream from the bridge and 3.1 km upstream of the mouth (Environment Canada, 1989). Table 8 shows that the comparison of estimated flow to gauge-measured flow were within ±23%. Note the variability of river flows (from 26 m^3/s in early August to 147 m^3/s in mid May) and how quickly the flow volume can change (eg. May 7 to 12). The monthly total water discharge for May through October was 230, 264, 142, 88.5, 44.7, and 51.6 x 10^6 m^3 (Environment Canada, 1989). The measurements in the table show that the river discharge (Station E) is several hundred times the combined volume from the four inlet creeks, indicating their minimal potential to influence lake water quality.

Creek temperatures ranged from 7° to 17° and averaged 11°C. Temperature data showed that the water temperatures warmed as summer approached then

Date (hour)	Creek Station (Figure 6)	Conductivity (uS/cm)	Temp. (°C)	Flow (m^3/s)
May 7 (1530-1700 h)	A	45	7	0.02
	B	64	12	.10
	C	63	10	.08
	D_1	40	7	.01
	E (River)	19	5	49. [41]
May 12 (1430-1530 h)	A	46	8	0.02
	B	63	14	.11
	C	66	11	.09
	D_2	101	9	.02
	E	19	6	130. [147]
May 18 (1215-1400 h)	A	52	8	0.01
	B	68	9	.08
	C	69	8	.07
	D_2	108	8	.03
	D_1	42	8	.01
	E	18	5	99. [76]
July 22 (1130-1300 h)	A	56	11	0.01
	B	69	17	.11
	C	78	15	.04
	D_2	116	11	.03
	E	23	14	[45]
Aug. 3 (1100-1215 h)	A	55	13	0.01
	B	70	17	.08
	C	77	16	.04
	D_2	101	13	.03
	E	26	14	[26]
Oct. 2 (1615-1730 h)	A	55	9	0.01
	B	62	11	.10
	C	66	10	.04
	D_2	81	9	.03
	E	22	10	[31]

NOTES:
D_1 - Creek D at logging site 1000 m upstream of mouth
D_2 - Creek D at mouth
0.03 - example field estimate. 1 m^3/s = 35.3 cfs
[41] - Federal stream gauge #08LE027 reading for day

Table 8: Inlet Streams Measurements

declined with fall, that Creek A and Creek D were consistently the coolest and Creek B (Seymour Arm's drinking water source) was the warmest creek.

Conductivity measurements of the stream waters showed a rise during summer and decrease toward fall, similar to the temperature data. This increase in conductivity in mid summer may reflect increased nutrient content from geologic leaching, groundwater discharge and increased organics content. A mineralized groundwater discharge was found along the course of Creek D, resulting in the D_1 and D_2 sampling sites. Average creek conductivity (69 uS/cm) resembled the lake water (approximately 61 uS/cm) more than the Seymour River water which was substantially lower (21 uS/cm). Creek A was least ionized at 52 uS/cm, Creek D mouth (D_2) was the most ionized at 101 uS/cm, readings from creeks B and C fell within this range.

4.2.3 Discussion of Water Quality in Seymour Arm

Comparisons of water quality parameters from the early 1970's to this study appear in the following subsection. Data from sampling station to station in 1988 are compared in the next subsection, entitled Spatial Comparison. A comparison of water quality data from this study to the guidelines for recreational water for Canada, British Columbia and Ontario is presented in the next subsection.

Temporal Comparison

In 1971, lake water monitoring station #0500120 was established by the B.C. Ministry of the Environment off Encounter Point halfway along the Seymour Arm. It is a deep-water station where sample is composited throughout the phototrophic zone. Monitoring station #0500065 was established by B.C. Environment on the Seymour River at the Quaft Road bridge in 1978. It is 5.3 kilometres upstream of the river mouth and of this study's sampling station #10. Water chemistry data from these two stations during the early and late 1970's and in 1987, are important for comparative purposes. The results of the nutrient-related parameters from these two stations and results from this study are presented in Table 9.

Station, N:P Ratio	(# of samples)	TP n	TP R	DP n	DP R	TN n	TN R	NH_3 n	NH_3 R	$NO_2^- + NO_3^-$ n	$NO_2^- + NO_3^-$ R
LAKE											
#0500120 Encounter Pt. N:P> 46.7	1971-73 (7)	<3.0	<3.0-<3.0	<3.0	<3.0-<3.0	140	70-190	33.3	<10-80	<27	<20-40
#9 Seymour Arm N:P = 29.1	1988 (5)	4.8	3-7	<3.0	<3.0	138	100-200	<6.8	<5-10	<42	<20-80
means of #1-#9 Seymour Arm N:P= 29.3	1988 (45)	4.5	3-7	<3.0	<3.0	127	60-200	<7.0	<5-19	<41	<20-130
RIVER											
#0500065	1978 (1)	7	N/A	<3.0	N/A	140	N/A	6	N/A	50	N/A
Seymour R.	1979 (2)	8.5	8-9	5.5	5-6	150	90-210	9	9-9	80	50-110
mouth	1987 (6)	8.7	4-18	<4.3	<3-9	188	140-230	<6.7	<5-13	103	80-130
N:P= 19.6											
#10 Seymour R. N:P= 25.1	1988 (5)	6.0	3-11	<3.0	<3.0-<3.0	142	80-240	6.6	<5-12	76	40-130

Table 9: Comparison of Water Quality Data for Seymour Arm and Seymour River (ug/L)

n - average R - range N/A - not applicable Source of data: B.C. Environment

Table 9 first shows a comparison of nutrient concentrations between station #0500120 and station #9 (the deepest, southernmost and nearest station to #0500120), followed by a comparison to the mean nutrient concentration from all lake stations (#1 to #9). Second, the table compares river station #0500065 to river station #10, using the same parameters.

Regarding the lake samples, note how closely the means and ranges of the parameters resemble one another. It would appear that nitrite and nitrate, total nitrogen and dissolved phosphorus have changed little between 1971 and 1988 in the Seymour Arm. However, total phosphorus appears to have risen by more than 50% in concentration (from <3 to 4.6 ug/L), ammonia concentration has decreased on average (from 33 to <7 ug/L) and in range, and nitrate has increased in range from <20 - 40 ug/L up to <20 - 130 ug/L in 1988. There is an increase in the ranges of values from 1988 over 1971.

The increase of >50% in the concentration of TP in lake water from 1971 to 1988 may be a result of contributing factors such as:

- improved analytical capability;
- environmental conditions (rainfall, sunshine, temperature, time of day, algal blooms);
- sampling technique, and laboratory turn-around time;
- station #0500120 and station #9 located 7 km upstream are not readily comparable as assumed, perhaps because of dilution from inlet streams or groundwater or the precipitation of phosphorus as water flows down the arm;
- some other reason.

Assuming that the data are correct, the 17-year period has resulted in an increase of at least 50% in the concentration of total phosphorus. This may be a result of human activities such as logging (Hare 1984, Shaw 1986), road-building (Ponce and Gary, 1979), or shoreline development (Ponce and Gary 1979, Gosz 1975, Vallentyne 1974).

Nutrient-related water quality parameters were consistent over time in the Seymour River. Nitrate concentration averaged 76 ug/L, which is lower by 5% than in 1979 and by 42% than in 1987. The 1988 averages for the five nutrient parameters are less than the five averages for 1979 and 1987. The averages are very close to the data from the single sample in 1978. The ranges are greater for the 1988 nitrogen parameters compared to other years. Also, the N:P ratio is similar. The table shows a comparison of the ratio of the two prime nutrient parameters, total nitrogen to total phosphorus. The N:P ratio is a common interpretive tool in limnological literature and was used in previous water quality work on Shuswap Lake (Nordin 1986, Ross 1984). The consistency of the N:P ratio over time indicates that neither TN nor TP have changed appreciably, or that both have changed proportionately.

In 1988 no water samples exceeded 2 ug/L of chlorophyll "a" (as seen in Table 7) and the 45 lake samples averaged less than one microgram per litre. These levels are indicative of oligotrophic waters (Table F-1, Appendix F). Similar data were reported by Holmes (1987) for Seymour Arm at Encounter Point, and for most of Shuswap Lake during 1978 and 1979. The exception was the eutrophic conditions in Tappen Bay (Ross 1984, Holmes 1987).

As seen in Figure 9 and Appendix C(1) to (5), most chemical parameter concentrations tended to drop off slowly over the time period of the study. The exceptions are pH and conductivity, which rose slightly during the summer months. Chlorophyll "a" average concentrations appeared to do the opposite, decreasing from early to mid May to their lowest levels between late July and early August, then rebounding in the fall. This pattern is typical of diatom algae which are common to oligotrophic waters, as opposed to blue-green algae which are common to eutrophic waters and which tend to bloom in mid summer.

Spatial Comparison

The previous section discussed the results of all 1988 water samples compared to results of earlier water samples from the 1970's and 1980's. In this section sample results will be examined for all stations within a single sampling date. Results for each of the five dates will be discussed in order to determine if chemical differences existed between stations on one or more occasions, and to attempt to explain why such differences occurred. Refer to Appendix C(1) to C(6) for laboratory analyses and procedures, and to Figure 9 for the plotted values of the main parameters.

The May 9 samples show few signs of potential contaminant pathways or sources affecting the lake water. Of interest is the comparatively higher NH_3 values at stations 6 and 7 on Silver Beach - possibly indicating localized nitrogen fixing bacterial and algal activity. The data do not appear in the next sampling ten days later, do not affect the TN values at those stations, and do not correspond to elevated TP or chlorophyll "a" values.

A pattern of higher chlorophyll "a" concentrations from sampling deeper and more representatively through the phototrophic zone in the water column than the grab samples, is apparent in the May 9 sample data and the remaining four sample runs.

May 19 shows small differences between the three composite and the six grab samples of lake water. Compared to May 9 results, a general increase in total P in the water is apparent along with a slight decrease in concentrations of nitrogen parameters and sodium. The 0.2 mg/L higher chloride value at station 2 compared to other stations, may indicate an influence from barnyard leachate. However no other parameters support the slight rise in the chloride value recorded adjacent to the barnyard on May 19.

Samples from stations along the beach in late July tended to show that something is influencing the concentrations of TP, Na^+, and likely Cl^- and pH at stations 8 (the hotel dock), station 7 (165 m east of the dock in the houseboat moorage area) and station 6 (in the middle of the cordoned swim area, Figure 8). The 1.3 mg/L Na value at stations 6 and 7 on July 26 was 0.2 mg/L above the three composite samples that day, and 0.1 mg/L above the remaining four shallow lake water samples. The rise in concentration of these parameters at these locations may be reflecting the level of pleasure boating and swimming activity at the time of sampling. Sample 7 was taken between moored houseboats during both summer samplings, and therefore may indicate local, temporary waste water releases.

This is not evident one week later on August 2, 1988, when Cl^- values have dropped slightly to below detection limit of 0.6 mg/L, all TP values are at but not below the detection limit of 0.003 mg/L, and pH and conductivity values are not at extremes of their range. Of the three stations where an ionic influence was apparent on July 26, only station 8 showed any similar signs by August 2. Sodium was 0.1 mg/L above values at nearby stations and NH_3 was elevated in comparison to others nearby (0.017 vs. 0.005 mg/L for stations 8, 7, 6, 5 respectively). The ammonia values may have reflected dilute grey water or septic effluents or both.

The October 3 run showed no apparent trends or influences on water chemistry. Most Cl^-, NH_3 and NO_3^- values were lower than detection, and the values of pH, conductivity and TN were similar to values recorded in early May, when recreational usage of the shorezone was also limited.

Summary

With chemical concentrations so low in value, even slight anomalies may be significant. Chemical data indicate possible negative influences from human activity at station 8 (the hotel dock in front of The Pub) in late July and early August, and in July at stations 7 (the houseboat moorage) and 6 (the public swim area). Chemical data indicate possible negative influences from agricultural activity at station 2 (the cattle barnyard) on May 9 and May 19.

Lake water measurements taken along with the five sample runs were presented in the previous section, and indicate the following anomalous situations. Station 8 had the highest field conductivity of all stations on May 9, 15, 19, and July 26, 1988. The lowest dissolved oxygen readings per run were recorded at station 8 on May 9, stations 8 and 2 on May 15, station 7 on May 19, and station 2 on October 3, 1988.

Growth of aquatic weeds believed to be Potamogeton richardsonii (pond weed) was apparent at station 2 (at the cattle barnyard) and at station 8 (at the hotel dock) only.

Temporally and spatially, the range of chemical data was limited. Also, concentrations were very close to instrument detection and therefore test precision (Table C (6)), necessitating caution in data interpretation. Water chemistry of the lake near shore and at depth on the upper Seymour Arm was consistent and indicative of an oligotrophic system (Table F-1). From the data it appears that potential shorezone influences occured near the cattle barn, at the dock in front of The Pub and along the beach where houseboats moor and people swim. These influences may indicate agricultural runoff and waste water of human origin, respectively.

A general increase in parameter concentration was evident from May to mid-summer. A general decrease in parameter concentration was evident from mid-summer to October. This pattern could indicate that recreational activity had affected water quality in the study area, or that freshet contributions were declining.

Measurements for conductivity and temperature of the water from Creeks A, B C and D indicated that they were similar to the lake water. The exception was Creek D, which mixed with a groundwater seep near its mouth and discharged to Bughouse Bay at about 100 uS/cm. The combined average flows from these four small perennial creeks was 1/1300 of the average flow from the Seymour River. It was concluded from these measurements taken over the five month study period that the small creeks (which averaged about 68 uS/cm) and the Seymour River (which discharged 1,300 times more water at about 21 uS/cm) were not detrimental to lake water quality. However, the four small creeks add very little inflow to Bughouse Bay. The Seymour River added higher concentrations of dissolved oxygen to the lake water, along with higher concentrations of nitrate and total phosphorus.

Comparison to Federal and Provincial Objectives

Acceptable concentrations of chemical parameters in water - be it surface water or groundwater - are hard to quantify, and change with time as better information becomes available. The particular usage of the water affects acceptability (Ontario Ministry of the Environment 1984, CCREM 1987).

Table 10 shows Seymour Arm water in comparison to contemporary recreational chemical water quality (maximum values) objectives, when available, and for higher quality guidelines such as for drinking water quality objectives when recreational objectives are lacking for the federal government and for the provinces of British Columbia and Ontario. Concentrations of parameters analyzed during the study fall well within these guideline values for recreational water usage, even within the more strict guidelines for human drinking water.

Government Agency	Chemical Cond.[a]	Parameter (mg/L, unless pH[b]	otherwise specified) $NO_2^- + NO_3^-$	NH_3	TP	Na^+	Secchi[c]
Environment Canada[d]	<750	5.0-9.0	<10	f	f	<250	>1.2
Province of B.C.[e]	f	f	f	f	<0.01	f	>1.2
Province of Ontario[g]	<750	6.5-8.5	<10	<0.02	<0.02	f	>1.2
Seymour Arm, 1988	60	7.7	<0.041	0.007	0.005	0.7	6.2

a uS/cm - 750 is approximated from TDS = 500 mg/L
b pH scale (logarithmic)
c metres below water surface, a minimum acceptable value
d CCREM, 1987 (except c) recreational water objectives
e B.C. Ministry of Environment 1986, recreational water objectives
f no objective specified
g drinking water objectives (except c), Ont. Ministry of Environment, 1984

Table 10: Comparison of Recreational Water Quality Objectives (Maximum Acceptable Values, Except Secchi Depth)

Quantifying water quality objectives is not an exact science but an evolving process. Subsequently, guideline criteria are more often "scientific judgements" (Ontario Ministry of Environment, 1984) than hard facts. The Canadian Water Quality Guidelines describe on page 2-7 that apparent colour is "an aesthetic quality which cannot be quantified", and that true colour (filtered) "depends upon the preference of the users, and it is impossible to put an absolute value upon it" (CCREM, 1987).

Objectives are defined better for human drinking water and for livestock drinking water than for human recreational waters. This illustrates further the difficulty in quantifying water quality standards. Recreational guidelines involve visual and aesthetic parameters which are subjective and subsequently difficult to measure. In this regard, the opinions of lake users on the state of water quality are very relevant.

Direct chemical limitations on recreational water quality are by necessity very few, since people swim contentedly in oceans or saline prairie lakes (CCREM 1987, Parkes 1973). Water chemistry is of less concern for water recreation, than for water consumption. With the exceptions of a minimal Secchi disc depth, a maximum value for conductivity, and somewhat vague standards for odour and turbidity, parameters for recreational water quality are related to bacteriological assessment and physical appearance (CCREM, 1987). Physical properties (which may result from nutrient concentrations and may reflect bacteriological densities) are those most obvious to anyone who swims: offensive weed growth or objectionable aquatic life, odours, petroleum deposits or films, offensive odour and taste, scum or deposit, floating debris (both natural and anthropogenic).

Though the water of Seymour Arm is good by all standards, is it being adversely affected by cumulative anthropogenic inputs? This question requires further and long-term study to be adequately addressed. Quantifiable cumulative effects are difficult to assess for many chemical parameters in most watersheds (Gosz, 1982). The differentiation between nutrients which occur naturally and anthropogenically is very awkward. It would be an easy task if phosphorus originating from human activities was chemically different (and therefore traceable) from naturally occurring forms of phosphorus. It is not.

Previous impact studies on water-based recreation have been juxtaposed - some studies concluded that impacts existed, while other studies concluded that water-based recreation yielded no environmental impacts (Ponce and Gary 1979, Gosz 1982, Williams 1987).

4.3 Questionnaire Results

4.3.1 Interviewing Shuswap Lake Residents and Visitors (Q1)

As outlined in Section 3.5.1, adults typical of their family or cohort group who had the experience of at least two prior visits to the Shuswap, were interviewed between July 21 and August 2, 1988, using a questionnaire specifically developed for such a purpose (Appendix D).

The majority of persons approached for Q1 response were receptive. It was stated clearly that the only desirable answers to questions were candid responses of the respondent. The level of discretion and promise of anonymity in the interviews provided some respondents with security, but most people did not require such protection. Resultant attitudes and practices of the 179 Shuswap Lake users interviewed are presented and discussed in the following section.

In Q1, respondents were asked 27 questions, 11 of which had more than one component and 12 of which invited explanation or comment. Summarized results of Q1 responses appear in Table 11, and are augmented with respondent comments in Table 12, which follows. Following these two tables of summarized findings is a description of the demographic breakdown of respondents ("Demographics"), the results of questions which were excluded from detailed analysis and the reasons for their exclusion ("Exclusions"), and detailed results of questions which were analyzed ("Inclusions"). The findings are summarized and discussed in the following subsection which is entitled "Summary".

Shuswap Lake users were concerned about the lake's water quality, use and development. All respondents (100%) thought that good water quality was important and should continue. Approximately 47% believed that lake water quality had not changed during their experience, and about 35% felt that it had worsened. Thirty-five percent of respondents could think of potential sources of lake water contamination, and 63% could not. Nearly 70% had concerns about pleasure boats with overnight accommodation which were unrelated to water quality (as per question #24). Over 80% felt that grey water was detrimental to water quality, had never seen human sewage in the water of Shuswap Lake, wanted a waste water pumpout station at Seymour Arm, and thought that the houseboat industry was an economic benefit to the local economy. There was a high percentage of uncertainty to responses about the availability of relevant regulatory agencies. Sixty-eight percent of respondents thought that all lake uses were compatible, 50% would recommend restricting some uses and 21% would recommend stopping some uses.

Over half the people interviewed embellished their responses with comments (Table 12). The comments are considered to be important information because they are usually unsolicited and spontaneous, and always undirected. The respondent was not answering a specific question when offering comment, but stating something he or she felt was important.

Several misconceptions were noted from a minority of respondents (less than 25 comments so they do not appear in Table 12). One of these was that the Shuswap Lake shoreline length was about 1000 km. In actuality it is about 312 km in length. Some respondents thought that there were 500 to 800 houseboats on the lake. There were about 375 commercial and private houseboats on the Mara and Shuswap Lakes system during the latter half of 1988, and this number has not changed appreciably since (Prystai, 1990).

