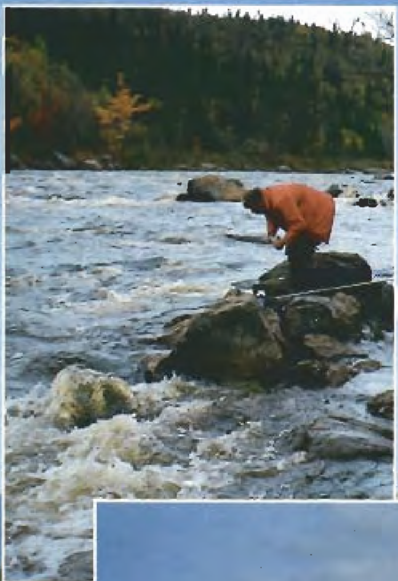
Regional Water Resources Study of the Eastern Avalon Peninsula



GOVERNMENT OF NEWFOUNDLAND AND LABRADOR

DEPARTMENT OF ENVIRONMENT AND LANDS
WATER RESOURCES DIVISION

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REGIONAL WATER RESOURCES STUDY OF THE EASTERN AVALON PENINSULA

FINAL REPORT

PREPARED FOR

WATER RESOURCES DIVISION
DEPARTMENT OF ENVIRONMENT
GOVERNMENT OF
NEWFOUNDLAND AND LABRADOR

SEPTEMBER 1987

EXECUTIVE SUMMARY

The Regional Water Resources Study of the Eastern Avalon Peninsula is intended as the first in a series of studies of the water resources of the Province of Newfoundland. Its purpose is to provide information to assist the Water Resources Division of the Department of Environment in its water planning and management activities.

The study undertook the following tasks:

- To assess the natural availability of water in the study area, considering both average and low flows;
- To develop a method to predict yield;
- To assess the availability of groundwater;
- To document water quality and identify areas of degradation;
- To identify instream uses;
- To project demand for all the communities and industries in the study area and to estimate yield for all water supply systems;
- To analyze supply and demand for all communities in the study area;
- To provide an overall assessment of water use by region, including both water supply demands and other water and basin uses;
- To rank regions in order of demand for their water resources, and to assign them to categories according to the overall availability of water.

A map showing areas of equal mean annual runoff was prepared from flow and precipitation data.

Low flows were estimated for the four natural gauged rivers with the longest records. Low flow measures derived from both flow duration and flow frequency analysis were used. The non-dimensionalized one month low flow having a return period of one in ten years was selected for use in this study. The non-dimensionalized average for the four gauged rivers was taken as the low flow predictor for ungauged catchments.

About 75 river basins in the study area were then identified. In addition, about 40 coastal areas drained by very small streams were also identified. For each basin, the average annual flow and the one in ten year one month low flow were predicted.

The streamflow records were used to develop a method to estimate available yield, for a given estimate of storage. This technique was extensively used in the supply/demand analysis.

Groundwater availability was assessed using the results of Water Resources Report 2 - 6 on Hydrogeology of the Avalon Peninsula. Groundwater supplies are closely connected with surface water, and there are no major aquifers in the study area. Although data on reliable yields are sparse, the close connection between surface and groundwater suggests the vulnerability of groundwater supplies to dry periods.

Water quality was documented using data from the long-term joint monitoring program of the federal and provincial Departments of Environment. Data from a number of other sources were also used, particularly to identify areas of degradation.

The natural waters in the area tend to be soft, slightly acidic, and low in most constituents except iron and manganese. Colour and turbidity levels tend to be elevated. These characteristics make the water generally good for domestic purposes, although elevated colour and turbidity are aesthetic concerns. The softness of the water is good for industrial uses because scaling on boilers and pipes is unlikely to create problems, but softness combined with low pH tends to make the water corrosive.

Three generic groundwater groups were identified in the hydrogeological report, calcium bicarbonate, sodium bicarbonate, and a soft water with characteristics similar to surface water.

The key water quality concerns identified in this study were

- potential degradation due to anthropogenic causes
- high sensitivity to acid rain
- possible coastal and estuarine pollution.