A third misconception noted through comments from about 10% of respondents was that the lake flushed its volume four to seven times annually. The lake has a calculated volume replacement rate of approximately 0.5 times per annum or once every two years (Appendix F). These respondents, similar to those who mentioned the subject in questionaire Q2, seemed to believe that volume replacement purified the lake absolutely.

Number, question	Response (% of 179 sampled) Yes	No	Unsure/No Response	Number of Comments
6. Noticed decrease in water quality at:				
(a) Seymour Arm?	43	43	14	113
(b) lake generally?	35	47	18	89
(c) specific areas?	24	44	32	63
7. Know of land-based contamination?	35	63	2	62
8. Improvements to Seymour Arm area?	66	30	4	184
9. Continued water quality important?	100	0	0	N/A
11. Houseboats important economically?	89	11	0	N/A
12. Enough regulation on lake?				30
-RCMP	51	38	10	
-Fisheries and Oceans Canada	38	30	30	
-Wildlife (B.C. Environment)	32	31	37	
-B.C. Environment/Parks	49	41	10	
18. (b) Know of any adverse lake discharges?	27	56	17	48
19. Seen human feces in water?	16	82	2	N/A
21. Grey water a lake contaminant?	85	2	13	8
23. Sani-station for Seymour Arm?	88	10	2	29
24. Any concerns about boats not related to water quality?	70	28	2	192
25. (a) Lake uses compatible? lake	68	25	7	63
Seymour Arm	49	27	24	33
(b) Restrict any uses? lake	50	43	7	109
Seymour Arm	45	30	25	99
(c) Stop any uses? lake	21	67	12	50
Seymour Arm	17	54	29	37
26. Other concerns about Seymour Arm development?	55	42	3	139
27. Other concerns about Shuswap Lake?	51	45	4	136

Table 11: Summary of Q1 Results - Question Responses

Comment	No. of Comments
Problems with number of houseboats on lake - restrict expansion (101), stop expansion (62), decrease or lessen present number (24)	187
Water is more weedy (than in past)	105
Problems with houseboaters - excessive noise (56), pilot skills (12), drunkenness (12)	80
Stop grey water discharges to lake water	77
Water is less clear (than in past), more foamy	71
Stop clear cut logging practice in Shuswap	63
Create separate moorage areas for houseboats	63
Restrict (shorezone) industry	61
Restrict (shorezone) private development	57
(Too much) garbage on beaches, shores, in water	55
Stop agricultural runoff, development	50
Present level of development is good	48
(Improve) gasoline handling, lessen spills	35
Development level acceptable if monitored/regulated	32
Upgrade/inspect shorezone septic systems	30
Respect rights, property of others (lake users)	27
Control beach fires (use pits)	26
Improve/expand park facilities	25

Note: only one comment per subject per respondent was accepted.

Table 12: Summary of Q1 Results - Comments Received

Demographics

Interviews using questionnaire Q1 were completed with lake users who fulfilled the qualifying criteria as detailed in Section 3.5.1. Lake users included lake residents and repeat visitors. The demographic breakdown of the total sample follows. It should be noted that the two major groups of respondents, residents and visitors, are mutually exclusive.

<u>Residents</u> (102 in total)	
Permanent - Seymour Arm area	18
elsewhere on lake	12
Seasonal - Seymour Arm area	62
- elsewhere on lake	10
<u>Visitors</u> (77 in total)	
Campers (with or without small watercraft)	37
Roomers (hotel, cabin, or visiting a resident)	9
Boaters - private, runabouts day-use	4
- private (owners of) pleasure boats with overnight accommodation	5
- commercial (renters of) pleasure boats with overnight accommodation	22

In arriving at the numbers of interviewed visitors and residents, no effort was made to better represent one group than another, or to skew the selection. During the two-week interview period, effort was made to obtain thoughtfully completed questionnaires by people typically found near Seymour Arm in mid-summer, 1988. The selection of respondents was controlled by their presence and by the pre-established quota sample number of 175 to 200 interviews.

Personal data were not incorporated into the questionnaire. Attitudes about water quality and resource usage were sought, not personal information.

More than 98% of adult persons who qualified to complete the questionnaire agreed to do so. Three persons refused. The percentage of refusal was low considering that the author wanted from respondents: 20 to 40 minutes of their vacation time, seriousness, privacy or minimal distraction and effort.

Exclusions

For the reasons described below, questions 1, 2, 3, 4, 5, 10, 13, 14, 15, 16, 17, 18, 20 and 22 were excluded from more detailed analysis. Each will be discussed briefly.

Question #1 asked potential respondents if they could speak on their own behalf or on behalf of their party. Since the question was permission to conduct the interview, there is no need for analysis. Question #2 simply categorized people into lake user groupings. This information was used in the demographic profile overleaf. Question #3 dealt with the municipality of respondents' permanent homes. It showed that Calgary was home to the largest group (30%), followed closely by southern British Columbia including Kamloops and Vancouver (27%). The third largest group was other Albertans (mainly from Edmonton) at 23%. The smallest groups were Shuswap Lake residents at 16%, followed by "others" at 4%. These data compare to B.C. Ministry of Lands, Parks and Housing (1987) visitor profile which showed that 50% of Shuswap Lake users were Albertans, about 45% were British Columbians including locals, and 6% were "others".

Questions #4 and #5 documented that respondents qualified by having at least two previous visits to the Shuswap, one of which included Seymour Arm.

Question #10 asked "who owns Shuswap Lake?" Most respondents (45%) knew that the lake itself (not its shoreline) belonged to people, held in trust by government, but were unsure which people and what government. Twenty-seven percent thought that the water belonged to the province of B.C. (which is true), and 18% thought that the water belonged to Canada. Thirty-seven percent answered in a non-aligned fashion that made assessment impossible, such as "all of us, everyone, the public". The remaining 12% tied their answer to paying taxes, to living locally or to being a lake user.

Question #13 responses were used in the assessment of shorezone domestic sewage practices (mainly in Seymour Arm), and was never intended for analyses within the context of the total sample. See Section 4.1.1. Question #14 was significant only for owners of private houseboats, cruisers and yachts and was therefore applicable to only 3% of the Q1 sample group. One private houseboat had a porta-potty, the other had a black water holding tank and both released grey water. Three cruisers released grey water but had 250 L capacity black water holding tanks.

In question #15, no one admitted throwing domestic garbage into the water or on shore. Yet comments from other questions indicated that garbage in the water and on shore was an important concern of users from all groups in the sample. Someone was leaving garbage behind but apparently not Q1 respondents.

Question #16 showed that many people who were renting a houseboat had done so at least once before, and that their previous houseboating experience was often the basis of their knowledge of the lake. Less than 15% of residents had rented houseboats. Question #17 related to the respondents witnessing discharges from watercraft and where these discharges had occurred. Responses were about even - half positive, half negative. Positive responses identified grey water from houseboats and cruisers, gasoline losses from runabouts and unknown material from all boat types. The frequency of sightings ranged from "rare" to "uncommon" and the number of respondents was less than half of the total sample.

Question #18 (a) followed up on #17, asking if the respondent knew of other areas on the lake that may be adversely affected by watercraft discharge. Response was low. Those who responded were split between "yes", "no" and no response. Of those answering "yes" who then indicated where these areas were, the Sicamous Narrows marina locations, public beaches and the Cinnemousun Narrows were the areas most frequently mentioned. These locations reflect references in Section 2.1.5 to the B.C. Ministry of Environment (1988) and in Section 2.1.6 to B.C. Ministry of Lands, Parks and Housing (1987), that demonstrate the popularity of narrows, beaches and services at narrows and at beaches. Question #18 (b) received better response and is discussed in the following section.

Question #20 was a follow-up to question #19 about human feces sightings. Since 82% of users reported never having seen human fecal matter in the lake, only 18% could answer question #20. Of those 18% that could answer the question, few chose to do so.

Question #22 dealt with respondents' knowledge of pumpout station locations. Q2 indicated that people renting houseboats had black water storage capacity for one week, and were provided by most houseboat company operators with a 1987 map showing four sani-station locations (Columbia-Shuswap Regional District, 1987). These maps were outdated however, and the only sani-station still in operation in 1988 (excluding the houseboat headquarters) was at Cinnemousun Narrows. Subsequently many renters of commercial houseboats were ill-informed about sani-stations. Most permanent and seasonal residents knew of this situation. Answers to question #22 showed that the more mobile users, such as boaters, believed that more sani-stations were needed around the lake. Since the question was answered by half of the respondents, the results were not analyzed. However, the question indicates a key finding of the study: many users were discontent with the number of inoperative sani-stations. Comments and other questions in Q1 also covered this topic.

Inclusions

Following are the analyzed response data for questions number 6, 7, 8, 9, 11, 12, 19, 21, 23, 24, 25, 26 and 27. These data have been summarized in Table 11 at the front of this section.

Note that one person could comment on more than one problem or concern, but only one comment per subject per respondent was counted. However, some subjects were very similar to one another, and were grouped together as a single subject for simplicity of presentation. Subsequently, total comments may appear to outnumber the total respondents as seen with the first entry in Table 12. Note also that comments were solicited for some questions (eg. "specify" or "comment"), but were not directed. Comments were collected from all questions and presented together by subject in Table 12.

Question #6 asked respondents if they had noticed any positive or negative changes in water quality in (a) the Seymour Arm area, (b) in the lake as a whole, or (c) in any particular location of the Mara-Shuswap system. Comments were welcomed.

#6 (a) indicated the following for water quality changes in the Seymour Arm area:

43% felt that water quality was worse
41% said "no change", and 2% said that it was better
9% were unsure, 5% did not respond

When the major responses were broken down to the major subsets of all visitors and all residents, the responses looked like this:

(41%) "No" change - 57% visitors, 30% residents
(43%) "Yes, worse" - 21% visitors, 60% residents

#6 (b) indicated the following responses regarding changes in water quality throughout Shuswap Lake:

46% said "no" change
35% said "yes, worse"
14% were "unsure"
4% had no response
1% felt water quality had improved

In subsets, 77% of the 22 houseboaters said "no" change. Of 37 campers, 59% thought there was no change. 27% of the 62 seasonal Seymour Arm residents and 18% of Shuswap basin residents thought that there was no change in water quality.

#6 (c) indicated the following data regarding water quality changes for specific areas of the lake:

44% said "no" change
24% said "yes, worse"
18% were unsure
14% did not respond

Generally, campers and Seymour Arm residents responded with high percentages "unsure" and "no response" - indicative of an assumed lack of mobility. Private boaters and houseboat renters had low "unsure" and "no responses" - perhaps because their mobility allowed them a better perspective on water quality in other areas of the lake.

Question #7 was an open question pertaining to possible contaminant pathways from the land to the lake. The data indicate concerns regarding potential contaminants and ways to reduce their effects. 63% of respondents did not know of any land-based sources of contamination; 35% did, and 2% did not respond. Logging practices and private development in the shorezone topped the list of comments.

Question #8 was also an open question asking respondents to suggest improvements to water quality in the Seymour Arm area. 66% said "yes" they could and explained their suggestions; 30% said "no", and 4% did not respond. Nearly 200 separate comments were offered. Generally, residents tended to comment on houseboating practices, houseboaters tended to comment on park facilities, and campers commented on houseboaters and amenities.

Question #9 asked respondents if continued lake water quality was important to them. No one answered "no", or "not very". 78% of respondents indicated "yes, very" and 21% indicated "yes". One person did not respond.

Question #11 asked people if they believed that the local houseboat industry was important economically and if so, to what degree. 89% believed that it was an important or very important economic benefit to the region; 11% believed that the industry was not important to the local economy.

Question #12 asked respondents how they felt about regulatory authority on the lake. The question directed responses to four categories: TM = too much, S = sufficient, NE = not enough, NR = no response. The question was applied to the following agencies: police, fisheries, municipal, wildlife, environment/parks, other. As the "municipal" category does not seem appropriate in retrospect because it is small and it received little response, it will not be analyzed. B.C. Ministries of Environment and Parks were a single entity during 1988, and must be reported as such.

The total sample reported the following responses about the presence on the lake of each agency:

- police - (Royal Canadian Mounted Police)	TM - 1%	S - 51%	NE - 38%	NR - 10%
- fisheries - (Fisheries and Oceans Canada)	TM - 2%	S - 38%	NE - 30%	NR - 30%
- wildlife branch - (B.C. Ministry of Environment)	TM - 0%	S - 32%	NE - 31%	NR - 37%
- Environment/Parks - (B.C. Ministry of)	TM - 0%	S - 49%	NE - 41%	NR - 10%

Broken down to visitors and residents, the data take on a different configuration.

	Police (%)			Fisheries (%)			Wildlife Br.(%)			MOE/Parks (%)		
	S	NE	NR	S	NE	NR	S	NE	NR	S	NE	NR
Total	51	38	10	38	30	30	32	31	37	49	41	10
Visitors	65	18	16	35	20	44	30	19	51	62	33	6
Residents	39	54	6	39	38	20	33	40	27	38	47	14

Question #18 was similar to questions 7 and 17. It asked the respondent if he or she knew of (other) areas in the Shuswap that may be affected by discharges from (a) watercraft or (b) any source. Part (a) received poor response and was not analyzed for reasons explained in the preceeding section. Question 18 (b) received good response and was analyzed. The total Q1 sample responded as follows: 17% offered "no response" or were "unsure", 27% said "yes" they knew of such areas and followed through with comments, and 56% answered "no". These data are juxtaposed to those from Q2, which also posed this question to respondents. See Table 13.

Question #19 dealt with sightings of human feces in lake water and was based upon information received in the early stages of the study. Fully 82% of respondents had never seen human fecal matter anywhere in the lake system. 12% had seen feces at least once in the Seymour Arm area but never elsewhere. 4% had seen feces at least once elsewhere but never in the Seymour Arm area. 2% did not respond. Visitors reported never having seen human feces more often (92%) than residents (76%). The group reporting to have seen the most feces was seasonal residents of Seymour Arm.

Question #21 asked people's opinions on whether grey water (a) could degrade lake water quality and (b) should be considered a lake contaminant. A decisive 85% of respondents answered "yes" to both questions, and 2% answered "no" to both questions. The breakdown of "yes/yes" responses to main subgroups was 84% for visitors and 92% for residents - a very close split. Of the total sample, 13% answered with at least one "don't know" or "no". Only eight comments were offered but they seemed to be well-informed and quite specific. One comment concerned the relationship between phosphorus and weeds. Four comments were about assimilation capacity and dilution. The remaining three comments dealt with concentrations of boats and subsequent loadings to the lake.

Question #23 asked respondents if they thought that a sanitary pumpout station should be located in the area for (a) black water, (b) grey water or (c) both. 88% said "yes" to (c) both. Only 2% were indecisive on this question, answering with "don't know" or "no response". 7% said "no" to the station, and 3% said to install a pumpout station for black water only.

Question #24 was an open question for concerns about pleasure boats with overnight accommodation that were not related to water quality. 70% of respondents said "yes" they did have such concerns and explained them; 28% had no concerns and 2% had no response. The question generated nearly 200 separate comments, with "excessive noise from houseboaters" from 56 people topping the list (see Table 12).

Question #25 was in three parts dealing with Shuswap Lake recreation generally and recreation in the Seymour Arm/Silver Beach area specifically. It asked (a) if uses are compatible now, (b) would the respondent recommend restricting some uses (and which ones), and (c), would the respondent recommend stopping some uses (and which ones).

#25 (a) asked respondents: "are all present uses (boating, water sports and swimming, fishing, agriculture, industry, aircraft, shoreline development, water supply) compatible in the lake, and in the Seymour Arm area?" Sixty eight percent answered "yes"; 25% answered "no", 7% had no response. There were 63 comments offered.

Regarding upper Seymour Arm, 49% of respondents thought all uses were compatible; 27% did not think so and 24% were uncertain or did not respond. Generally, the lake received more responses and comments than did the Seymour Arm area. Seventeen percent of visitors said "no" about the lake; 26% said "no" about the Seymour Arm area. Lake residents were split equally - 32% said "no" about compatibility of uses lake-wide, and 31% said "no" about compatibility of Seymour Arm area uses.

#25 (b) generated over 200 comments. It asked if respondents would recommend restricting some uses of (i) the lake, (ii) the Seymour Arm area. Regarding restrictions of uses of the whole lake, 50% of respondents said "yes" they would recommend some, 43% said "no", and 7% had no response. Of the "no" responses, 59% were visitors and 41% were residents.

Regarding restricting uses in the Bughouse Bay area, 45% said "yes" they would recommend restricting some uses of the lake resource, 30% said "no" and 25% had no response or were not sure. Of the 30% who said "no", 61%

were visitors and 39% were residents. This demonstrates a very similar ratio to that for general lake use. It appears to indicate that 50% more of the visitor population is satisfied with the status quo than of the resident population. Respondents were less certain about restricting Seymour Arm uses than about restricting uses throughout the Shuswap. The yes:no ratio is much closer for the lake (50:43) than for the Bay area (45:30).

#25 (c) asked respondents if they would recommend stopping some uses of the lake in general and uses at Seymour Arm in particular. Regarding the lake, 21% said "yes" they would stop some uses while 67% said "no". 12% offered no response - 9% of the visitors and 15% of the residents. At Bughouse Bay, 17% said "yes" to stopping some uses, 54% said "no". 29% offered no response - 19% of visitors and 29% of residents. These results seem to indicate that respondents were apprehensive about ending one or more activities of other lake users. This respect for other people's rights to use the resource - despite apparent disagreements over usage - was apparent in other questions and in comments. It is also clearly evident in Q2 responses (Table 13).

Question #26 was an open question asking if the respondent had any other concerns about development in the study area, to which 55% said "yes" and elaborated, 42% said "no", and 3% did not respond. The highest percentage of negative comments came from permanent residents of the Shuswap and of Seymour Arm at 68% and 56%, respectively. The lowest percentage of negative comments (23%) came from houseboaters. Of the 139 comments offered, "restrict shorezone development" was the most popular (19 persons).

Question #27 was an open question similar to question 26 but pertaining to unaddressed concerns about the whole lake. 4% did not respond or had no response, 45% answered "no", and 51% responded "yes" they did have unaddressed concerns, then explained them. 52% of residents said "no" and 45% of residents said "yes". For the visitors, 35% said "no" and 61% said "yes". This may indicate that visitors had more concerns than residents, a situation reflected in question 26 results, but somewhat atypical of other questions where visitors voiced less concern than did residents.

Discussion

Generally, lake users cared about the continuation of good quality lake water, and wanted to maintain that quality by protecting the lake from excessive development, misuse, or mitigable impacts.

General observations by the interviewer included: lake users with years of experience yielded more detailed answers than those with only several years' experience or visits; boaters were often well versed on other locations around the lake; campers tended to favour facilities-related responses; residents were usually well informed locally but less informed on other Shuswap locations; visitors tended to be less concerned or more satisfied with the status quo lake usage than residents. An important observation was that many Q1 respondents returned to the Shuswap year after year.

Respondents were quite forgiving of other people's perceived misuses or excesses, as opposed to those of industry (including agriculture and forestry) or those of municipalities (District of Salmon Arm and Sicamous). Most respondents were conscious of other people's rights to usage, and recognized that care did not imply ownership.

This came through clearly in question #25 where the respondent was asked if some lake uses should be restricted or stopped. The number for stopping some uses is much less than the number for restricting some uses (Table 11). More people would recommend curtailing some activities than disallowing them all together.

Another interesting trend in the data is the difference in attitude between the two major subset groups - visitors and residents. Visitors seemed more open about lake usage and less critical of misuse than residents. Visitors with less (visits) experience of the lake seemed less concerned - or their concerns were directed more toward facility improvements than attitudinal change - than did visitors with ten or more years lake experience. Experienced visitors in turn seemed less concerned about the lake than seasonal or permanent residents. This difference in attitude likely reflects differences in commitment to the lake, such as investment in property.

Questionnaire results indicated that respondents were adamant about stopping grey water releases and equally decisive about the status of grey water as a contaminant to lake quality. The desire for a pleasure craft (and recreational vehicle) grey water and black water pumpout station near Seymour Arm was also clearly defined by respondents. All three issues generated over 80% positive response.