The three principal instream uses in the study area are hydropower, tourism and recreation, and fisheries. The first two contribute substantial economic benefits to the study area. The third, fisheries, is of value in assuring the public of good water quality, and in conserving fish and wildlife. It also contributes to recreation and public amenity.

The supply/demand analysis indicated that there is sufficient water to supply community and industrial needs, assuming that proposed projects (or suitable alternatives) to upgrade and expand existing systems are undertaken where necessary. The St. John's regional water supply system dominates the supply/demand situation; a number of communities near St. John's are looking to the regional system to supply their future requirements.

The overall water use assessment indicates that although water is abundant in the study area, there is considerable pressure on water use, particularly in the northern area from Holyrood to Petty Harbour to Pouch Cove.

Present and potential conflicts exist, particularly between water supply and hydro power and between water supply and tourism and recreation. The region was divided into sub-areas; these were ranked as follows in order of decreasing pressure on their water resources

North-Central
North
East
West
Southeast
South.

A number of conclusions were drawn and recommendations made. The principal conclusion was that the water resources of the study area are an important natural resource, with substantial socio-economic benefits. Careful management of all watersheds, not only those protected for water supply, is required to maximize these benefits.

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GLOSSARY OF ABBREVIATIONS

ADA	St. John's Agriculture Development Area
AES	Atmospheric Environmental Services
BOD	biological oxygen demand
CMA	St. John's Census Metropolitan Area
DFO	Department of Fisheries and Oceans
EPS	Environment Protection Service
JTU	Jackson Turbidity Units
NAQUADAT	National Water Quality Data Base of Environment Canada
NTU	nephelometric turbidity units
TCU	true colour units
TDS	total disolved solids
TOR	Terms of Reference
WSC	Water Survey of Canada
WQG	Canadian Water Quality Guidelines

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1 - INTRODUCTION

1 - INTRODUCTION

1.1 - Objectives

This report, on the regional water resources of the eastern Avalon Peninsula, is the first of a series intended to cover the whole province.

The overall objective of the study is to provide information to assist government in the planning and management of water resources in the study area. The specific objectives, summarized from the Terms of Reference, are

1. To assess the availability of water, using existing data.

2. To examine the current use of water, with some indication of future needs.

3. To assess supply and demand, and to identify areas of present or potential conflicts.

4. To assess water quality.

5. To rank areas according to their supply-demand situation, and make appropriate recommendations.

This report first addresses surface water availability in Chapter 2, followed by groundwater availability in Chapter 3. The present state of water quality is described in Chapter 4. Water demands for instream uses, chiefly hydro power, fisheries, and tourism and recreation, are presented in Chapter 5. An analysis of supply and demand for withdrawal uses follows in Chapter 6. The final two chapters assess the overall water use situation, identify conflicts, draw conclusions, and make recommendations.

1.2 - **Sources of Data**

A large number of reports and other sources were used to obtain data for this study. These are presented in the List of References at the end of this report. In addition, staff from various levels of government, as well as other agencies, were most helpful in supplying information and comments. These include

- Government of Newfoundland and Labrador
  - Department of Environment
  - Department of Development and Tourism
  - Department of Fisheries
  - Department of Municipal Affairs
  - Department of Health
  - Department of Culture, Recreation and Youth
  - Executive Council, Newfoundland Statistics Agency
  - Department of Forest Resources and Lands
  - Department of Rural, Agricultural and Northern Development
  - Department of Mines and Energy

- Government of Canada
  - Agriculture Canada
  - Fisheries and Oceans
  - Statistics Canada
  - Environment Canada

- Municipal Authorities
  - City of St. John's
  - St. John's Metropolitan Area Board
  - Most communities in the study area

- Newfoundland Light and Power Co. Ltd.