Respondents were quite divided about the role and presence of various authorities on the lake. Half of respondents thought that the RCMP and B.C. Environment/Parks were sufficiently represented on the lake, but were uncertain about the presence of federal fisheries and provincial wildlife officials. Approximately 40% of all respondents wanted more law enforcement in the Shuswap from the RCMP and B.C. Environment/Parks. As indicated, a difference in attitude was apparent between residents and visitors - over 60% of visitors thought RCMP and Environment/Parks were sufficiently represented on Shuswap Lake as opposed to less than 40% of visitors. Generally, respondents wanted more enforcement of present regulations, not more regulations (Table 12).

Houseboating, shorezone development from all sectors and water quality concerns were very important to visitors and residents of the Shuswap. This is reflected in the number of comments received, as seen in Table 12, and in the quality of many comments. Sometimes unsolicited comments were more revealing and informative in terms of how respondents really felt about an issue, than the questionnaire question which generated the comments.

Surveys of public opinion about the usage of recreational water bodies have been undertaken before in Canada and in the Shuswap. O'Riordan and O'Riordan (1972) discussed municipal planning and management problems centred around increasing environmental stress (mostly from agricultural runoff and municipal waste water effluents) upon Lake Okanagan and Shuswap Lake. Parkes (1973) surveyed recreational water users in coastal Nova Scotia, eastern Quebec and southeastern Saskatchewan. Parkes was interested in the public perception of local water quality, how public perception affected water-based recreation. He surveyed users to determine if they would pay for improvements to, or maintenance of, present water quality.

B.C. Lands, Parks and Housing (1987) conducted a survey of 169 boaters on Shuswap Lake in order to gauge public sentiment about marine development.

Common threads in approach and results between these surveys and this study, along with differences, will be discussed briefly.

The O'Riordan and O'Riordan study (on municipal sewage effluents and eutrophy in the Okanagan and Shuswap watersheds) included a survey of Salmon Arm residents and politicians at the time. Over 80% of respondents (in 1972) felt that water quality in Tappen Bay would worsen in the future, and 45% felt that local water quality was worse than in the past. The water quality aspect of the O'Riordan and O'Riordan (1972) study is of interest in that it is readily comparable to this work. Q1 results show that 35% of respondents felt that water quality had diminished in Shuswap Lake. 20 respondents were concerned specifically about District of Salmon Arm development and sewage plant effluent to Tappen Bay. Q2 respondents were similarly concerned about municipal expansion and sewage plant effluent.

The study determined cognitive dissonance in Salmon Arm and Penticton aldermen concerning various alternative sewage treatment schemes. That is, the aldermen did not vote (act) according to the way they felt. They felt that a high quality effluent was important to the maintenance of water quality, but voted for inexpensive, low efficiency sewage treatment.

Respondents ranked water concerns well above public health, roads or police protection, and were willing to pay at least $60 per household (in 1972) for good sewage disposal. The District of Salmon Arm portion of the study concluded by stating that environmental policy is as much a product of faith as technical information. Another similarity was that 18% of Q1 respondents felt that 1988 lake policies and planning needed more attention and enforcement, not more technical content or information.

The B.C. Parks (1987) study was of boaters only - not general lake users as was Q1. Findings which were similar to this study included a high proportion of comments about litter in and near the water, keeping the shorezone in a natural state and/or undeveloped, controlling houseboat renters, and lake user profiles. Findings which were dissimilar included a high proportion of comments related to boating and park use - more wharves, better signage, overcrowding in parks. The B.C. Parks study outlined proposals to better manage some areas by rezoning and increasing or forbidding development, and by the acquisition of more parkland. It recognized user conflicts but did not offer any solutions.

The document recognized that the lake may have a boat carrying capacity, and that crowding depreciated the quality of the lake experience. Q1 respondents frequently mentioned the same thing, or alluded to the quality of the lake experience when suggesting control over boat numbers and commenting upon the compatibility of various lake usages.

Parkes (1973) wanted to determine if people who perceived water to be of questionnable quality would use it recreationally. Parkes wanted to see if people also would pay to preserve water quality. "Changes in water quality do not lend themselves to precise market quantification for benefit/cost purposes....but....attitude studies aim at what individuals see in their environment...what it means to them...how they act towards it". (p.2.)

Parkes (1973) found cognitive consistency tended to increase with increasing income and occupation level. (More wealthy and educated people were willing to pay for their convictions.) He also found that user awareness of water quality was not contingent upon on-site water quality. Such a finding applies to this study since research was conducted near good quality water (Seymour Arm) and yet concerns about water quality were widespread. Parkes (1973) found that on average 60% of respondents were willing to pay for improved water quality. However, Parkes found significant regional differences between peoples' recognition of water quality problems (which was high) and their willingness to pay for continued quality. Recreational water users in the South Saskatchewan study area were most willing to pay, followed by those in the coastal Nova Scotia study area, and those in Quebec's Eastern Townships study area.

As with the O'Riordan and O'Riordan (1972) study and the Parkes (1973) study, respondents in this study equated decreased water quality with increased weed and algae growth in shallow waters near shore.

4.3.2 Interviewing Shuswap Lake Rental Boat Company Operators (Q2)

The only pleasure boats with overnight accommodation that were for hire on the Shuswap in 1988 were houseboats offered by ten companies. Senior management personnel (usually the owner) from all ten companies offering houseboats for rent on Shuswap and Mara Lakes completed Q2, under the same degree of discretion and anonymity provided to Q1 respondents. Absolute anonymity was more difficult to ensure than for Q1 respondents since the sample group was limited to ten persons. However, question responses (Table 13) and comments (Table 14) do not indicate source. Information specific to each company is presented as ranges and averages, again not specifying the source. The operators were content with this arrangement. Eight of the ten Q2 interviews were completed in person on July 21, 1988 at Sicamous, B.C. One was completed in person on October 1, 1988 in Sicamous, B.C. One was completed over the telephone on September 22, 1989. Temporal disparity is not considered to be significant. The interviews followed questionnaire Q2 (Appendix E) and took approximately 30 minutes to complete.

All 10 respondents chose to answer all questions. There was no discernable tendency for any operator to be the exception, or to be consistently contrary or obscure. Results of the interviews are presented and discussed in the following section.

The first part of the questionnaire for houseboat rental company operators dealt with quantitative information. This information is unique to Q2, as several questions in Q1 were unique to non-commercial lake users. Quantitative information is not included in summary Tables 13 and 14.

Nine company fleets were headquartered in or near to Sicamous. One fleet was headquartered near Sorrento. The rental companies had been in business from four to twenty years, and averaged eleven years. The average age of a rental houseboat on the lake was 3.5 years. The number of rental houseboats owned by each company ranged from 8 to 132, and averaged 33 boats. The total number of rental houseboats on the Mara-Shuswap lake system was 327 ± 5, as of October 1988.

The number of privately-owned houseboats, a number much more difficult to ascertain, is estimated at 45 ± 15. Therefore the minimum number of houseboats on the lake in late 1988 was about 375 (Appendix G). Seven of the ten operators did not plan to expand the size of their houseboat fleets. Three company operators did plan fleet expansions. Planned expansions would raise the number of rental houseboats from 327 ± 5 to approximately 362 ± 5 craft within two years. Subsequently, the total number of houseboats (commercial and private) on the Shuswap would increase to approximately 410 craft.

Nine companies operated two, three or four models of houseboat. One company offered one model of houseboat and one model of powered decks for recreational vehicles (RV decks). For the most part, the models operated by each company were less than five years of age.

Table 13 summarizes the responses of the ten houseboat company operators to the questionnaire Q2, under the three categories of waste water, lake water quality, houseboating and lake usage. The operators' responses were often polarized and definite - thirteen questions were answered with either "yes" or "no" answers by the entire group.

With respect to the question on lake ownership, none of the respondents thought that ownership of the lake could be private. All ten persons believed that the government was the holder on behalf of the people. Similar to Q1, there was uncertainty over which tier (provincial or federal) of government was responsible. The majority answered (correctly) in favour of the provincial government, on this single question that had a definite answer.

Two possible misconceptions were noted from the interviews. First, six of the respondents mentioned "soap" or detergent products which were "biodegradable", but made no mention of P content of the builder and felt that the product was therefore environmentally safe. Second, three of the ten persons commented that they believed that the lake had a "flushing rate" of four to seven (volume changes) per year.

These comments and others are shown in Table 14. The information is considered to be as important to the study as that from Table 13, in that these comments though solicited were spontaneous and undirected. The table was compiled from all comments in the same fashion as Table 12 for Q1. In the same fashion as the Q1 survey, only one comment per subject per respondent was counted. Note that the top entry in Table 14 (as with the top entry in Table 12) is a sum of like comments presented together and exceeds the number of respondents.

All ten houseboat rental company operators agreed to allow plumbing inspections of their rental boats. These inspections were never undertaken. None of the operators showed any hesitation or concern over the potential inspections, which was more the point of the question than actually crawling through 25 to 30 models of houseboats looking for diverter valves (see Appendix G). All believed that their industry was important to the local economy. Respondents seemed to be well informed about recreational issues and genuinely concerned about lake water quality. Two operators reported that their boats retained grey water. Two others reported that they were prepared to retain grey water on board their boats. The other six operators reported having at least considered grey water retention. Seven of the ten persons interviewed thought grey water was not a lake contaminant (question #10), yet several minutes later when asked if grey water could degrade water quality (question #23), six answered "yes" and one was not sure.

In summary, the operators appeared to be sympathetic to the condition of the lake water, and to be aware of issues which affected the Shuswap. Most were conducive to possible changes in grey water handling practices. There

Number, question	Response (% of 10) Yes	No	Don't Know/ No Response
Regarding grey water, black water:			
8. Instruct customers about waste disposal?	90	10	0
9. (b) Know provincial policy on grey water?	70	10	20
(c) Know federal policy on grey water?	90	0	10
10. Grey water a lake contaminant?	30	70	0
11. Grey water a contaminant at popular moorings?	30	60	10
12. Discharge grey water to lake?	80	20	0
16. Could a customer readily discharge black water?	0	100	0
17. Agreeable to inspection of (fleet) plumbing systems?	100	0	0
23. (a) Grey water potential to degrade water quality?	60	30	10
24. Sani-station for Seymour Arm			
a) black water?	70	30	0
b) grey water and black water?	40	50	10
Regarding lake water quality:			
18. Noticed decrease in water quality at:			
a) Seymour Arm?	0	40	60
b) lake generally?	20	80	0
c) specific areas?	60	40	0
19. Continued water quality important?	100	0	0
22. (b) Know of any adverse lake discharges?	80	20	0
Regarding houseboating and lake usage:			
21. Houseboats important economically?	90	0	10
25. Any concerns about boats not related to water quality?	70	30	0
26. (a) Lake uses compatible?	90	10	0
(b) Restrict any lake uses?	40	60	0
(c) Stop any lake uses?	10	80	10

Table 13: Summary of Q2 Results - Question Responses

Comment	Number of Comments
Shuswap River/Sicamous Narrows has problems - agriculture (5), weeds (4), sewage odours (2)	11
Control private shorezone development, sewage systems	7
Biodegradable "soaps"/detergents safe, usage encouraged	6
More enforcement required (RCMP, B.C. MOE)	6
Cruisers (from coast) discharge black water	5
Stop clear-cutting, logging to shoreline	4
Salmon Arm has problems - sewage, development	4
Lake has high (volume) flushing rate, dilution	4
Restrict "boat" numbers	3

Table 14: Summary of Q2 Results - Comments Received

was a very different emphasis on their concerns compared to the Q1 respondents. General impressions from the interviews were those of openness, interest, and perceived hostility from the lake using public.

Q2 respondents felt strongly about the following issues: the importance of maintaining lake water quality, the compatibility of present lake uses, the need for increased regulative authority on the lake, and that the ownership of the water body is in the public domain. The operators felt that since there was no law against releasing grey water, opposition from the public was unwarranted. Nearly half the respondents thought that the lake flushed itself frequently and that biodegradable cleaning agents were benign in the environment. The operators felt that other sources of contamination of the lake should be addressed and cleaned up. These sources included: agricultural practices along the Shuswap River, the District of Salmon Arm sewage treatment plant outfall and urban development, private waste water systems at cottages around the Shuswap, sewage systems along the Sicamous Channel, and waste water discharges from private cruisers from the coast.

4.3.3 Comparison of Results of the Two Surveys

The issue of grey water release to the lake water figured prominently in the questionnaires because it was identified by lake residents as a key issue when the study was initiated and when the questionnaires were designed. Subsequently, grey water concerns figured prominently in the results of both questionnaires.

Grey water is not as dilute and innocuous as one would imagine wash water to be, but is quite similar to black water in terms of bacterial densities and concentrations of solids, oxygen demand parameters and total Kjeldahl nitrogen. The reader is referred to Appendix H which shows that wash water and toilet water contain equal or near-equal quantities of total coliform and fecal coliform indicator bacteria. The concentrations of total phosphorus in black water and in grey water do not compare as closely as the other four parameters. Gauging waste water TP concentration is explained for each study and comparisons may be made between studies in which different P concentrations of waste water were assessed. As the marketplace moves toward zero phosphate content in detergent products, differences in P concentration in black water and grey water will increase. Concentrations of bacteria, SS, BOD and TN will remain the same.

Seven of ten Q2 respondents felt that grey water was not a lake contaminant and supported their arguments by stating that the provincial government allowed grey water release. They were following provincial policy and regulations. They felt maligned that public opinion against grey water release was directed at them. The operators felt that the onus regarding grey water was on the province, not on them. When the question was rephrased however, 60% felt that grey water could degrade water quality. On the other hand, Q1 respondents felt quite strongly (85%) that grey water was a contaminant to the lake and could degrade water quality.

Q1 respondents felt that the policy and laws were simply wrong. They seemed to express their dissatisfaction by isolating pleasure boats with overnight accommodations as culprits, despite knowing that the provincial environment ministry allowed grey water release (Appendix I). Provincial policy was much more abstract to Q1 respondents than to houseboat company owners and operators. The majority of Q1 respondents did not seem to care that pleasure boats with overnight accommodation in Shuswap Lake released grey water legally. They simply disliked the release of grey water.

In essence and for whatever reasons, Q1 respondents were of the majority opinion that grey water was an environmental detriment while the majority of Q2 respondents were split on the issue, dependent upon wording.

When the houseboat operators' comments and the public lake users' comments are compared, they are dissimilar on some issues and in close agreement on others. A major discrepancy is noted on the topic of boat numbers. Only three of the ten Q2 respondents mentioned "boat" numbers on the lake, and none of them mentioned houseboats specifically. It is the most popular comment by Q1 respondents, and houseboats were mentioned exclusively.

Specific comments on houseboat operation and moorage are rated as the third and seventh most popular comments. Other comments from Q1 might allude to the houseboating industry indirectly, such as restricting shorezone industry, current development level acceptability and respect for rights and property of lake users.

Another difference was related to the location of agricultural runoff problems in the agriculturally-developed southern portion of the lake. Respondents to Q2 (nine of whom were headquartered on or downstream of Mara Lake) specified that the problem was localized around the Shuswap River, upstream of Mara Lake. As explained in Section 4.1.2, little data exist for the Shuswap River, so comparisons between the Shuswap River and other agriculture area watercourses such as the Salmon River or the Eagle River, must be based on minimal information. In Q1, the majority of the 50 persons who mentioned runoff from southern farmlands were not so specific, mentioning the Shuswap, Salmon and Eagle Rivers, White Creek and Canoe Creek. Another discrepancy was that half of the ten houseboat company operators felt that private cruisers discharging black water was a major concern, whereas less than 25 of the 179 (14%) Q1 respondents mentioned cruisers.

A very similar level of concern (40% of Q2 respondents versus 35% of Q1 respondents) was expressed over stopping clear cut logging practices in the Shuswap Lake watershed. This is very interesting because no question on either questionnaire mentioned the practice of clear cutting, or used terms such as "logging", "forestry", or "timber".

4.3.4 Summary

The majority of Q1 and Q2 respondents felt that maintaining water quality in Shuswap Lake is important or very important (100%, both Q1 and Q2), that multiple uses of the lake are compatible, that the houseboat industry is economically important to the region. Respondents to Q1 and Q2 agreed that commercial houseboats did not dump black water into Shuswap Lake and that this occurrence (on a commercial level) was a thing of the past.

Approximately half of Q1 and Q2 respondents felt that more enforcement from the RCMP and B.C. Environment was needed in the Shuswap, that the multiplicity and degree of multiple usage of the lake resource at present was compatible. Of Q1 respondents, 67% would not recommend stopping any uses, compared to 80% of Q2 respondents. Generally, both survey groups agreed that the resource should be shared and that different interests had equal usage rights.

The following differences on issues were noted between Q1 and Q2 respondents. 85% of Q1 respondents believed that grey water was a potential contaminant to the lake, while 70% of Q2 respondents did not believe it was a contaminant but 60% believed it could degrade water quality. Q1 respondents (88%) felt that a sanitary waste water disposal facility for grey water and black water should be located in the upper reach of the Seymour Arm, compared to 40% of Q2 respondents. In Q1, 35% of respondents felt that water quality throughout the lake had decreased within their experience, while only 20% of Q2 respondents felt this way. On the same question, 80% of Q2 respondents felt that water quality had not decreased, compared to 47% of Q1 respondents who felt that water quality had not decreased and 18% who were unsure or had no response.

5.0 SUMMARY AND PROGNOSIS

Water Quality, Measured and Perceived

As reflected in deep water sampling station #9, the chemical water quality of upper Seymour Arm is sufficient to exceed federal recreational water standards (CCREM, 1987), and drinking water standards for Ontario (Ontario Ministry of the Environment, 1984). Water quality does not appear to have changed significantly since sampling began in the early 1970's. Chemical concentrations and chlorophyll "a" levels are near to the minimum detection limits and classify the lake water as oligotrophic to ultra-oligotrophic (Ross 1984, Holmes 1987).

Literature on the lake as a whole indicates that potential sources of contaminants including dissolved phosphorus originate from agricultural runoff to the Salmon and Eagle (and possibly Shuswap) Rivers, from the effluent of the District of Salmon Arm sewage treatment plant, from geologic conditions in the Salmon River basin, and from development in the shorezone.

The upgrading of the District's sewage treatment plant to tertiary treatment has significantly decreased the nutrient content of the effluent released to Tappen Bay. Respondents to both questionnaires Q1 and Q2 were unaware of the improvements to the plant which occured in mid-1988.

Agricultural runoff from shorezone farms in the Salmon River and Shuswap River basins has not been abated (Holmes, 1990), but is recognized as a problem which requires the implementation of a comprehensive abatement program (B.C. Ministry of Environment, 1988). The perception of lake users concerning agricultural contamination of inlet streams is quite accurate - there is a problem and a problem is perceived.

In terms of the perceptions of the lake users, both public and business, potential problems from anthropogenic sources of contaminants exist at shorezone commercial and agricultural enterprises. Possible sources of contaminants to the lake at Seymour Arm include the shorezone enterprises in the settlement, but proof of such sources was not established.

Several misunderstandings were noted through questionnaire results and interaction with lake users during the course of the study. These include the lake's volume replacement time, the length of the lake's shoreline, the number of houseboats headquartered in the watershed, biodegradable detergents, and possibly grey water.

The lake's average volume replacement time, based on the 69-year average discharge, is approximately two years. It ranges from the most recent estimate of 1.7 years to the number quoted most often in the literature, 2.1 years. This means that a volume of water equivalent to the volume of the lake passes through the outlet every two years or so. This is a rate of 0.5 volumes/year, not four to seven volume changes (or flushes) per year, as frequently mentioned by residents and visitors alike.

The lake's shoreline is approximately 312 km in length, less than one third of the length quoted by some residents and visitors (1000 km), and less than one fifth of the length mentioned by others (1000 miles).

Estimates of boat numbers, as seen in Table G-1, were derived from marina owners, the boating public, and commercial boat operators. The number of commercial houseboats is the most accurate number in the table. There were 327 ± 5 houseboats for rent as of October, 1988 and their numbers have not increased by more than five percent since then (Prystai, 1990), despite the estimated 14% expansion indicated in Q2 interviews. The most frequent estimates quoted by lake users were 500, 700 and 800 commercial houseboats.

The biodegradability of detergents does not refer to phosphorus content, but to the fact that the surfactant does not persist as foam, as it did in the 1960's. The term refers to aesthetics as much as environmental protection. The misconception noted in Q2 and Q1, comments that "biodegradable" means zero phosphate content, will become less apparent and less frequent as more P-free detergents enter the marketplace.

As detailed in Section 4.3, grey water was perceived as a potential detriment to water quality by a majority of the lake using public. It was viewed as potentially detrimental, but not as a contaminant, by half of the houseboat operators. The limited literature on grey water, indicated that grey water was not benign (Olsson et al 1968, Laak 1971, Winneberger 1974, Pancuska et al 1975, Antonic and Pancuska 1976, Smith et al 1977, Brandes 1977, MacLaren Engineers 1987, Beak Consultants Ltd. 1988), but is poorly understood. Much of the scientific data are Canadian in origin and have been available for a decade. Some of the studies cited in Appendix H question whether grey water is harmless. The Province of Ontario commissioned two studies on pleasure boat waste water discharges to better understand grey water characteristics and implications. The Province of British Columbia helped support this study of water quality and recreational lake usage, knowing that the grey water issue was intrinsically involved.

The release of grey water to protected, slow-flushing embayments such as Bughouse Bay, has been questioned from a human health perspective, as illustrated in Appendix H. Concentrations of conventional water quality parameters such as BOD, suspended solids and coliform indicator bacteria have been shown through research cited to be comparable between black water and grey water. Nutrient (N and P) concentrations which tend to be low in grey water, and do not contribute significant loadings to Shuswap Lake as seen in Table 3. (Far more phosphorus enters the lake from apatite leaching, the District of Salmon Arm sewage treatment plant and agricultural runoff to rivers at freshet (Table 3)). Nutrient loading and subsequent potential eutrophication from grey water release, is not an issue.

However, argument against the release of grey water is also based on the aesthetic values of the majority of Shuswap Lake (public) users, as demonstrated in the questionnaire Q1 results (Tables 11 and 12). As illustrated in section 4.2.3, most recreational water quality parameter guidelines are not readily quantified but tend to be subjective in nature - based on aesthetics such as clarity, odour, surface films, floating debris or objectionable aquatic life. Subsequently, the preference of the recreational water users for desirable water characteristics (CCREM 1987, p.2-7), and users' perceptions of water quality, are relevant.

Grey water release into Shuswap littoral waters, though low in volume, is a readily-controllable, highly visible waste practice which occurs where the highest recreational usage occurs. It originates from activities based in recreation and leisure, not from activities which may be considered essential such as municipal services or food production, and not from geologic weathering processes beyond human control.

Recreational Impacts and Current Legislation

Research indicated that the effects and impacts of water-based recreation on water quality are inconclusive (Ponce and Gary 1979, Gosz 1982, Gunn 1987, Williams 1987). Within the scope of this study, no impacts upon water quality were discerned through chemical analyses of water samples. Possible impacts were noted from measurements of lake water DO and conductivity at several locations along the Seymour Arm waterfront. None of the literature dealt with recreational impacts on water quality. Municipal sewage and agricultural impacts and the negative effects of shorezone development were addressed (Ross 1984, Holmes 1987).

The lake using public and business sector perceive impacts from recreation ranging from garbage on crowded beaches and excessive noise from boaters, to less tangible impacts such as declining quality of the boating or cottaging experience as a result of boating density and shorezone development, both of which reflect increasing tourism in the Shuswap. As has been previously documented specifically (B.C. Ministry of Lands, Parks and Housing, 1987) and generally (Gunn 1987, Williams 1987), it is the natural affinity of a region which often draws people to the extent that their increasing presence eventually undermines the region's initial attraction.

Currently, there is no federal legislation or regulation explicitly banning the discharge of grey water to recreational waters (Appendix I). The Canada Shipping Act excludes black water and grey water releases from watercraft, but proposed sewage discharge regulations under the Act are being reviewed by the Privy Council (Holmes, 1990). It is believed that the proposed Pleasure Craft Sewage Pollution Regulations will address black water retention only (Birnbaum 1990, Holmes 1990).

It must be assumed that grey water is not considered to be a water quality contaminant since it is excluded from federal and provincial definitions of contaminants. Several pieces of provincial legislation (Appendix I) come close to requiring on-board grey water retention but stop short, including the British Columbia Litter Act and the British Columbia Waste Management Act, the (federal) Canada Water Act and Ontario Regulation 305. In the United States, two states require grey water retention and a third state is considering such action.

The political will to change current B.C. environmental legislation to include grey water handling, is apparently lacking. This may be a result of lacking scientific information. Results from the survey of public lake users, however, show that the sampling of the electorate strongly supported water quality maintenance. Results from the survey of operators of commercial pleasure boats on the Shuswap showed that maintaining water quality was important and that the local industry was concerned about its image and perception by the public.

Future Needs

A review of available water quality data indicated that there are definite and significant sources of eutrophying nutrients entering the lake system, including agricultural inputs from farms to watercourses, municipal sewage treatment plant effluent, effluents and losses from municipal, private and commercial development in the shorezone, and natural geologic inputs.

A review of shorezone activities and practices at Seymour Arm indicated that potential contaminant pathways to the lake existed. Potential could increase with user demand, unless addressed with appropriate abatement measures.

A review of collected opinions on Shuswap Lake water quality and recreational usage indicated that a majority of lake users reported opposing water quality degradation, unlimited boat densities, and uncontrolled waste water practices and development in the shorezone.

Lake morphometry limits development opportunity and recreational activity along much of the steep-sloping shorezone. Alluvial fans at rivermouths are sensitive (protected) areas for wildlife with poor construction and effluent attenuation characteristics (B.C. Ministry of Environment, 1988). They appear attractive, but are not available for development. Consequently, hard commercial developments and soft recreational developments compete (Gunn, 1987) for suitable development land along the Shuswap Lake shorezone (B.C. Ministry of Environment, 1988).

The federal water policy inquiry stated that because of increasing human influence upon water resources, former experience may be a poor guide to future needs (Pearse et al, 1985). The federal government has also made a commitment to become proactive instead of simply reactive about water issues, and to cooperate with provincial governments in water resources management (Pearse et al, 1985). Results of this study indicate that Shuswap Lake users would welcome such policies.

In the near future natural environments will become increasingly desirable tourist experiences, and therefore marketable tourism opportunities (Mill and Morrison, 1985). Undeveloped locations are becoming increasingly popular even now as tourism trends towards wilderness parks and away from theme parks (Mill and Morrison 1985, McIntosh and Goeldner 1986, Gunn 1987). A strategy of minimal development may be accommodated into land use planning quite readily, and does not require major start-up capital.

This study determined through interviews and interactions with local and tourist users of Shuswap Lake, and through personal communications, that there is considerable common ground held by various interest groups. The most obvious expression of this is the lake itself. Each phase of this study was focussed on the lake. This study confirmed the findings of previous studies by Parkes (1973), O'Riordan and O'Riordan (1972), and B.C. Ministry of Lands, Parks and Housing (1987), that water quality is very important to people. O'Riordan and O'Riordan (1972) showed that Shuswap residents were willing to pay extra (beyond taxes) for lake water of good quality. The importance of water quality and future lake development to lake users in this study was illustrated by the interview refusal rate. Only three out of the nearly 200 persons who qualified as respondents were unwilling to participate.

Shuswap Lake permanent and seasonal residents (including business people) often indicated in conversation that a healthy lake was good for everyone. Gunn (1987) expressed a similar relationship by stating: "Resource assets are so intimately intertwined with tourism that anything erosive to them is detrimental to tourism...all that citizens aspire to for themselves - their quality of environment and quality of life - are the very foundations for a quality tourism" (p.245).

Shuswap Lake is a commonly owned water resource that faces increasing usage pressures - recreational including tourism, municipal and industrial including forestry and agriculture. Residents and visitors who use the lake regularly have expressed a strong desire to protect the present high quality of lake water and to be part of the process of deciding the lake's future.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

1. A review of the literature indicates that Shuswap Lake has 301 km of shoreline and an area of 310 km^2. The lake has a volume replacement time of approximately two years, based on the volume of approximately 1.9×10^{10} m^3 and the 69-year average discharge at the outlet. This represents a change in water equivalent to this volume of approximately 0.5 times annually.

2. The steeply sloping and often rocky shorezone precludes much of the lake perimeter from private development because of potentially high engineering costs. Conversely, the natural morphometry creates user conflicts and development pressure at the relatively few shallow embayments and beaches - resulting in a potential concentration of contaminants at the locations which are most popular with lake users.

3. Boat harbour areas are usually shallow, sheltered, slow flushing waters which are more susceptible to the impacts from conventional water quality contaminants than flowing waters.

4. The only pleasure boat sewage pumpout station in operation during summer 1988 - other than houseboat rental company headquarters - was at the Cinnemousun Narrows. The three other stations on the lake which were advertised as being operative, were not.

5. As of October, 1988 there were 327 ± 5 commercial houseboats, an estimated 45 ± 15 private houseboats, an estimated 90 resident cruisers and yachts, and an estimated 1250 ± 250 resident runabouts in the Shuswap. Pleasure boats with overnight accommodation totalled 525 at peak season. The estimated total number of powered boats was 1800 ± 300.

6. Potential land-based sources of lake water contamination identified at Seymour Arm were shorezone commercial operations, including: the sewage disposal system for the bar, the hotel marine gasoline distribution system, the floating store and its fuel storage and distribution system, and the cattle farm yard and grazing area along the north shore of Bughouse Bay.

7. Land-based potential sources of lake water contamination were identified around Shuswap Lake. These included: agricultural (livestock and orchard) runoff to the basins of the Salmon and Eagle Rivers (and probably the Shuswap River as well); the District of Salmon Arm sewage treatment plant effluent which has been improved but still discharges nutrients to Tappen Bay, and petroleum spillage at commercial outlets. These sources have been identified previously but have not been abated.

8. Water-based potential sources of contamination to all locations around the lake included petroleum spillage from all types of motorized boats, waste water discharges from pleasure boats with overnight accommodation, litter from lake users.

9. The literature on grey water is limited to about one dozen documents. All studies noted the variability of chemical concentrations of grey water and black water, and the parallel in concentrations of BOD, COD and suspended solids. Bacteriologically, grey water exceeded raw municipal sewage in bacteria densities, and was usually in the same order of magnitude as black water. Fresh grey water tended to contain more bacteria than holding tank stored grey water. Stored grey water tended to contain more bacteria than stored black water. Confounding factors in methodology make exact comparisons of study results difficult. Four studies indicated that grey water was a possible human health hazard because of fecal coliform bacteria.

10. The limited sampling program undertaken indicated that the Seymour River chemical (mainly nutrient parameters) water quality does not appear to have changed appreciably since the early 1970's. The limited sampling program undertaken indicated that the chemical (mainly nutrient parameters) water quality of the Seymour Arm of Shuswap Lake does not appear to have depreciated measurably since the late 1970's. However, total phosphorus, while still very low, has apparently increased by more than 50%. The lake water is oligotrophic, as supported by water quality measurements for electrical conductivity, dissolved oxygen concentration and water clarity.

11. Water quality in the study area did not change significantly from spring through autumn, 1988, based upon analytical results of 50 water samples taken at 10 sample locations. This indicates that natural influences on the lake, land-based sources of nutrients, and water-based sources of nutrients and chemical parameters measured were not severe during the study period.

12. Opinions and attitudes of a sample of recreational lake users centred at Seymour Arm in mid-1988 were surveyed. Water quality was very important or important to all 179 lake users surveyed. Other definitive survey results show that 89% believed that the houseboating industry was financially beneficial to the Shuswap, 88% wanted a pumpout station at Seymour Arm and 85% of lake users considered grey water to be detrimental to water quality. About 40% believed that (a) water quality had not changed in their experience, (b) more RCMP and Environment/Parks presence was required to enforce existing regulations, (c) their concerns about Seymour Arm and the Shuswap had been addressed in the survey, (d) it was not necessary to restrict some uses of the lake. The most frequent comments by respondents involved these topics: the number of houseboats on the lake, clear cut logging practices, over-development of the shorezone (private, commercial, industrial), noise pollution and gasoline handling practices.

13. Opinions and attitudes of operators of rental pleasure craft on Shuswap Lake were surveyed. All ten rental boat company operators believed that water quality was very important or important. All ten considered grey water retention on board their craft, regardless of their opinions on grey water. The operators felt that the houseboat industry was unduly maligned by the public. Seventy percent did not believe that grey water was a contaminant in open water, but 60% felt that grey water could degrade water quality. Eighty percent did not believe that lake water quality had decreased in their experience. The operators felt strongly about the compatability of various lake uses, and the need for more regulation and enforcement from police and environmental agencies.

14. Minor wording changes to either the British Columbia Waste Management Act or the British Columbia Litter Act, would be necessary to accommodate any changes in waste water handling practices. Two federal laws also require minor changes to accommodate changes in waste water handling practices. These are the new (Canada Shipping Act) Pleasure Craft Sewage Pollution Prevention Regulation, and the Canada Water Act.

15. Implementation of recommendations concerning the maintenance of water quality would likely be facilitated by support from a majority of the voting public, based upon survey results. Support may also be expected from the houseboat company operators, based upon survey results. Dealings with provincial officials during the course of this study suggest potential support from appropriate agencies for stricter waste water controls. The findings of this study indicate the likelihood that no group would oppose legislative changes aimed at the protection of the lake upon which the local economy and lifestyle depend.

6.2 Recommendations

1. It is recommended that the single operational sanitary pumpout station on the Shuswap in 1988 be augmented with the installation of a new sanitary pumpout station near the head of Seymour Arm. The pumping and disposal facility should have the capacity to handle the increase in volume that any changes in waste water handling practices might create. The Seymour Arm station should be a large septic tank and tile field system (to avoid haulage problems), located downstream of the headwater. Such a location would eliminate the possibility of spillage or leachate affecting quiet high-usage waters near Silver Beach. The station should be provided by the province, charge sufficient user fees to ensure operating and maintenance costs are met, and create seasonal employment opportunities.

2. It is recommended that so-called "porta-potty" toilets, and "maverick" pumps used for offloading waste water to receiving waters from pleasure boats, be banned in Shuswap Lake. Sewage discharge to recreational waterways and maverick pumps are illegal, but porta-potties are not illegal. A ban would close the legal loophole. This recommendation could apply to recreational waters throughout the province.

3. It is recommended that all marinas on Shuswap Lake, including the two facilities at Seymour Arm, be inspected by the appropriate provincial authorities for compliance to proper gasoline handling practices, and compliance to relevant environmental protection legislation.

4. It is recommended that the B.C. Ministry of Environment modify the operation of the District of Salmon Arm sewage treatment plant until effluent standards for a tertiary treatment facility (such as phosphorus levels of 1 mg/L) are achieved. This action would help to protect the waters of Tappen Bay from further point source nutrient loadings.

5. It is recommended that monitoring of water quality in Shuswap Lake continue on a regular basis and that future monitoring include at least two Seymour Arm sampling stations used in this study.

6. It is recommended that the Province of British Columbia consider placing a ceiling on the number of commercial boats allowed on the Shuswap system. A control on the number of boats on the lake would help to maintain the quality of the boating experience, as concluded in the 1987 survey of boat owners by the B.C. Ministry of Lands, Parks and Housing. It would also help maintain the present level of economic benefit from the rental boat industry. Results from this study indicate that houseboat fleet expansion is unlikely to occur beyond modest proportions in any case.

7. A review of the limited literature on grey water indicates that it may represent a health hazard, especially in small bays and in poorly flushed locations where pleasure boats congregate. Grey water contains concentrations of solids, oxygen demanding substances and potentially pathogenic bacteria which may exceed those of other waste waters such as municipal sewage and domestic black water. Opinions from the public indicate that grey water is perceived as a contaminant and is aesthetically distasteful. It is recommended that the B.C. Ministry of Environment consider banning the release of grey water into the receiving waters of Shuswap Lake, in favour of retaining grey water on board pleasure craft for disposal at designated sanitary stations.

8. It is recommended that the provincial government consider changes to appropriate pieces of legislation such as the revised Canada Shipping Act regulations or the British Columbia Waste Management Act or the British Columbia Litter Act, to prepare legal support for the potential onboard retention of grey water. In this fashion, federal and/or provincial law can reflect the reality of increasing user pressures on water resources, and protect waterways in the future. Provincial authorities should administer the change. The costs of compliance should be borne by the appropriate boat owners.

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APPENDICES

That which is common to the greatest number
has the least care bestowed upon it.

from "Politics", c.345 B.C., Aristotle

A lake is the landscape's most beautiful and expressive feature.
It is the earth's eye; looking into which
the beholder measures the depth of his own nature.

from "Waldon", 1857, Henry David Thoreau

APPENDIX A

Tributaries of Shuswap Lake*

Sicamous Arm
- Shuswap River (including Mara Lake, Sicamous Creek and the Sicamous Narrows)
- Eagle River

Salmon Arm
- Salmon River
- Canoe Creek
- Tappen Creek
- White Creek

West Arm
- Adams River
- Scotch Creek
- Ross Creek
- Corning Creek
- Onyx Creek

Seymour Arm
- Seymour River
- Two Mile Creek
- Five Mile Creek
- Celesta Creek
- Blueberry Creek

Anstey Arm
- Anstey River
- Hunakwa Creek
- Four Mile Creek
- Queest Creek
- Pete Creek

*Excludes intermittent watercourses

APPENDIX B

Detailed Locations of Lake Water Sampling Stations, Stream Measurement Stations

Water sampling and measurement stations are illustrated on Figure 6. Stations 1, 3, 4, 8 and 9 were fixed locations. Stations 2, 5, 6, 7 and 10 could and did vary slightly on a north-south axis as water level changes affected the shoreline. Below are the location details of lake water sampling Stations 1 to 10, and input stream measuring Stations A to E. Reproducibility of stations is defined herein, and outlined in Section 3.0.

(a) <u>Lake Stations 1 to 10</u>

Station 1: Located in 15 m of water at the head of Bughouse Bay (east end), 200 m from each of the northern and eastern shorelines; in line with bay mouth centre (Station 4), and Creek B outlet.

Station 2: On north shore of Bughouse Bay, 5 m from the end of fenceline extending into water from Alfred Daniels' cattle barn (30 m from mean shoreline, 60 m south of cattle barn).

Station 3: In the Cove, 15 m off-shore (in 9 m of water) opposite the former Fisheries cabin, midway between the navigational light and Daniels Store.

Station 4: Centre of Bughouse Bay mouth between the navigational light and the south shore (17.5 m water depth).

Station 5: 15 m from shoreline opposite centre of public road separating the Provincial Park from private property; 350 m west of Station 4.

Station 6: 15 m from shoreline at the constant southern-most point of Silver Beach; centre of buoy system defining public swim area; 150 m west of Station 5.

Station 7: 15 m from shoreline, directly opposite (and southwest of) the permanent picnic table shelter, second from the west; 150 m northwest of Station 6, 165 m southeast of Station 8.

Station 8: 5 m west of midpoint of the hotel (eastern) pier; approximately 165 m northwest of Station 7.

Station 9: In 28 m of water, in line with Station 4 at the centre of Bughouse Bay outlet and Station 1 at the head of the Bay; 700 m due south of the government dock, 700 m due east of the solitary A-frame cottage on the south shore.

Station 10: 50 m inland of centre of Seymour River mouth; in 1.5 m of water; 20 m from each bank.

(b) Inlet Stream Stations A to E

Station A (Creek A):	3 m upstream of culvert channelling the northern-most creek under East Road; (east end of Bughouse Bay) 650 m south of Seymour Arm Bay Road intersection)
Station B (Creek B):	As above, 3 m upstream of culvert on next creek to south crossing under East Road, 200 m south of Station A.
Station C (Creek C):	As above, 3 m upstream of culvert on the next creek to the south crossing under East Road, 550 m southwest of Station B.
Station D (Creek D):	40 m upstream of creek mouth on mid-south shore of Bughouse Bay; 200 m along abandoned first road to west off East Road; 1100 m southwest of Station C.
Station E (Seymour River)	At north footing of bridge over Seymour River, on Quaft Road 200 m south of its intersection with Road 1020.