- Newfoundland and Labrador Hydro

1.3 - Study Area

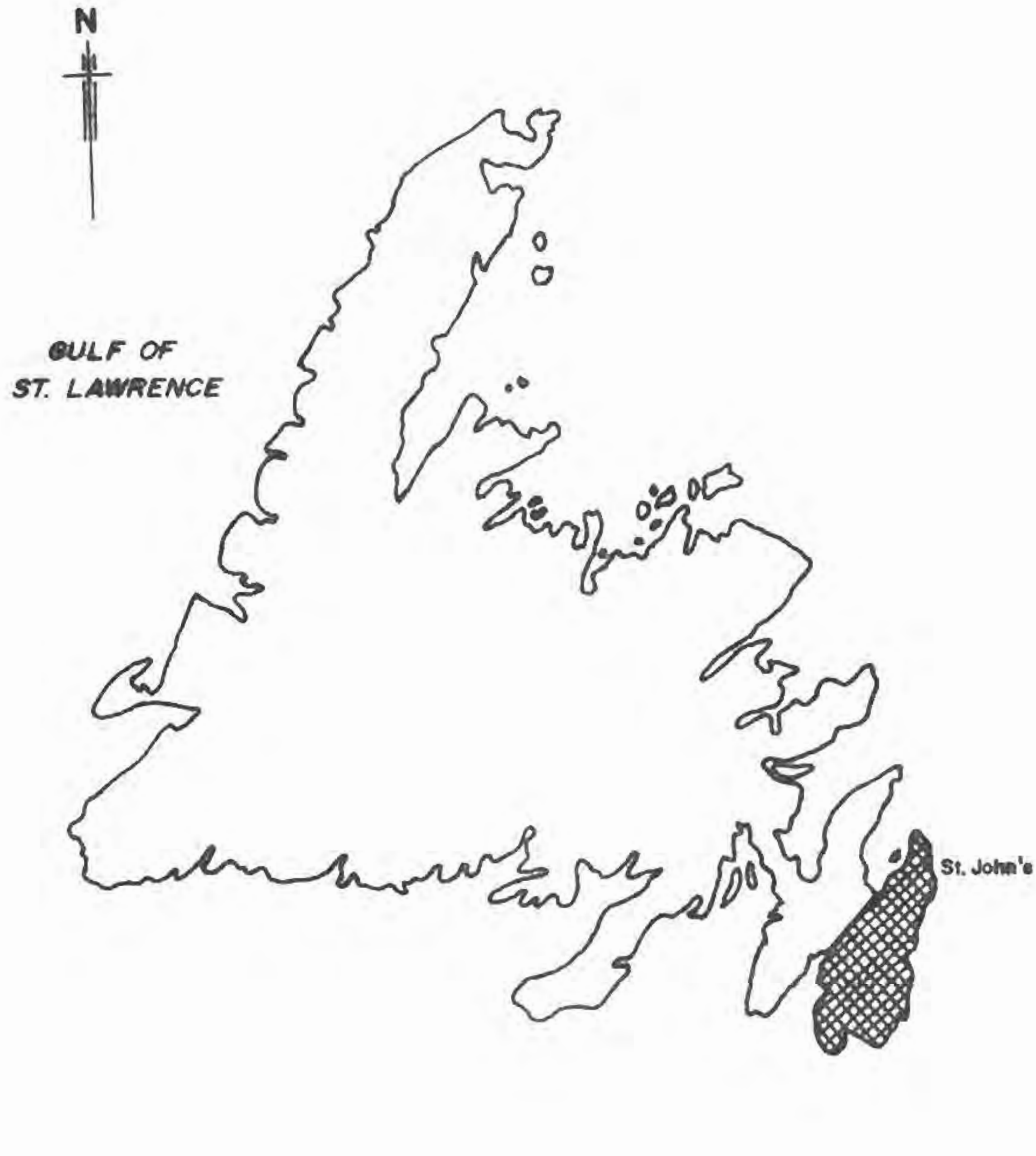
The study area is located in the southeastern corner of the Island of Newfoundland, as shown in Figure 1.1. Its area is about 4800 km^2.

A spine of high hills, with several peaks over 300 m, runs north-south. The coastline is steep in the north, becoming somewhat gentler to the south. Inland, the northern region has more productive land, and most of the population lives in this region. The large central area is poorly-drained and barren, with numerous ponds and bogs. Part of this central area has been developed for hydro power.