Station, Type	pH	cond.	TON	TKN	TN	NH_3	$NO_2^-+NO_3^-$	DP	TP	Na^+	Cl^-
			Chemical Parameter in mg/l*								
1 - composite	7.8	65	0.08	0.08	0.16	<0.005	0.08	<0.003	0.006	1.4	<0.5
2 - surface	7.8	65	.13	.13	.20	< .005	.07	< .003	.004	1.4	< .5
3 - surface	7.8	65	.09	.09	.17	< .005	.08	< .003	.004	1.3	< .5
4 - composite	7.8	63	.11	.11	.19	< .005	.08	< .003	.006	1.3	< .5
5 - surface	7.8	64	.07	.08	.16	.006	.08	< .003	.004	1.3	< .5
6 - surface	7.8	65	.09	.11	.19	.018	.08	< .003	.004	1.3	< .5
7 - surface	7.8	64	.08	.10	.18	.019	.08	< .003	.004	1.3	< .5
8 - surface	7.8	65	.11	.12	.20	.006	.08	< .003	.004	1.3	< .5
9 - composite	7.8	63	.11	.12	.20	.007	.08	< .003	.006	1.3	< .5
10- surface	7.5	29	.11	.11	.24	< .005	.13	< .003	.011	0.6	< .5
n - all stations	7.8	60.8	.01	.11	.19	< .01	.08	< .003	.005	1.3	< .5
n - stations 1-9	7.8	64.3	.01	.10	.18	< .01	.08	< .003	.005	1.3	< .5

* except pH (logarithmic pH units) and specific conductance (uS/cm)

Appendix C(1): Chemical Results for May 9, 1988 Water Samples

Station, Type	pH	cond.	TON	TKN	TN	NH_3	$NO_2^- + NO_3^-$	DP	TP	Na^+	Cl^-
			Chemical Parameter in mg/l*								
1 - composite	7.6	68	0.08	0.09	0.17	0.011	0.08	<0.003	0.006	1.2	0.5
2 - surface	7.7	70	.09	.09	.15	< .005	.06	< .003	.005	1.2	.7
3 - surface	7.7	70	.10	.11	.17	.010	.06	< .003	.005	1.2	.5
4 - composite	7.6	69	.08	.09	.16	.008	.07	< .003	.005	1.1	.5
5 - surface	7.7	70	.09	.09	.15	< .005	.06	< .003	.005	1.2	.5
6 - surface	7.7	70	.09	.10	.16	.010	.06	< .003	.005	1.2	.5
7 - surface	7.7	70	.10	.11	.17	.007	.06	< .003	.005	1.2	.5
8 - surface	7.7	70	.09	.10	.16	.007	.06	< .003	.006	1.2	.5
9 - composite	7.6	68	.09	.10	.18	.010	.08	< .003	.007	1.1	.5
10- surface	7.5	31	.07	.08	.20	.006	.12	< .003	.009	0.5	< .5
n - all stations	7.7	65.6	.09	.10	.17	< .008	.07	< .003	.006	1.1	< .5
n - stations 1-9	7.7	69.4	.09	.10	.16	< .008	.07	< .003	.005	1.2	.5

* except pH (logarithmic pH units) and specific conductance (uS/cm)

Appendix C(2): Chemical Results for May 19, 1988 Water Samples

Station, Type	pH	cond.	TON	TKN	TN	NH_3	$NO_2^- + NO_3^-$	DP	TP	Na^+	Cl^-
			Chemical Parameter in mg/l*								
1 - composite	7.7	65	0.08	0.08	0.10	<0.005	<0.02	<0.003	0.004	1.1	0.6
2 - surface	7.8	72	.09	.09	.11	< .005	< .02	< .003	.004	1.1	.6
3 - surface	7.8	72	.09	.09	.11	< .005	< .02	< .003	.004	1.2	.6
4 - composite	7.7	64	.07	.07	.09	< .005	< .02	< .003	.004	1.1	.6
5 - surface	7.8	72	.10	.10	.10	< .005	< .02	< .003	.004	1.1	.6
6 - surface	7.8	72	.08	.08	.10	< .005	< .02	< .003	.004	1.3	.6
7 - surface	7.8	72	.10	.10	.10	< .005	< .02	< .003	.006	1.3	.6
8 - surface	7.9	72	.11	.11	.11	< .005	< .02	< .003	.007	1.2	.7
9 - composite	7.6	65	.07	.07	.10	< .005	.03	< .003	.004	1.1	.6
10- surface	7.4	33	.04	.04	.08	< .005	.04	< .003	.003	0.5	< .5
n - all stations	7.8	65.9	.08	.08	.10	< .005	< .02	< .003	.004	1.1	< .6
n - stations 1-9	7.7	69.6	.09	.09	.10	< .005	< .02	< .003	.005	1.2	.6

* except pH (logarithmic pH units) and specific conductance (uS/cm)

Appendix C(3): Chemical Results for July 26, 1988 Water Samples

Station, Type	pH	cond.	Chemical Parameter in mg/l* TON	TKN	TN	NH_3	$NO_2^-+NO_3^-$	DP	TP	Na^+	Cl^-
1 - composite	7.8	69	0.06	0.06	0.08	<0.005	<0.02	<0.003	0.003	1.1	<0.5
2 - surface	7.9	74	.07	.07	.09	< .005	< .02	< .003	.003	1.1	< .5
3 - surface	7.8	74	.07	.08	.10	< .006	< .02	< .003	.003	1.1	< .5
4 - composite	7.8	64	.09	.09	.11	< .005	< .02	< .003	.003	1.0	< .5
5 - surface	7.9	73	.11	.11	.11	< .005	< .02	< .003	.003	1.1	< .5
6 - surface	7.8	72	.11	.11	.11	< .005	< .02	< .003	.003	1.1	< .5
7 - surface	7.8	73	.09	.09	.11	< .005	< .02	< .003	.003	1.1	< .5
8 - surface	7.9	73	.06	.08	.10	< .017	< .02	< .003	.003	1.2	< .5
9 - composite	7.7	65	.08	.09	.11	< .007	< .02	< .003	.003	1.0	< .5
10- surface	7.4	30	.04	.05	.09	< .012	.04	< .003	.003	<0.5	< .5
n - all stations	7.8	66.7	.08	.08	.10	< .007	< .02	< .003	.003	<1.0	< .5
n - stations 1-9	7.8	70.8	.08	.09	.10	< .007	< .02	< .003	.003	1.1	< .5

* except pH (logarithmic pH units) and specific conductance (uS/cm)

Appendix C(4): Chemical Results for August 2, 1988 Water Samples

Station, Type	pH	cond.	TON	TKN	TN	NH_3	NO_2^-+NO_3^-	DP	TP	Na^+	Cl^-
			Chemical Parameter in mg/l*								
1 - composite	7.7	64	0.06	0.06	<0.08	<0.005	<0.02	<0.003	0.005	1.1	<0.5
2 - surface	7.8	62	.04	.04	< .06	< .005	< .02	< .003	.005	1.1	< .5
3 - surface	7.8	62	.06	.06	.08	.005	< .02	< .003	.005	1.0	< .5
4 - composite	7.7	62	.06	.06	.08	< .005	< .02	< .003	.005	1.1	< .5
5 - surface	7.7	62	.10	.10	.10	< .005	< .02	< .003	.005	1.1	< .5
6 - surface	7.8	62	.08	.08	.10	< .005	< .02	< .003	.005	1.0	< .5
7 - surface	7.8	62	.07	.07	.09	< .005	< .02	< .003	.005	1.0	< .5
8 - surface	7.8	62	.07	.07	.09	< .005	< .02	< .003	.005	1.0	< .5
9 - composite	7.7	62	.10	.10	.10	< .005	< .02	< .003	.004	1.0	< .5
10- surface	7.6	32	.05	.05	.10	< .005	.05	< .003	.004	0.5	< .5
n - all stations	7.7	59.2	.07	.07	.09	< .005	< .02	< .003	.005	1.0	< .5
n - stations 1-9	7.8	62.2	.07	.07	.09	< .005	< .02	< .003	.005	1.0	< .5

* except pH (logarithmic pH units) and specific conductance (uS/cm)

Appendix C(5): Chemical Results for October 3, 1988 Water Samples

Parameter	Method	Range (mg/L unless specified)	Precision (coefficients of variation)	Accuracy (relative error)
NH_3	Automated colourimetric analysis, Berthelot Reaction	0.005 to 0.500 (N)	@ 0.018 mg/L, 5.1% @ 0.190 mg/L, 0.7%	$\pm$1.5% (river water)
TKN	Block digestion, automated colourimetric analysis	0.01 to 10.0 (N)	@ 0.116 mg/L, 6.9% @ 0.239 mg/L, 2.9%	$\pm$2% (river water)
Cl^-	Automated colourimetric: mercuric thiocyanate	0.5 to 50.0 (Cl^-)	@ 1.56 mg/L, 3.2% @ 33.49 mg/L, 0.4%	$\pm$ 0.7% (@33.5 mg/L)
Chlorophyll "a"	Colourimetric: extraction (ug/L)	0.5 to 100 ug/L	data not available	data not available
TON	Calculation (TKN-NH_3)	0.01 to 1.60	@ 0.311 mg/L, 9.5% @ 0.372 mg/L, 9.4%	@ 0.283 mg/L $\pm$10.2%
NO_2^- + NO_3^-	Automated colourimetric analysis: cadmium reduction	0.02 to 0.200 (N)	@ 0.211 mg/L, 1.8% @ 1.426 mg/L, 0.8%	@ 1.432 mg/L $\pm$0.4%
pH	Electrometer	0.0 to 14.0 pH units	@ pH 2.1, 8.1, 12.1 S.D. = 0.1	n/d
TP, DP	Automated colourimetric: digestion plus ascorbic acid reduction	0.003 to 0.500 (P)	@ 0.140 mg/L, 1.0% @ 0.432 mg/L, 1.6%	@ 0.339 mg/L, $\pm$1.6%
Na^+	Automated flame photometric	0.1 to 50.0 (Na^+)	@ 5.74 mg/L, 0.9% @ 40.69 mg/L, 0.3%	@ 44.24 mg/L, $\pm$0.6%
Conductivity	Conductivity meter	Minimum value 1 umhos/cm	@ 66.4 umhos/cm, 1.2%	n/d

Source: Data Standards Group, B.C. Ministry of Environment 1980

Appendix C(6): Methods, Precision and Accuracy of Chemical Tests

APPENDIX D

Questionnaire #1

Residents of and Visitors to the Seymour Arm Area, Shuswap Lake

(Q1)

QUESTIONNAIRE #1 - RESIDENTS OF AND VISITORS TO THE SEYMOUR ARM AREA, SHUSWAP LAKE

1. Could you be considered a spokesperson for your group or family? Yes_______ No ______

2. Into which of the following lake-user categories do you best fit?

Residents	Visitors to Bay	Visitors Using Watercraft
Landowner _____ Renter _____	Hotel or Cabin _____________	Private__________ Owner ___________
Area ____________________________	Visiting a Resident____________	Commercial_______ Renter __________
Years Residence ________________	Length of Intended Stay___Days	Overnight Accommodations___________
Type: Seasonal _______________	Arrived by:	Type of Craft _____________________
Permanent _______________	overland___ferry___	Length of Intended Stay____________
Business: Yes______ No _______	airplane___watercraft____	No. of Persons ______________

3. What is the municipality and province (or state) of your permanent residence?

____

4. How often have you visited Shuswap Lake in the past 20 years?

Never _______ Once _______ 2-5 Times _______ 6-10 Times _______ At least once a year ______

5. How often have you visited the Seymour Arm area in the past 20 years?

Never _______ Once _______ 2-5 Times _______ 6-10 Times _______ At least once a year ______

6. Have you noticed any change(s) in the water quality (such as clarity, colour, odour, weed growth) of

(a) Bughouse Bay area:

No_______ Yes, Better _______ Yes, Worse _______ Unsure _______ No response _______

Explain change(s)____

____

(b) **Shuswap Lake generally:**

No_______ Yes, Better _______ Yes, Worse _______ Unsure _______ No response _______

Explain change(s)____

____

(c) **Other specific area(s) of the lake:**

No_______ Yes, Better _______ Yes, Worse _______ Unsure _______ No response _______

Specify area(s) ____

Explain change(s)____

7. **Are there any land-based sources of potential water quality contamination or nutrient enrichment that you are aware of and wish to point out?** No_________ Yes_________

If Yes, specify ____

____

8. **Do you have any suggestions to improve the water quality in and near Bughouse Bay?** No_______ Yes _________

____

____

____

____

9. **Is the continued quality of the lake water important to you:?**

Yes, very _____ Yes_____ Not very important______ No______ No comment______

10. **Who owns Shuswap Lake?** ____

11. **Do you believe that the watercraft rental industry is beneficial to the regional economy?** No _____ Yes _____

If "Yes", to what degree is the industry economically beneficial?

Insignificant ________ Low _______ Moderate ________ Don't know _________ High ______ Very High_________

12. How do you feel about regulative authority on the lake?

	Too Much	Sufficient	Not enough	No response
Police (Federal)	____	____	____	____
Fisheries (Federal)	____	____	____	____
Municipal	____	____	____	____
Wildlife (Prov.)	____	____	____	____
Environment/Parks (Prov.)	____	____	____	____
Other (specify)	____	____	____	____

Comments ____

____

____

13. Residents: How do you dispose of liquid wastes on your property?

Septic Tank System

Sewage only ______
Sewage and greywater ______
Unknown ____
Age ______yrs.
Last evacuated __________,19__
Last inspected __________,19__
Length of Tile Field ______m
Distance from shore ______m
Slope ____% Soil Depth ___m
Soil type(s) ________________

____

Holding Tank(s)

Sewage only ______
Sewage and greywater ______
Unknown ______
Age ______yrs. Unknown ____
Last evacuated _____, 19 ___
Construction ____________
Number of tanks __________

Grey Water

Still well ____________
Discharge overland _____
Discharge into lake ____
Slope ____%
Soil Depth ____m
Soil type(s) __________

____

Outhouse

Age ______ yrs.
Dist. from shore
_______ m
Slope _____%
Soil Depth ____m
Soil type(s) ______

____

14. Visitors: How do you dispose of liquid wastes from your watercraft?

Greywater, Sewage Share Holding Tank(s)

Pumpout stations only _____
Discharge to lake possible
No ___ Yes ___
via overflow _____ via release ______
Capacity __________ gal/l
Number of tanks _________

Greywater in Separate Tanks(s)

No greywater tank ______
Pumpout stations only _____
Discharge to lake possible
No ___ Yes ___
Discharge to lake encouraged
No ___ Yes ___
via overflow ____ via release ____
Capacity __________ gal/l
Number of tanks __________

Sewage Tank(s)

Pumpout stations only ______
Discharge to lake possible
No ______ Yes ______
Discharge to lake encouraged
No ______ Yes ______
Via overflow ______________
Via release ______________
Capacity _______ gal/l.
Number of tanks ___________

15. **Visitors: How do you dispose of domestic garbage from your watercraft?**

____

____

16. **Have you previously rented a watercraft with sleeping accommodations on Shuswap Lake?**

Yes, ______times   Yes, once _______   No ________

17. **Have you ever noticed any discharges originating directly from watercraft -**

(a) in the Bughouse Bay area? No _____ Yes _____ Watercraft type(s)_______________________________

(b) elsewhere on the lake? Location ____________________ No ______ Yes ______ Watercraft type(s)_______________

If "Yes", how common an occurrence is it?

(a) _______ Rare _______ Occasional _________ Common ________ Very common ________
(b) _______ Rare _______ Occasional _________ Common ________ Very common ________

18. **Do you know of any other area(s) on the lake that may be adversely affected -**

(a) by watercraft discharge? No _________ Yes ________, specifically ____________________________________

____

(b) by any discharge? No __________ Yes ________, specifically ____

____

19. **Have you ever seen human feces in the water of -**

(a) Bughouse Bay area Often ________ Occasionally _________ Seldom ________ Never __________
(b) Other location(s), specifically (i)_______________________(ii)___________________(iii)_______________________

(i) Often ________ Occasionally _________ Seldom ________ Never __________
(ii) Often ________ Occasionally _________ Seldom ________ Never __________
(iii) Often ________ Occasionally _________ Seldom ________ Never __________

20. **Do you suspect that releases of human sewage originate from (a) campgrounds?**
(b) watercraft?
(c) cottages?

Definitely ________ Yes ________ No ________ Definitely not ________ Don't know ________

21. **Do you believe that greywater -**

(a) has the potential to degrade water quality? Yes____ No____ Don't know ____

(b) should be considered a potential lake contaminant? Yes____ No____ Don't know ____

22. **Do you know the location(s) of approved watercraft holding tank pumpout stations -**

(a) On the lake? No_______ Yes_______ Location(s)________________________________

____

(b) On the Seymour Arm? No_______ Yes_______ Location(s)________________________________

____

23. **Do you think it appropriate to locate a proper watercraft holding tank pumpout station in the vicinity of Bughouse Bay for**

(a) Sewage Yes ______ No ______ Comments ________________________________

(b) Greywater Yes ______ No ______ Comments ________________________________

(c) Both Yes ______ No ______ Comments ________________________________

24. **Do you have any other concerns about watercraft with sleeping accommodations that are not related to water quality?**

No ____ Yes ____, specifically ________________________________

____

____

25. **These questions regard usage of the lake (and specifically the Bughouse Bay area) as a resource. Uses include boating, fishing, water sports and swimming, aircraft, water supply, agriculture, industry and shoreline development.**

(a) **Are all present uses compatible?** Lake: Yes ____ No ____ Bay: Yes____ No____

Explain if "Yes"____

____

(b) **Would you recommend restricting some use(s)?** Lake: Yes _____ No ____ Bay: Yes______ No ______

Explain ____

____

(c) **Would you recommend stopping some use(s)?** Lake: Yes____ No ____ Bay: Yes_____ No _____

Explain ____

____

26. **Do you have any concerns regarding use or development of the Bughouse Bay area that have not been addressed?**

No _____ Yes ____, specifically ____

____

____

27. **Do you have any concerns regarding use or development of Shuswap Lake that have not been addressed?**

No _____ Yes ____, specifically ____

____

____

APPENDIX E

Questionnaire #2

Owners of Rental Watercraft with Sleeping Accommodations

(Q2)

QUESTIONNAIRE #2 - OWNERS OF RENTAL WATERCRAFT WITH SLEEPING ACCOMMODATIONS

1. What kind of rental watercraft with sleeping accommodations does your firm operate?

   sailing yachts________ motor launches________ houseboats________

2. How many of these watercraft do you operate?

   1 to 10_____ 11 to 20____ 21 to 30____ 31 to 40____ 41 to 50 ____ More than 51 _____

3. How many years has your firm operated on Shuswap Lake? _____ years

4. Where is your fleet headquartered? ____

5. What is the average age, and the age range of your fleet?

   average______years old range______to______years old

6. Does your firm plan to expand its fleet size in the future?

   Yes, by____% Maybe, by____% No____ No, decrease by____% Don't know _____ No comment _____

7. How many models of watercraft does your firm operate on Shuswap Lake? ______________________

8. Do you instruct your customers about solid and liquid waste disposal?

   ____

9. Regarding policy on greywater discharge -

(a) what is your company's? ____

(b) what is the provincial government's? ____

(c) what is the federal government's? ____

10. Do you consider greywater to be a potential lake water contaminant?

    No____ Unsure____ Yes____ No Comment ____

    Please explain ____

11. Would your answer above change for popular moorings where watercraft may congregate, as opposed to single watercraft plying open water?