The climate is dominated by the ocean environment. The south-flowing cold Labrador current prevents summer temperatures from rising much above 20°C. In the winter, the moderating effect of the ocean generally keeps winter temperatures above -10°C. The warmest month is July and the coldest is February, with mean temperatures at St. John's Airport of 15.5°C and -4.5°C respectively.

The region has among the highest precipitation rates in Canada, and precipitation is distributed fairly evenly throughout the year. Because of the moderate winter temperatures, winter precipitation can fall as either rain or snow. Section 2 discusses the precipitation and runoff in the area in some detail.

Geologically, the region is located in the Avalon zone. This zone is similar to areas of western Europe and northern Africa; a basement of volcanic rocks is overlain by sedimentary groups. Glaciation has removed much of the overburden, and bedrock is frequently exposed, or close to the surface.



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Study Area

FIG. 1.1

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The chief natural resource of the area has traditionally been fish. The fishery is still the base of much of the region's economic activity. Farmland is generally of poor quality, with some exceptions. A pyrophyllite mine at Manuels is the only other primary industry. Large reserves of offshore oil have been found, but to date, no production has taken place. The surface waters of the study area are themselves an important resource, contributing benefits through hydro power, tourism and recreation, and fisheries and wildlife.

St. John's, as the provincial capital, has developed into an important service and administrative centre. Some associated light industry is located in and around St. John's. Most of the population (over 90 per cent) lives in the St. John's census metropolitan area. Most of the better agricultural land is found in this area as well. Economic activity outside the St. John's area centers around the fishery; consequently most communities are located along the coastline. Some peat operations and minor agricultural activity also takes place in the southern part of the region.

2 - AVAILABILITY OF SURFACE WATER

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[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

2 - AVAILABILITY OF SURFACE WATER

The assessment of the availability of surface water requires an estimate of mean annual flow and its variation over the region, of seasonal distribution and of low flows. For this study, mean annual runoff over the region was first estimated. It was then used directly to estimate mean annual flow, and also as the basis for predicting seasonal variation and low flows.

The estimation of long term mean annual runoff in the study area is described in Section 2.1. Sections 2.2 and 2.3 discuss seasonal distribution and low flows, and Section 2.4 describes the methodology developed to assess the benefits of storage. Section 2.5 then provides an estimate of average annual flow and natural low flow for all the basins in the study area. Detailed descriptions of the methodology for the various sections are presented in Appendix A.

2.1 - Mean Annual Runoff

The mean annual runoff is the average amount of water that runs off a basin in a year. It is measured for convenience as a depth (e.g. in millimeters or inches). Average annual flow volume is then the product of the mean annual runoff and the drainage area.

A convenient method of estimating mean annual runoff at ungauged catchments is to use a map showing the isolines of mean annual runoff in a region. Such a map was produced a number of years ago and has proved very useful (e.g. 3). Since then, additional precipitation and streamflow data have become available. A revised map of mean annual runoff was thus prepared for this study.

The two types of data analyzed were stream flow data from the hydrometric stations operated by the Water Survey of Canada (WSC) under the Canada-Newfoundland Hydrometric Surveys Agreement, and the precipitation data from the Atmospheric Environment Service (AES) network. Streamflow data from WSC records are the primary source, because they measure the runoff over the basin directly. Runoff can also be calculated by subtracting evapotranspiration from precipitation data at AES stations; the evapotranspiration is estimated from climatologic data. Because streamflow data points are sparse, the precipitation records can be useful in interpolating and extrapolating the data.

To prepare the map, mean annual runoff was plotted at the centroids of gauged basins, and at climatological stations. Isolines were then drawn to identify areas with similar mean annual runoffs.

The plotted points and final map are presented in Figures 2.1 and 2.2. A complete description of the data used and the methodology is given in Appendix A1. Figures 2.3 and 2.4 show locations of gauged basins and climate stations considered in the analysis.

2.2 - Flow Variation Through the Year

The examination of flow variation through the year in this section and the analysis of low flows described in Section 2.3 are based on the records from the four unregulated streams with record lengths longer than 10 years, Rocky River (02ZK001), Northeast Pond River (02ZM006), Northwest Brook (02ZN001) and Waterford River at Kilbride (02ZM008). Rocky River is located just outside the study area, and was included because of its long record.