Yes, different situation______ Unsure______ No, same situation______

Explain ____

12. How is sewage disposed of on your rental watercraft? ________________________________

____

13. What is the capacity of the sewage holding tank(s)? __________(L or gal.) Number of tanks __________

14. How is greywater disposed of on your rental watercraft? ________________________________

____

15. What is the capacity of the holding tank(s)? _________(L or gal.) Number of tanks ___________

16. Is it possible for a renter of your average watercraft who possesses a layperson's knowledge of plumbing, to discharge into the lake water:

(a) the sewage?

definitely not ______ doubtful _____ maybe _____ definitely _____ no response ______

(b) the greywater?

definitely not ______ doubtful _____ maybe _____ definitely _____ no response ______

(c) both?

definitely not ______ doubtful _____ maybe _____ definitely _____ no response ______

17. May I inspect the plumbing systems, or at least the blueprints, of your watercraft?

Yes, both _______ Yes, blueprints only _______ No _______ No response ______

18. Have you noticed any change(s) in the water quality (such as clarity, colour, odour, weed growth) of

(a) Bughouse Bay area:

No_______ Yes, Better _______ Yes, Worse _______ Unsure _______ No response _______

Explain change(s)____

____

(b) Shuswap Lake generally:

No______ Yes, Better ______ Yes, Worse ______ Unsure ______ No response ______

Explain change(s)____

____

(c) Other specific area(s) of the lake:

No______ Yes, Better ______ Yes, Worse ______ Unsure ______ No response ______

Specify area(s) ____

Explain change(s)____

19. Is the continued quality of the lake water important to you:?

Yes, very _____ Yes_____ Not very important______ No______ No comment______

20. Who owns Shuswap Lake? ____

21. Do you believe that the watercraft rental industry is beneficial to the regional economy? No _____ Yes _____

If "Yes", to what degree is the industry economically beneficial?

Insignificant ________ Low _______ Moderate ________ Don't know _________ High ______ Very High________

22. Do you know of any other area(s) on the lake that may be adversely affected –

(a) by watercraft discharge? No _________ Yes ________, specifically ____

____

(b) by any discharge? No __________ Yes ________, specifically ____

____

23. Do you believe that greywater -

(a) has the potential to degrade water quality? Yes____ No___ Don't know ____

(b) should be considered a potential lake contaminant? Yes____ No___ Don't know ____

24. Do you think it appropriate to locate a proper watercraft holding tank pumpout station in the vicinity of Bughouse Bay for -

(a) Sewage Yes _____ No ______ Comments ______________________

(b) Greywater Yes _____ No ______ Comments ______________________

(c) Both Yes _____ No ______ Comments ______________________

25. Do you have any other concerns about watercraft with sleeping accommodations that are not related to water quality?

No ____ Yes ____, specifically ______________________

____

____

26. These questions regard usage of the lake (and specifically the Bughouse Bay area) as a resource. Uses include boating, fishing, water sports and swimming, aircraft, water supply, agriculture, industry and shoreline development.

(a) Are all present uses compatible? Lake: Yes ____ No ____ Bay: Yes_____ No_____

Explain if "Yes" ______________________

____

(b) Would you recommend restricting some use(s)? Lake: Yes _____ No ____ Bay: Yes______ No ______

Explain ______________________

____

(c) Would you recommend stopping some use(s)? Lake: Yes____ No ____ Bay: Yes_____ No _____

Explain ______________________

____

APPENDIX F

Lake Classification, Eutrophication and Volume Replacement Time

Lakes and Eutrophication

Fresh water bodies are classified under a system of qualifiable and quantifiable characteristics called trophic state (Hutchinson, 1969). Trophic state describes the nutrient content and the capacity of the water body to support phytoplankton (Hutchinson, 1969), or its biological productivity (Vallentyne, 1974). The three major trophic states of lakes are oligotrophic, mesotrophic and eutrophic.

Oligotrophic means a state of nutrient malnourishment. Oligotrophic lakes are frequently cold, clear, deep water bodies that are well-oxygenated throughout the water column, support salmonids and low algal production.

Eutrophic lakes are well-nourished and basically opposite to oligotrophic lakes, they are warmer, more shallow and less clear. Usually eutrophic lakes cannot support salmonids because of stratification of the water column which results in oxygen depletion in the hypolimnion waters in mid-winter and/or in mid-summer. Between these extremes are mesotrophic lakes which may exhibit characteristics of both but belong to neither category. Table F-1 presents characteristics of the three trophic levels of lakes.

Eutrophication means the addition of nutrients to lake water and the effects of such nourishment. The O.E.C.D. Water Management Research Group in 1970 defined it this way: "Eutrophication is the nutrient enrichment of waters, which frequently results in ...increased production of algae and other aquatic plants, deterioration of fisheries ...water quality and other responses which are objectionable or impair water use" (p.3) (Organization for Economic Cooperation and Development, 1970).

Few lakes were "born" eutrophic, but developed from mesotrophic and oligotrophic lakes (Vallentyne 1974, Rodhe 1969). The process of this evolution is based on the natural, slow process of sedimentation. The natural process of aging by nutrients takes millenia, but can be accelerated by man through the addition of nutrients to a lake.

Parameter	Oliogotrophic	Trophic State Mesotrophic	Eutrophic
Depth: Relative Mean (m) Max. (m)	 Deep >15 >25	 Medium 10-15 15-25	 Shallow <10 <15
Basin Shape	Steep	Moderate	Gentle
Water Clarity	High Transparency	Transparent	Low Transparency
Epilimnetic Biological Productivity	Low 50-250 $mgC/m^2/da$	Moderate 250-1000 $mgC/m^2/da$	High >1000$mgC/m^2/da$
Nutrient Supply	Low	Moderate	High
Relative Water Temperature	Cold-Cool	Cool	Cool-Warm
Hypolimnion Oxygen	Constant, Minimal Stratification	Decreases over Moderate Stratification	Depletes over Definite Stratification
Secchi Disc (m)	>5	3 - 5	<3
Fish Species	Lake Trout	Perch, trout	Perch, carp
(Benthic) Midge Larvae Species	Tanytarsus Lugens	Sergentia Coracina	Chironomous Plumosus
(Epilimnetic) Algae Species	Cyclotella Comta (a diatom)	Fragilaria crotonensis (a diatom)	Oscillatoria rubescens (blue-green)
Phytoplankton (cells/ml water)	<1000	1000-5000	>5000
Total N (ug/l)	<100	100-500	500-1000
Total P (ug/l)	1-10	10-30	>30
Chlorophyll "a" (ug/l)	0 - 2	2 - 7	>7

(Modified from several sources including Hutchinson 1969, Vallentyne 1974, Cole 1975, Nordin 1986)

Table F-1: Characteristics Typical of the Trophic State of Lakes

Through waste water outfalls, agricultural runoff, industrial effluents and cooling waters, leachate from landfill sites, erosion from deforestation, and airborne nitrogen compounds mainly from fertilizers (Ruttner 1963, Hare 1984, Marlund and Rotty 1985), the trophic status of lake water, with all the accompanying physical, chemical, biological changes involved, can be altered quite quickly.

Vallentyne (1974) gave examples on which the nutrient enrichment of water by man had accelerated the growth of algae and weeds in "years or decades that would require thousands of years to come about in the absence of man".

O'Riordan and O'Riordan (1972) gave a very specific and relevant example of eutrophication. They stated in Okanagan Water Decisions that "Detailed limnological studies carried out in the Okanagan lakes (excluding Shuswap Lake) in 1970 reveal a marked change in the flora and fauna since the last survey conducted in 1939...when the lakes were extremely oligotrophic" (p.23).

In the natural state, lakes evolving from eutrophic to oligotrophic state are uncommon (Vallentyne, 1974). Immediate recovery from eutrophication is less easily accomplished than eutrophication (Vallentyne 1974, Rodhe 1969, Hutchinson, 1969). Through luxury uptake (Stoker and Seagar 1976, Schindler 1974) macrophytes and microphytes absorb more nutrients than they need, as a precautionary mechanism. With cessation, this concentration of nutrients and chemicals is slowly released through decomposition, back to the littoral zone water, flora, fauna and sediments. However, Schindler (1974) showed in the Experimental Lakes in northern Ontario that very little phosphorus was released from sediments to hypolimnion waters, and that eutrophication can be reversed through nutrient input control.

With the addition of excess nutrients (especially phosphorus), excessive plant growth results (Lind 1974, Vallentyne 1974, Schindler 1974 and Hutchinson 1969). Phosphorus is usually the most important nutrient to lake ecosystems and the process of eutrophication as it is most frequently the limiting nutrient in the aquatic ecosystem (Hutchinson 1957, Schindler 1974, Lind 1974, Cole 1975).

Vollenwieder and Dillon (1974) said "Although the concept of loading is applicable to any element or compound ... nitrogen and phosphorus ... are widely accepted as the chemical factors most often determining productivity of lakes ... and phosphorus ... is the nutrient most frequently controlling eutrophication" (p.3). Nitrogen cycles from nitrate to nitrite to ammonia and back through the action of nitrogen-fixing bacteria, the availability of oxygen and the biological and chemical "demand" for nitrogen. The importance of nitrogen to an aquatic ecosystem is usually secondary to the importance of the less-common element phosphorus. The natural ratio is approximately N:P = 15:1 (Ross, 1984). Phosphorus in water appears in both soluble (DP) and particulate forms, and maybe organic or inorganic (Hutchinson 1957, Hammer 1977).

Natural P comes from leaching of apatite (as with the Shuswap) and other P-bearing rocks, and organic decomposition. Phosphorus cycles through the aquatic ecosystem constantly. It is a biologically active element dependent upon the metabolic synthesis of micro and macro-flora, or the degree of decomposition within the system (Lind, 1974). Lower P concentrations occur at times of higher synthetic activity and vice-versa, a result of luxury uptake. Anthropogenic sources of P are mainly agricultural runoff and municipal sewage treatment plant effluent.

Previous to 1973 when the Canada Water Act limited the amount of phosphates in laundry detergents to 5% by weight, high phosphate content in municipal waste waters was the major phosphate source. It is estimated that 70% of the P content in municipal sewage came from household detergent use (Stoker and Seager 1976, Hammer 1977). A detergent may be defined as a cleaning agent that includes a petrochemical or synthetic surfactant (Stoker and Seager, 1977). Detergents are clothes laundry powders and liquids, and automatic dishwashing powders and liquids. They exclude lye-based bath soaps, oil-based liquids for manually washing dishes and volatile solvents. Detergents consist of compounds that can be categorized as additives, surfactants and builders.

A surfactant is a wetting agent which reduces the surface tension of water and permits water to penetrate fabric. Original surfactants were not as bacteriologically "biodegradable" as initially assumed by manufacturers in the 1950's, but persisted as foam in receiving streams. Chemical structure was altered by manufacturers so that branched carbon chains were replaced with straight chains. Biodegradability is only a biochemical property of the surfactant, not a chemical property of the builder. Alkyl and straight alkyl sulphates are now the most popular surfactants.

The builder portion of most laundry detergents consisted of polyphosphates. The role of the builder was to tie up (sequester) the hard ions Ca^{++} and Mg^{++} and to raise the alkalinity of the washwater.

The phosphate content of the builder was reduced from approximately 90% in 1965 to <5% after 1973. In 1969 and 1970, NTA (nitrilotriacetic acid) was used as the builder, but was withdrawn from the market because it might react with heavy metals to increase possible problems with toxicity (Hammer 1977, Stoker and Seager 1976). In 1990 three manufacturers introduced products with no dye or perfume additives and zero phosphate content.

The builder in detergents is now a sodium complexed NTA which does not react with heavy metals. With the changes to detergent formulation, and increasing emphasis on tertiary sewage treatment (nutrient reduction), domestic and municipal effluents released to receiving waters have improved over the past, and create less potential for eutrophication.

Volume Replacement Time

For the purpose of clarity, the common term "flushing rate" will not be used here. The concept of lake water change will be referred to as "volume replacement rate". Volume replacement rate may be defined as the rate at which a water body changes an amount of water equivalent to its volume. It will be expressed as volume replacement time, or the amount of time in years for the replacement of one lake volume equivalent of water.

Sources of inflow water to a lake are surface water influents, precipitation on the lake surface, groundwater effluent to the lake floor and discrete groundwater effluents such as springs. Sources of water losses from a lake are surface water effluent (the outlet), evaporation and seepage out through the lake floor (Hutchinson, 1957).

Volume replacement time can be calculated by dividing the lake volume by the total inlet stream flow, when this quantity is known (Berner and Berner, 1987). A long replacement time is common to poorly drained lakes, not to lakes with substantial surface water inputs. Generally, poorly drained lakes tend to be small, shallow lakes and well drained lakes tend to be large and deep. Times range from one to one hundred years for most lakes. Long replacement time indicates a water body that exchanges water sluggishly, and subsequently responds poorly to mitigative efforts to reduce water pollution (Berner and Berner, 1987).

All four sources of incoming water, and the water losses due to evaporation and groundwater seepage out through the lake floor are reflected in the outlet discharge. When inlet stream flow is not known (but average outlet discharge is known), average volume replacement time can be determined simply by dividing the lake volume by the average annual outlet discharge.

A complex means of calculating volume replacement time involves the following quantifications: measuring and calculating surface influents and groundwater effluents, calculating the contribution of direct rainfall to the lake surface using meteorological records, measuring the outlet discharge and calculating the rate of evaporation. The calculation for losses due to evaporation is a function of atmospheric temperature and pressure, sunlight hours, wind speed, duration and direction, relative humidity and transpiration from vegetation (Hutchinson, 1957). In theory, this level of detail may yield a more accurate figure for an instantaneous volume replacement time, but not necessarily a more meaningful figure. That is to say, a lake's volume replacement rate during freshet may be substantially greater than during periods of thermal stratification.

The averaged annual discharge through the outlet yields a generalized volume replacement time. Calculations which account for short term meteorological events are more relevent for shallow lake basins such as those of prairie lakes, than for deep lake basins such as Shuswap Lake.

The volume replacement time of a lake may be compared to a full bathtub, with a tap adding water at one end and a spout releasing water at the other end. Shuswap Lake has a complex shoreline shape consisting of five arms, as illustrated and described in Section 2.1.3. Each arm has inlet streams (Appendix A) and the lake has only one outlet. Despite the complex shape of the lake, the single outlet follows the bathtub analogy and allows for the calculation of volume divided by outlet discharge. A lake with more than one outlet is a rare and usually temporary phenomenon (Hutchinson, 1957).

Vallentyne (1974) contended that flow through of a single volume does not cleanse a vessel and in terms of a lake basin the same principle applies: a single slug of nutrients entering the lake would take repetitive lake volume changes to be eliminated. Typically, however nutrients enter drainage basins continuously (Vallentyne, 1974). Shuswap Lake data indicates that approximately two-thirds of the phosphorus from the Salmon and Eagle Rivers enters the lake during the one month freshet period (B.C. Ministry of Environment, 1988).

The volume of Shuswap Lake was first determined to be 1.91 X 10^{10} m^3 from data based on soundings undertaken in 1949 by the International Salmon Fisheries Commission. This same volume is recorded in the Fish and Wildlife Branch Lake Inventory Data Retrieval (Grace, 1990). Ross (1984) reported this volume in her Report 84-20 on Shuswap Lake. From 1915 to 1984, flow rates at the Inland Waters Directorate stream gauge number 08LE031 on the South Thompson River at Chase, B.C., ranged from a minimun of 179 m^3/s in 1929 to a maximum of 415 m^3/s in 1976 (Water Survey of Canada, 1985). Over the 69-year period, flow through the outlet averaged 288 m^3/s. Based on these data, the simple volume replacement calculation (lake volume divided by mean annual discharge at the outlet) yielded a volume replacement time of 2.1 years. Holmes (1987) calculated the volumes of each of the five arms of the lake to total 1.57 X 10^{10} m^3, yielding a volume replacement time for Shuswap Lake as a whole of 1.7 years.

The discrepancy between the two values (about 21.5%) is readily accounted for when the methodology of determining lake volume is considered. Transects of depth measurements (maximum 162 m) are transcribed onto maps of the lake surface (301 km^2) in order to produce contours of equal depth. On the completed contour map (with all its inherent errors in depth measurement, transcription and scale), each contour is traced by planimeter. The area of each depth interval of the lake is determined. This process allows for considerable error: physically tracing the contours which may require some degree of interpretation, measuring the areas of each "layer" of depth, and arriving at a total volume by summing each depth multiplied by its area. That two people arrived at answers within 22% of one another is not surprising. Holmes (1990) stated that he considered the volume replacement time of 1.7 years to be accurate to only $\pm$50% (based upon lake volume calculations, not average outflow) and that the discrepancy of a few months average annual volume replacement time for the whole lake is unimportant. Holmes (1990) stressed that the most important point about the average volume replacement time of Shuswap Lake are that it is about two years, not ten or thirty years.

The surface level of Shuswap Lake fluctuates less than $\pm$ 2m, and may be considered to be in steady state. Steady state occurs when water inputs and water outputs are balanced or very near to being balanced, and is reflected in minor lake surface elevation fluctuations (Berner and Berner, 1987). Steeply-sloping basins tend to be less sensitive to short term minor lake level fluctuations than shallow basins. This assumes that there is quick discharge from the basin to the lake and that the outlet profile is wide and shallow (Hutchinson, 1957). A 0.5 m increase in lake level would affect the surface area and drainage characteristics of Shuswap Lake (which averages 62 m in depth) much less than a shallow, flat basin lake with an average depth of 8 m.

Another factor concerning volume replacement time that bears explanation is thermal stratification of temperate zone lakes. As a result of climatic conditions and the density of water at different temperatures, lakes stratify into three distinct layers: the surface epilimnion, the intermediate metalimnion and the hypolimnion at depth. The metalimnion represents the thermocline, the zone where water temperature changes quickly with depth. During summer and winter periods of stratification, the water from influent steams often cannot penetrate the density barrier of the metalimnion (Ruttner 1953, Hutchinson 1957, Vallentyne 1974). Influent stream water pushes epilimnion water through the outlet. Therefore, the flushing effect does not apply year around to the whole water column, but mainly the upper layer (Ruttner, 1953). The replacement time for epilimnion water is shorter than that for the hypolimnion.

Between periods of stratification in dimictic (twice mixing) lakes such as the Shuswap, the thermocline is displaced downwards through mixing of the water column by currents caused by the force of the wind, and by the changing temperature of the air. The downwards displacement continues until the thermocline ceases to exist because the whole water column is of equal temperature and density, and in circulation. This is called vernal or autumnal turnover. Only during these periods of oxygenation and complete mixing, can dimictic lakes flush hypolimnion water through the lake outlet. Also, nutrients and fines in the uppermost lake sediments are suspended in the water column at these times, and subsequently available to leave through the outlet (Ruttner 1953).

To say that a lake has a volume replacement time of about two years does not mean that water from every location around a lake passes through the outlet within that time frame (Berner and Berner, 1987). The relevance of a relatively quick volume replacement time is that it helps maintain water quality by keeping incoming nutrients moving toward the outlet and therefore out of the lacustrine environment. The importance of Shuswap Lake's volume replacement time (and rate) is that it can be measured in months not in decades.

This is critical to the lake with respect to mitigation of nutrient and contaminant loadings. If for example the volume replacement time were twenty five years, the lake would be far more susceptable to eutrophication from anthropogenic sources of nutrients (agricultural runoff, shoreline development) and from natural apatite leaching. Volume replacement time affects the lake itself and affects users of the lake resource, both from the viewpoint of water quality. The volume replacement time of Shuswap Lake is discussed further in Sections 4.3.1 and 4.3.2 on lake user attitudes and perceptions, in Appendix H on grey water characteristics and in Section 5.0.

APPENDIX G

Pleasure Boats in the Shuswap

Pleasure boats with overnight accommodation are water craft that are equipped with a galley (kitchen), head (bathroom including a toilet, sink and usually a shower stall and/or a bathtub) and two or more beds for a crew of at least three persons. There are three types: motor cruisers (or cabin cruisers or cruisers), sailing yachts (as opposed to sail boats which could be day-sailors), and houseboats. Pleasure boats with overnight accommodation of the first two types were not for hire (on a commercial basis) on Shuswap Lake. Most pleasure boats with motors or sail were small and lacked sleeping accommodations, cooking facilities, and head facilities.

Pleasure boats with overnight accommodation have more potential than smaller (day) craft to emit various effluents or materials to the environment. Obviously, larger numbers of people stay aboard large fully-equipped pleasure craft for longer periods of time than aboard runabouts, day-sailors or powerless craft. Water storage and distribution is required for various uses including bathing, dish washing, toilet operation, food preparation, cleaning, drinking, teeth brushing.

Figure G-1 illustrates a generic plumbing design for houseboats, and with minor modifications, for cruisers and yachts. Differences in plumbing designs between houseboats, cruisers and sailing yachts involve mainly the number of fixtures and water storage tank sizes (potable water, hot water, black water and sometimes grey water). These differences depend upon the size and crew capacity of the vessel. A large houseboat sleeping ten persons would certainly have larger storage tank capacities and more fixtures (e.g. extra head sink, extra galley sink) than a small cruiser designed to sleep three persons.

Grey water from sinks is usually discharged by gravity through a submerged seacock in the hull of yachts and cruisers. Shower water is usually pumped overboard, as the sump is below waterline (MacLaren Engineers, 1987).

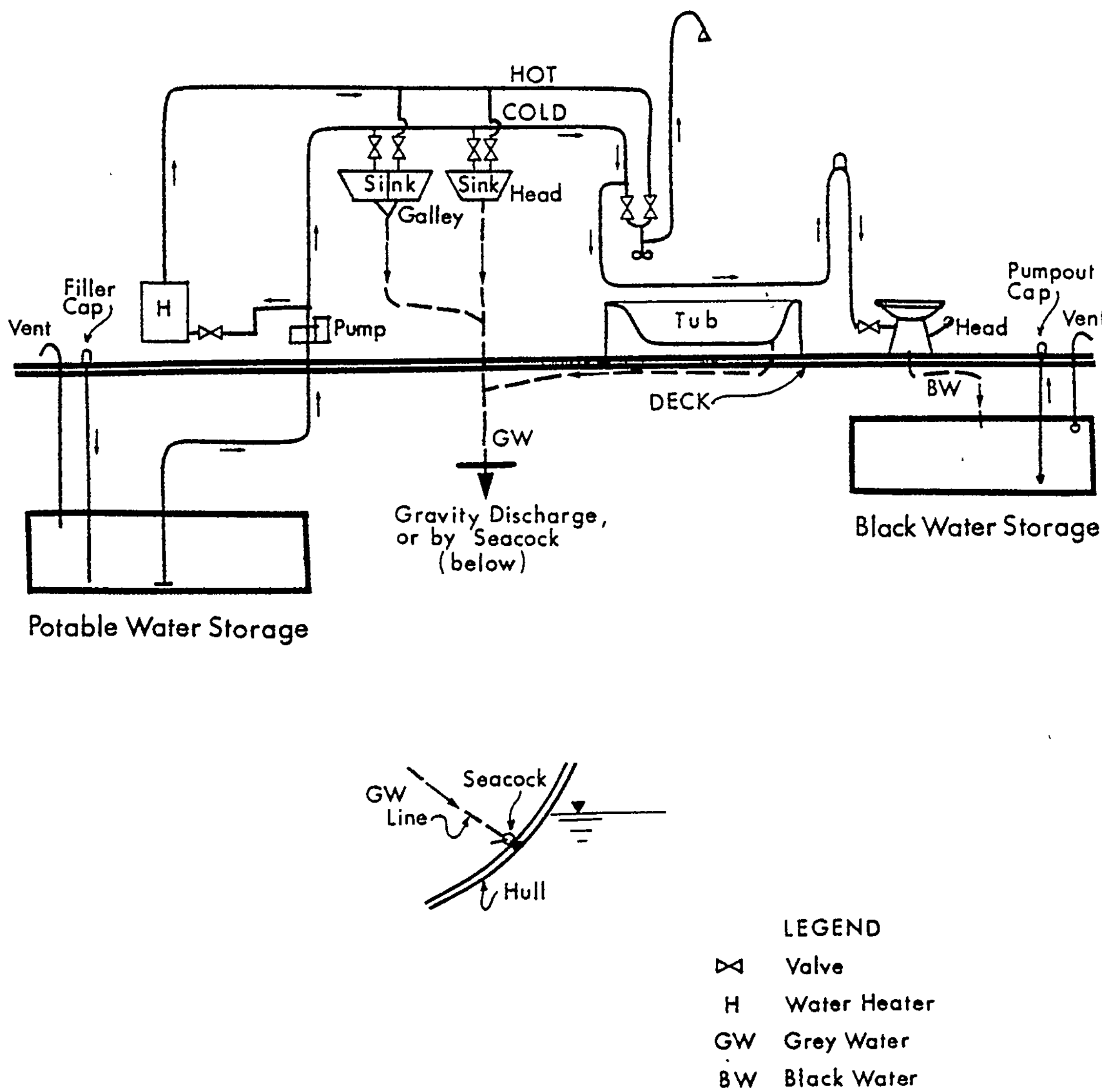

Figure G-1: Generic Plumbing Design for Medium Sized Cruiser, Yacht, Houseboat

Not to scale

source: modified from Mac Laren Engineers, 1987

In houseboats, where the whole deck is supported above the water line, a discharge pipe located between the pontoons at the stern of the vessel drains grey water to the receiving water below. In some of the commercial houseboats, grey water may be retained in a tank located in a baffled forward compartment of one pontoon or both pontoons.

Black water is stored in tanks that require vacuum evacuation through a deck fitting. Storage tank sizes vary with crew capacity from approximately 100 to 700 L. Toilet flushing water is most often the recreational lake water pumped onboard. However, it may also be from the potable water supply taken on board at launch time.

Some pleasure boats with overnight accommodation, especially older ocean-going cruisers and yachts, have a 3-way diverter valve which allows for sewage to be diverted from entering the tank and discharged directly to receiving waters via submerged seacock in the hull. This 'y' valve is illegal in fresh water Canadian jurisdictions, but not in the coastal areas (MacLaren Engineers, 1987).

Hand-operated pumps can be fitted to the deck outlet and discharge sewage overboard. Such "maverick" pumps are also illegal to use in fresh waters in Canada.

There is concern in the Shuswap about boats with "porta-potties" (portable toilets). One dozen Q1 respondents and five Q2 respondents complained that porta-potties were being emptied into the lake water. These accusations were levelled at owners of private houseboats, large runabouts and renters of recreational vehicle decks (motorized pontoon-mounted platforms which accommodate a camper truck or trailer, but have no head facilities).

The following table of estimated boat numbers for the Shuswap was obtained through interviews with houseboat rental company operators (Q2), two marina owners (Mackie 1989, Prystai 1989) and private boat owners (Q1).

Commercial houseboats (counted Oct./88)	327±5
Private houseboats	45±15
Cruisers, local	65
Sailing yachts, local	25
Cruisers, yachts from outside	75±25/year
Total Pleasure Boats (peak season)	525
Runabouts, local and day-use	1250±250
Total boats	1800±300
Total boat slips for rent	1200

Table G-1: Estimated Number of Boats on Shuswap Lake

Most of the pleasure boats with overnight accommodation on the Shuswap are commercial houseboats (327 in number) or private houseboats (approximately 45). However, as a result of age, individuality of design, construction materials and maintenance requirements, the number of private houseboats on the Shuswap is likely decreasing (Prystai, 1989). During the last decade, the commercial houseboat industry developed and its popularity has soared.

Cruisers and yachts are less common in Shuswap Lake than houseboats. For example, only five were encountered during the Q1 interviews at Seymour Arm in late July and early August 1988. Cruisers and yachts based in the Shuswap likely outnumber those from outside the basin (Mackie, 1989). Estimates of these numbers are 90 for Shuswap-based craft, and 75 per year from outside the Shuswap.

APPENDIX H - CHARACTERISTICS OF GREY WATER

Introduction

This section reviews the literature on grey water production in households, on ships and on pleasure boats with overnight accommodation. It details individual waste water studies from Sweden, Canada and the United States. The studies are presented chronologically, under the name of the author.

Then follows a review of the methodology and findings of two consultants' reports (MacLaren Engineers 1987, Beak Consultants Limited 1988) on grey water and pleasure boats. The reports were commissioned by the government of Ontario and used herein with permission (Birnbaum, 1989). The section ends with conclusions based on the information presented, a summary and a recommendation for Shuswap Lake.

Laak (1971)

R. Laak of the University of Connecticut used Standard Methods for the Examination of Water and Wastewater (12th Edition, APHA, AWWA, WPCF 1965) for oxygen demand parameters, and Hach Chemical Co. colourimeter and procedures for nutrients, "to determine the pollutional load and measure the dilution water used by each type of household plumbing fixture" for five 3-person households (Laak, 1971). Parameters analyzed in a chemical laboratory at The University of Connecticut were BOD, COD, NO_3, NH_3 and inorganic phosphate (PO_4).

Laak (1971) quantified water usage for each household fixture by measuring water volumes and number of uses per person per day. Fresh feces and urine volumes and qualities were measured per household over the six month study period. Consumer products (including dishwashing liquid, cleanser, cleaner ammonia, soap, shampoo, toothpaste, mouthwash, clothes detergent, bleach, softener and toilet paper) were measured for volume used and for chemical characteristics. Immediately after usage of a fixture (bathing, dishwashing, teeth brushing), a "fresh" waste water sample was taken. Samples were analyzed and the pollution strength of the waste water was determined analytically using the five parameters. Laak (1971) concluded that:

1) about one half the BOD and inorganic phosphates, and a majority of the inorganic nitrogen compounds originated in the black water;
2) consumer products contributed "less than one third of the total BOD, about 50% of PO_4 and an insignificant amount of nitrogen in the waste water from the households" (page 71);
3) soap usage caused a slight decrease in PO_4 while significantly increasing BOD and COD;
4) a broader data base is required, and,
5) to reduce water pollution and health hazards from household waste water less water should be used for toilet flushings.

The data from Laak (1971) relevant to this study is the comparison of the percentage of chemical characteristics found in grey water and in black water was presented in his Table 8. Findings are very similar to those of Olsson et al (1968) as reported by Winneberger (1974), and as will be discussed under Brandes (1977).

These chemical data from the Laak (1971) study, expressed as grams per person per day and as percentage of total waste water, have been incorporated into Table H-1.

Grey water and black water chemical concentrations (mg/L) from the Laak study have been incorporated into the averaged data from three other studies of waste water (one household study and two cargo ship studies), presented together in Table H-2.

Winneberger

A book by J.H.T. Winneberger entitled "Manual for Grey Water Treatment Practice" (1974) includes the article just discussed by Professor Rein Laak of the University of Connecticut.

On page 65 Winneberger summarizes grey water quality based mainly on the work of Olsson et al (1968), as follows:

- o 70% of BOD in household grey water eminates from the kitchen sink, 60% of phosphorus comes from the laundry, and 50% of the total nitrogen comes from the kitchen,
- o approximately 50% to 70% of the BOD, phosphorus, solids and total and fecal coliform bacteria originated in grey water.

Winneberger adds this caveat to interpretation of grey water characteristics: "While considering data collected at one place or another, it should be thoroughly borne in mind that grey water would vary from time-to-time, place-to-place, and in almost every conceivable way. Regardless of how statistically meaningful any one study would be, the data would not precisely describe all other situations" (page 67).

Antonic and Pancuska (1976)

The Antonic and Pancuska (1976) study was the basis for a system of "treatment of black water and grey water from commercial vessels to meet effluent quality requirements for undiluted discharge into the Great Lakes and other water bodies" (page i). Under the auspices of the Water Pollution Control Directorate (Environment Canada), the survey of waste waters was carried out on board a cargo carrier with a crew of 30 persons to determine black water and total waste water quantities and qualities. The marine waste water study followed another by Pancuska et al, (1975) and preceeded a third study by Smith et al in 1977. All three Ontario Research Foundation (ORF) studies used the same cargo ship, the S.S. John A. France. Sample sites were selected to collect grey water from showers only, grey water from the galley sink only, black water only (prior to emptying into the common waste water holding tank), and the ship's total waste water production (from the common holding tank). The sampling program consisted of three series of sampling, each consisting of hourly samples at each site on the ship, day and night. Sampling frequency was increased to thirty minutes at peak meal periods. Analytical results for the chosen parameters of BOD, TOC, SS, VSS and NH_3 were performed at the Environment Canada laboratories in Ottawa. The study did not include phosphorus analysis. The concentrations of three parameters of black water characteristics are presented in Table H-2. Pancuska et al (1975) did include phosphorus, as seen in Table H-2 referenced under MacLaren Engineers (1987).

Antonic and Pancuska (1976) reported that for waste water from the cargo ship SS John A. France ..."flow rates were much lower than expected, but the concentration of pollutants was much higher and varied over a wide range" (page viii). They found that BOD per person per day was 129 grams for toilet water and 196 grams for the total waste water. This implies that the daily concentration of BOD in grey water was 67 grams per person. However, cargo ships operate 24 hours a day, unlike pleasure boats.

Brandes (1977)

M. Brandes of the Ontario Ministry of the Environment reviewed the literature on grey water and black water characteristics in 1977. He conducted a nine month field study of domestic waste water in one three person household where grey water was wasted to one septic tank and tile field, and black water was wasted to a separate septic tank and tile field. Grey water included discharge from the kitchen and bathroom sinks, the bathroom tub and shower, and dishwashing. Black water included toilet discharge only. Only phosphorus-free detergents were used in the study household. Effluent from the clothes washing machine was excluded from both tanks.

Brandes (1977) felt that "fresh" samples were less appropriate than stored samples since effluent which reaches the groundwater has been "detained and digested for some days" (page 2) in the septic tank. Subsequently, weekly samples were taken from the two separate underground waste water tanks themselves. A total of forty-four effluent samples were taken by hand pump from both tanks collected from a constant depth below liquid surface. Detention times in the tanks were estimated at 10 days for the black water tank and three days for the grey water tank.

Brandes found that phosphorus was about twelve times higher in the black water than in the grey water tank where wastes including phosphorus-free detergents were collected. Dr. Brandes compared his chemical data to those of Olsson et al 1968, who studied ("fresh", not detained) grey water from five households where detergents with phosphorus were used exclusively. The difference was 1.4 mg/L TP (Brandes, 1977) compared to 7.8 mg/L TP (Olsson et al, 1968). Note that the Brandes study did not include laundry wastes. Laak stated this would lower the SS, BOD, COD and NO_3 levels.

The concentrations of other chemical parameters analyzed in the Brandes (1977) versus the Olsson et al (1968) studies were as follows: TS (528 vs. 518 mg/L), SS (162 vs. 141 mg/L), BOD (149 vs. 196 mg/L), TKN (11.3 vs. 6.5 mg/L) and NO_2 (0.04 vs. 0.01 mg/L). Note that the findings from Olsson et al (1968) are averaged with the findings of three other researchers. The differences between Brandes findings for grey water and black water are shown in Table H-2.

Brandes bacteriological samples were analyzed at the Ministry of the Environment's Laboratory Services Branch facilities on the same day that samples were obtained. He found total coliforms (organisms/100 ml of sample) to be 24×10^6 from the grey water tank, and 0.25×10^6 from the black water tank. Brandes compared this data to the Olsson et al (1968) findings of 3.6×10^6 org./ 100 mL for grey water. Fecal coliform bacteria were found to be higher in grey water (Brandes 1.4×10^6, Olsson et al 0.88×10^6) than in black water (Brandes 0.04×10^6). The Olsson study used standard microbiological laboratory procedures comparable to those of the Ontario Ministry of the Environment.

Brandes stated that the high bacteria counts in the study were likely a function of shorter retention time in the grey water tank, the availability of raw as opposed to digested food waste (page 13), and the possible interference of the genus Klebsiella (page 14). He discusses the two cargo ship studies by the Ontario Research Foundation (Pancuska et al, 1975 and Smith et al, 1977), both of which found densities of fecal coliforms from the shower grey water and from galley sink grey water ranged up to 10^6 to 10^8 organisms/100 mL sample.

Brandes (1977) concluded from his study of a household using phorphorus-free detergents where grey water excluding laundry waste was collected separately from black water, that "the average concentrations of TS, SS, BOD, TOC and COD in the efflents from the grey water and black (toilet) water septic tanks were of the same order of magnitude" (page 27). He also concluded that "the average quantity of fecal coliform organisms in the effluent from the grey water tank was 1.8×10^9/p.d, ie. approximately the same as in effluents from normal domestic septic tanks (2.0×10^9/p.d)" (page 27).

Brandes also found that samples of "fresh" waste water from the kitchen sink and from the shower (prior to entering the grey water tank), were higher in fecal coliforms (identified taxonomically as Escherichia Coli) than the grey water tank samples. This finding makes the Brandes study more comparable to the Beak study (1988), the Olsson et al study (1968), the Laak study (1971), and the ORF studies, in that the bacteriological samples were "fresh" as produced by the subjects, not stored in the tank for three days. Grey water released from pleasure boats is "fresh" as opposed to stored. "In view of the generally accepted indicator status of this organism in environmental pollution a potential health hazard could possibly be assigned to grey water effluents..." (page 17).

MacLaren Engineers (1987)

A literature review by MacLaren Engineers (1987) of three waste water studies (Brandes 1978, Olsson et al 1968, Smith et al 1977) compared the total and fecal coliform indicator bacteria densities found in grey water to those found in black water. The data were presented as organisms per 100 mL of sample, and organisms per person per day. All three studies included chemical analyses of the grey water and black water samples. Data from two other studies, Pancuska _et al_ 1975 and Laak 1971, were also presented.

These chemical data are presented below in grams per person per day. These relationships are shown in the following table which summarized the findings, as reported by MacLaren Engineers (1987) (page 3/40). The table shows contributions of grey water and of black water to the total waste water concentration of TP, SS, BOD and TN expressed as grams per person per day (g/p.d), and percentage (%).

Sample	TP g/p.d	TP %	SS g/p.d	SS %	BOD g/p.d	BOD %	TN g/p.d	TN %
Grey water from all fixtures	31.6	48.9	80.8	65.6	2.53	60.7	5.49	39.1
Black water	33.1	51.1	42.4	34.4	1.64	39.3	8.55	60.9
Total waste water	64.7	100.0	123.2	100.0	4.17	100.0	14.04	100.0

Source: MacLaren Engineers (1987) from data of Olsson _et al_ 1968, Laak 1971, Pancuska _et al_ 1975 and Smith _et al_ 1977.

Table H-1: Comparison of Percentage Contribution of Four Chemical Parameters in Grey Water and Black Water

MacLaren Engineers (1987) reported on the potential impacts on recreational receiving waters from the discharge of grey water by pleasure boats with overnight accommodation. The report consisted of a literature review, and the calculation of theoretical scenarios of potential recreational waters contamination by grey water loadings originating from pleasure boats.

A calculation was developed for the permissible number of pleasure boats discharging grey water in an embayment before the federal guidelines for bacteria in recreational waters are surpassed. It is based on background fecal contamination of a recreational bay, lack of mixing or flow through, a shallow (1 m) surface water depth of boating and swimming influence, the Canadian Water Quality Guidelines limit of 100 fecal organisms/100 mL of sample of recreational water, the maximum grey water bacterial concentration from Smith et al 1977, and zero die-off rate (short time frame).

Based on the assumption that the discharge of fecal coliforms by boats should not exceed the guidelines, a calculation was devised to estimate the number of pleasure boats which could discharge grey water to a bay over a 24 hour period without exceeding the guidelines. Different "scenarios" were created using different values for the variables such as decreasing the number of crew or area of the bay.

A caveat explained that the scenarios were based on assumptions and that actual field studies were required.

The MacLaren study concluded its review by stating that "discharge of grey water into lakes and rivers creates a danger similar to the release of black water from toilets, the latter being restricted by law" (page 3/30), and that "bacterial contamination of recreational waterways from grey water discharges is a significant factor under certain conditions" (page i).

Table H-2 shows mean concentrations of four chemical parameters from analyses of grey water and black water. The data were derived by MacLaren Engineers (1987) by averaging chemical results from four studies, two studies of domestic waste water (Olsson et al 1968, Laak 1971) and two studies of cargo ship waste water (Pancuska et al 1975, Smith et al 1977). Table H-2 also includes black water data, raw municipal sewage data, grey water and black water data from other studies, as referenced. Regarding TP in grey water, note that Beak Consultants Limited (1988) and Brandes (1977) exclude laundry wastes.

Sample Type (source)	TP	DP	SS	BOD	TKN	NH_3	TN
Chemical Parameter (mg/L)							
<u>Fresh Samples</u>							
Cargo ship Black water (Antonic & Pancuska, 1976)	n/d[1]	n/d	1173	1818	n/d	158	n/d
Houseboat Grey water (Beak Consultants Ltd., 1988)	4.3	3.7	574	514.6	44.7	5.1	>49.8
Raw municipal sewage[2] (Hammer, 1977)	10	7	240	200	30	n/d	50
Average kitchen/galley gw[3]	11	n/d	1313	502	85.6	n/d	n/d
Average bathroom gw	9.1	n/d	125	168.5	7	n/d	n/d
Average laundry gw	105.4	n/d	113	315.5	28.2	n/d	n/d
Average black water[4] (MacLaren Engineers, 1987)[5]	18.1	n/d	804	817	90	n/d	n/d
<u>Holding Tank Samples</u>							
Grey water tank (3 day retention)	1.4	0.2	162	149	11.3	1.7	11.4
Black water tank (10 day retention) (Brandes, 1977)[6]	18.6	15.2	77	90	153	138	153.2

1 - no data
2 - grey water and black water diluted by storm water runoff
3 - grey water
4 - (Pancuska et al, 1975).
5 - except 4 above, data from four studies (using phosphorus detergent), as referenced in Table H-1.
6 - Brandes (1977) - data from 19 samplings of grey water tank and 24 samplings of black water tank for household using P-free detergents. Laundry wastes not included.

Table H-2: Comparison of Average Chemical Concentrations in Grey Water, Black Water and Raw Municipal Sewage

Beak Consultants Limited (1988)

Table H-2 includes the means of the data obtained by Beak Consultants Limited (1988) on grey water samples from three locations on the test houseboat. For the purposes of this report, the three sample locations per craft (galley sink, head sink, shower) have been merged. The ranges of data from the nine houseboat samples are presented in Table H-3 below to demonstrate their variability. It was apparent from the nine samples each from the cruiser, yacht and houseboat that grey water from the galley sink was higher in chemical concentrations than that from the head sink or shower. This observation was also noted in the MacLaren Engineers (1987) report, in the study of separately contained domestic grey water and black water by M. Brandes (1977), and in a domestic waste water study by Laak (1971).

Houseboat Grey Water	Chemical Parameter (mg/L) TP	DP	SS	BOD	NH_3	TKN
Range	0.038-16.3	0.004-15.1	11.5-2800	12.4-2600	0.05-13.7	0.34-155

Source: Beak Consultants Limited, 1988

Table H-3: Ranges of Chemical Concentrations in Grey Water Samples from a Houseboat

These data show similarities with the data in Table H-2 for the parameters BOD, TKN and suspended solids. TP concentrations for houseboat grey water excludes laundry and automatic dishwasher detergents. (Therefore the reported TP concentration is most relevant to a discussion of grey water from pleasure boats). No commercial houseboats on the Shuswap have clothes washers or automatic dish washers on board (Prystai, 1989). Hand washing clothes products such as "Zero" contain little or no phosphate, as do both liquid detergent for hand-washing dishes and fat-based face soap.

Limited on-board usage of detergents which may contain phosphorus accounts for the low P concentration. The TP mean for houseboats is lower than the other grey water data (except Brandes, 1977) because of the minimal amount of laundry detergent used on board the Ontario-based pleasure boats in the study. Grey water from the houseboats is compared to raw municipal sewage (containing storm water runoff, black water and grey water) in Table H-2.

The Beak Consultants Limited (1988) study results showed that the ratio of litres of grey water produced per person per day to black water production was 1.5:1 to 2:1. (MacLaren Engineers (1987) determined this ratio to be 1.8:1. Antonic and Pancuska (1976) determined the ratio on board a cargo ship of 30 persons to be 1.6:1).

Based upon the Beak Consultants Limited (1988) study of grey water discharge from pleasure boats with overnight accommodation, the following table of chemical loadings from houseboats to receiving waters is derived from the recorded water use per person, the average number of boat crew members (six), and grey water chemistry results as presented in Table H-3. Note that the numbers refer to loading per boat, not to loading per person. Note also that the table is not comparable to the previous two tables because of its units, and the imprecise quantification of volumes of waste water for each study. However, Table H-4 is comparable to Table H-1 for grey water if Table H-4 values are divided by six.

Onboard Water Usage (Lpd)	Crew Members	Chemical Loading (grams/d) TP	DP	SS	BOD	NH_3	TKN
20	6	0.8	0.7	70	58	1.0	5.4

Source: Beak Consultants Limited, 1988

Table H-4: Summary of Loadings from Houseboat Grey Water Samples

Beak Consultants study involved presumptive (fecal coliforms, total coliforms) and taxonomic (E. Coli, Klebsiella, Pseudomonus aeruginosa) analytical procedures for bacteriological determinations. Efforts were made in both the sampling and analytical phases to maintain a high level of quality assurance and control. Sampling over 21 days from the houseboats, cruisers and yachts was undertaken morning and evening from the modified plumbing fixtures of the head shower and sink and the galley sink into sterile Naglene bottles. Bacteriological samples were then decanted into sterile glass bottles for delivery within 24 hours to the Ministry of the Environment laboratories. Fifty four duplicate samples were obtained for quality control. For water quantity determinations, each boat was outfitted with a water meter for potable water supply measurements, and each black water tank was dipped daily. In-stream (grab) samples to determine the effects of boat grey water discharge on three secluded embayments were collected twice daily at 10 sites in the bays and one control site well outside the bays. Samples totalled 396. The sites were selected by the consultant in concert with officials of the Ontario Ministries of the Environment and Natural Resources, and Parks Canada.

Chemical and bacteriological analyses were performed by the Ministry's Laboratory Services Branch. Each sample was analyzed for fecal coliforms, E. Coli and Pseudomonus aeruginosa (PA). Three samples from each fixture on each boat were analyzed for TP, DP, TS, SS, BOD, DOC, NH_3 and TKN.

TP and DP are approximately half the concentration in houseboat grey water that they are in untreated but diluted municipal sewage. SS and BOD are approximately twice the concentration in houseboat grey water than in raw municipal sewage (which is diluted with storm runoff). TKN and TN are about equal in concentration for both types of effluent. It would appear that houseboat grey water and average raw municipal sewage are very close in chemical composition.

The Beak (1988) report states that chemical "loadings were seen to be quite low" (page 3.5), but that "grey water contains high concentrations of TS, SS, NH_3, TKN, and TP and DP compared to raw domestic sewage" (page 3.4).

The average number of fecal coliforms released daily to receiving waters, expressed as a loading per houseboat, was estimated to be from 4.4×10^8 to 1.1×10^{11} (fecal coliform counts/boat/day).

Thorough taxonomic analysis and statistical tests indicated that many fecal indicator bacteria (FC, EC, PA) may not have been of fecal origin at all, but were Klebsiella pneumoniae and pseudomonus aeruginosa. Subsequently, they may not have been potential pathogens. The report was sceptical about pleasure boat grey water affecting water quality, except in confined embayments. The consultant found no statistically significant relationship between boat numbers and bacterial densities. "The effects of grey water upon the bacterial quality of embayment waters is highly site specific. In small heavily used bays effects can be observed. In larger, less used or better flushed locations, effects cannot be observed." (page 4.2)

Conclusions

1. Literature on grey water is limited to about one dozen articles.

2. Studies from 1968 to 1988 on grey water in households and on board vessels in Sweden (Olsson et al, 1968), the United States (Winneberger 1974, Laak 1971) and Canada (Pancuska et al, 1975, Smith et al 1976, Antonic and Pancuska 1976, Brandes 1977, and Beak Consultants Ltd. 1988) indicate that grey water resembles raw municipal sewage and black water in its biological and chemical makeup, especially in terms of oxygen demand, solids content and bacteria.

3. Presumptive analyses for total coliform and fecal coliform organisms in grey water were very similar to, equal to or greater than TC and FC levels in black water. Taxonomic identification of specific bacteria in a study of pleasure boats waste waters indicated that most bacteria may not have been of fecal origin (Beak Consultants Limited, 1988).

4. Fresh grey water samples tended to contain more bacteria, BOD and SS than grey water which had a three day digestion period in a (anaerobic) holding tank. Grey water septic tank effluent with a retention time of three days, contained more bacteria and BOD than the black water septic tank effluent with a retention time of ten days.

5. The kitchen sink or ship galley usually contributed the most bacteria, BOD and total phosphorus to total grey water, followed by laundry machine wastes (in studies where laundry was employed), the bathroom shower fixture and the bathroom sink fixture. TP concentrations were reduced ten-fold in grey water in studies where P-free detergents were used compared to studies where P-containing detergents were used.

6. In the study most relevant to Shuswap Lake, bacteriological and chemical loadings from grey water from pleasure boats with overnight accommodation to receiving waters, were found generally to be low. (No loadings from black water were assessed, so direct comparison was not possible). However, on a site-specific basis and especially in small poorly flushed embayments with high boat densities, effects could be observed (Beak Consultants Limited, 1988).

7. Four studies (Laak 1971, Brandes 1977 (which included data from Olsson et al 1968), MacLaren Engineers 1987, and Beak Consultants 1988) stated that grey water exhibits potential risk to human health, based on their reviews of the literature and/or their specific bacteriological study results.

8. As a result of confounding factors such as study subjects, setting, sampling methodology, detergent usage, no two studies in the literature are fully comparable. However, in most studies, the limited works of other waste water researchers was acknowledged and used as supporting information when chronologically possible. It was established in the literature that grey water was a waste water which exhibited characteristics equivalent to raw municipal sewage.

Summary and Recommendation

To summarize, grey water is closer in bacteriological and chemical makeup to black water than is frequently understood. Studies since 1968 on both effluents have shown similarities in concentrations of total and fecal coliform indicator bacteria, solids (total and suspended) and oxygen demand (biochemical and chemical). Nitrogen species concentrations are lower in grey water than in black water. Differences diminish between total phosphorus concentrations in black water and grey water when phosphorus-free detergents are considered. This relationship will prevail as more manufacturers introduce such detergents to the marketplace. The constituent characteristics of grey water have been demonstrated to be nearly equal to those of untreated municipal sewage, and to resemble undiluted toilet wastes. Several researchers expressed concern that high bacteria densities in grey water represent a potential human health hazard.

The widely varying chemical concentrations and limited information on chemical loadings data from the different studies reviewed here do not seem to warrant grey water retention by pleasure boats in Shuswap Lake, based solely on chemical loadings. (Phosphorus loadings from pleasure boats, rivers and sewage treatment plant effluent are discussed in Section 4.1.2).

Discussions with operators of houseboat rental companies indicated that planned fleet size expansions were unlikely or of modest proportions, as discussed in Section 4.3.2. These are supported by recent personal communications with the secretary of the local houseboat association and the Waste Management Coordinator with the B.C. Ministry of the Environment (Prystai 1990, Holmes 1990). Therefore, it appears that present loadings from grey water from pleasure boats will not increase significantly in the immediate future. To require grey water retention based on anticipated grey water loading increases alone, may be unwarranted at this time. Trends in the tourism industry, however, show increasing recreational usage of water resources (Williams, 1987).

However, based on: 1) indications that grey water released in slow flushing or heavily used embayments yielded bacteriological loadings which raised bacterial densities in recreational water to levels in excess of 100 organisms/100 ml sample (half the federal limit); 2) the observation that over 80 percent of lake users surveyed considered grey water release to be aesthetically distasteful and commercial lake users surveyed were unclear on its implications to water quality; and 3) the chemical loadings and fleet sizes discussed above, the following recommendation is offered. It is recommended that consideration be given to the retention of grey water in storage tanks aboard pleasure boats with overnight accommodation in Shuswap Lake. This precautionary measure would represent a proactive step toward maintaining a high standard of water quality, especially in sensitive areas such as popular embayments, for all lake users. Grey water release into Shuswap Lake waters should be discontinued in favour of proper disposal at sanitary disposal stations on land. Such waste water retention would make certain that public health concerns are addressed, and that the image of both the public users and the houseboat industry users is maintained.

Enforcement of required changes to regulations (Appendix I) could be enhanced educationally through public notices, mechanically through control devices on the plumbing systems of pleasure boats and legally through summary convictions of offenders.

APPENDIX I

Federal and Provincial Legislation, Common Usage of Resources

This section outlines the background to legislation on water, highlights where relevant pieces of legislation address effluent releases to recreational waters, and discusses common ownership and usage of resources. The following subsections explain the particular piece of legislation relative only to effluent releases. These are biased summaries because they do not and are not intended to highlight all subjects within each Act, a process which would be both lengthy and irrelevant.

Water law in Canada is based primarily in English common law, which included the doctrine of riparian rights. Riparian rights apply to owners of land in contact with water in a natural watercourse, such as land abutting a river. Riparian rights originally included rights to abstract, divert, or impound water, to have water flow in a natural state of quality and to have access to water (Macrory, 1985).

The concept deals mainly with rights to consume water, but includes the rights to natural water quality, to take fish, to bathe and to navigate. The right to use water is a common birth-right of British subjects (Woolrych, 1851). Legal complications have been numerous. Disputes have involved navigability and right of passage, water diversion or impoundment, the relationship between usage and quality, obligations of the landowner to the watercourse, property boundaries, fishing rights, immemorial rights of way, volume of takings during low flow conditions. (Percy 1988, Macrory 1985, Woolrych 1851).

Early Canadian water law excluded uses of water other than agricultural and industrial uses. It excluded water quality - a concept as old as English common law itself (Woolrych 1851, Macrory 1985). D.R. Percy (1988) believes that current water law cannot accommodate uses such as recreation, or the anticipated lower flows from climatic warming. Canadian water laws based upon apparent abundance of supply will face increasing legal scrutiny (Percy 1988).

Federal Legislation

The Canada Water Act (1970) provided for cooperative federal-provincial management of the country's water resources (Environment Canada, 1986-87). It stated that the minister and provincial minister(s) may designate water quality management areas (II, Section 9) which then become subject to special considerations (II, Section 13). The Act defined waste as "...any substance that...would degrade or alter...the quality of those waters to an extent that is detrimental to their use by man..." (I, Section 2).

The Canada Shipping Act (1970) addressed water pollution from ships plying marine and fresh water bodies - mainly ballast tank and hold flushings and petroleum releases. At present, Transport Canada is reviewing the Act and is about to introduce an amending regulation called the Pleasure Craft Sewage Pollution Prevention Regulations. These regulations are anticipated to pertain to sewage (assumedly black water only) from pleasure boats equipped with a head, and require holding tanks for such craft in sensitive waterways as designated by the provinces (Holmes 1990, Birnbaum 1990).

The Fisheries Act was enacted in 1857 to protect fish species and their habitat. The Act strictly prohibits deleterious substances from being discharged directly or indirectly into fish habitat. The Act (which has been amended many times) defines "effluents" so strictly that few discharges conform (Pearse et al, 1985).

In the preamble of the (1988) Canadian Environmental Protection Act (which deals with toxic substances) it is stated that..."it is necessary to control the dispersal of nutrients in Canadian waters". In Section 3(g) the Act defines a "substance" as "any animate matter that is, or any complex mixtures of different molecules that are contained in effluents...from any...undertaking or activity" (House of Commons, 1988). The Act empowers the Minister to formulate environmental quality guidelines, objectives and codes of practice. The Canadian Water Quality Guidelines (produced by the Canadian Council of Resources and Environment Ministers, hereafter called CCREM, 1987) are Canada's most current, comprehensive water quality guidelines.

British Columbia Legislation

The British Columbia Litter Act (1970) deals mainly with beverage bottles and cans. Its definitions of litter, waste and domestic sewage exclude wash waters. Regulation 136/70 under the Act states in Section 4 that no person should "discharge...dump...discard...dispose of...litter...into fresh water", and in Section 5 that no person should "discharge domestic sewage...waste...from a boat...houseboat...portable housing unit...into fresh water".

The Waste Management Act (1979) deals with mainly industrial handlers of waste materials, but has implications for recreational boating. In section 3 the Act prohibits waste to be introduced into the environment "in the course of conducting business, or via prescribed activity or operation, or in such a manner or quantity as to cause pollution."

Section 7 is very focused upon wastes from recreation and states that "no person shall discharge domestic sewage or waste from a...boat or house-boat...into any...body of water except (a) in compliance with a permit, approval, order, plan or regulation...(b) where disposal facilities are provided, in accordance to...regulations." This piece of legislation could easily be changed through minor modifications to terminology. For example, the term "domestic waste" is not in the definitions, and "domestic sewage" includes only black water.

The Environment Management Act (1981) lists environmental impact assessment powers which include declaring an existing resource use to have a detrimental impact, restricting the use and ordering the responsible party to comply to a specific directive.

Legislation in Other Jurisdictions

In Alberta, the Litter Act (1972) states that the present definition of litter is not limited and could change. The definition of litter includes "sewage".

Under Regulation AR35/73 of the Clean Water Act, however, the general prohibition disallows releasing to water "any substance capable of changing the quality of the water or causing water contamination." The Clean Water Act applies to industrial, municipal or private water facilities that involve surface water discharges, treatment or control.

In Ontario, the Environmental Protection Act prohibits discharges into the natural environment of contaminants exceeding levels in the regulations. Section 13 (1) (a) states that the prohibition applies to any likely impairment of the environment (from a defined contaminant) for any use that can be made of it. The Act's Regulation 305 - "Discharge of Sewage from Pleasure Boats" explicitly excludes grey water and deals specifically with human excrement, petroleum products and domestic waste. Under the Act's Regulation 310 - "Marinas", only black water is discussed. The Water Resources Act states that the definition of sewage can be changed and that the Minister decides what "may impair" the quality of water (Section 15).

In the United States, the State of New Hampshire has banned the discharge of grey water from pleasure boats to all lakes and rivers since 1983 (MacLaren Engineers, 1987). In the State of New York, grey water release from watercraft into Lake George is restricted. The prohibition of waste water releases into Lake Champlain and its tributaries is proposed by the States of New York and Vermont (Birnbaum 1990, MacLaren Engineers 1987).

In the Shuswap, there is no municipal bylaw concerning water quality protection from effluent discharge or the regulation of lake usage. The Columbia-Shuswap Regional District does not have any bylaw regarding pleasure boats with overnight accommodation other than a general bylaw concerning noise after 2300 h.

To summarize, there is no legislation in Canada, in any province including British Columbia or in the Shuswap, against releasing grey water to (recreational) receiving waters. At least two American states have banned grey water release and a third state is considering such action.

Minor changes in the wording of several pieces of Canadian legislation (federal and provincial) would be required to address changes in the handling of grey water. The British Columbia Litter Act Regulation 136/70, and Section 7 of the Waste Management Act (1970) already cover waste discharges from vessels including houseboats. They would require changes in terminology to accommodate effluents such as grey water. The political will to initiate the process required to affect legislative changes is lacking. The characteristics of grey water are detailed in Appendix H.

Common Usage of Resources

The fact that water resources are commonly owned by the people of Canada, and constitute a "free good" tends to be detrimental to water quality and leads to over consumption and other abuses (Harrison 1977). The concept of a free good or common ownership is self-defeating: as no one is responsible for the planetary airshed or oceans, they become contaminant sinks (Hardin 1968). The utilitarian tenet of the most good for the greatest possible number of users tends to break down over time as a result of opportunism, complacency, and environmental stress. Environmental stress is a direct result of increasing resource usage, and of increasing population (Hardin 1968, Parkes 1973, Pearse et al. 1985).

In our tradition of Common Law, water resources are considered to be owned in common, administered and managed as a public good by the provincial government. The attitude of common right and remote management, and the myth of an infinite supply of fresh water, has led to problems. According to Parkes (1973), water has "been regarded as a free good for anyone to use ... subjected to unrestricted use and abuse ... characterized by a general lack of foresight and concern for environmental consequences or the rights of others"(page 3). Parkes states that this abuse of a common good is most evident "in the field of water-based recreation" (page 5). Harrison (1977) supports this idea in his discussion on recreational planning and user conflicts along shorezones. He states that the shorezone "is the interface between highly different regimes of resource allocation. The land is more typically a private good belonging to specific proprietors, whereas the water is a common property belonging to all" (page 19). Common proprietorship does not imply common caretaking, however (Hardin, 1968).