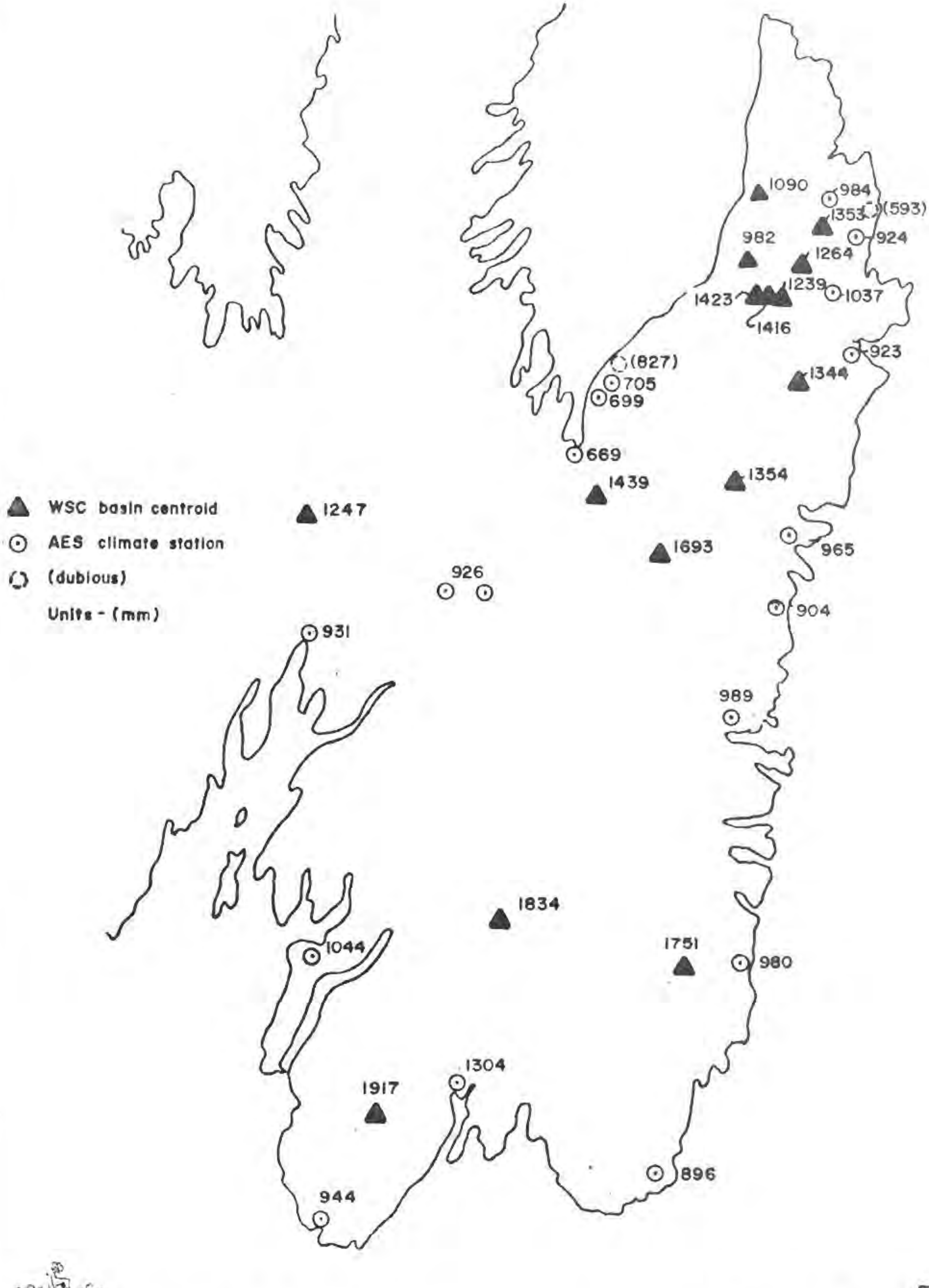

FIG.2.1

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Mean Annual Runoff Points

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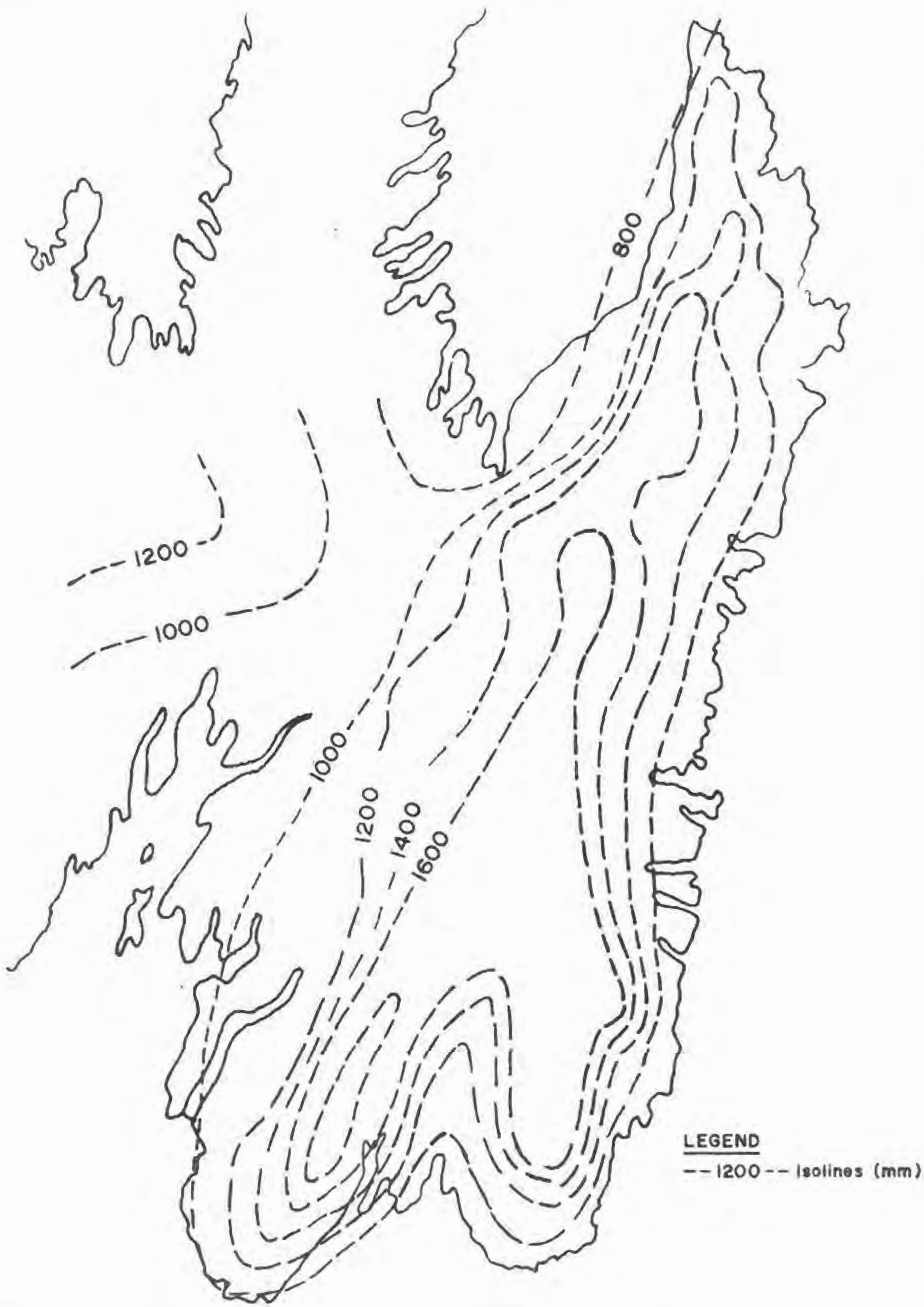

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FIG. 2.2

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Isolines of Mean Annual Runoff

NOTE: FOR A COMPLETE LIST OF GAUGED RIVERS SEE TABLE AI.I APPENDIX A

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Streamflow Gauges

FIG. 2.3

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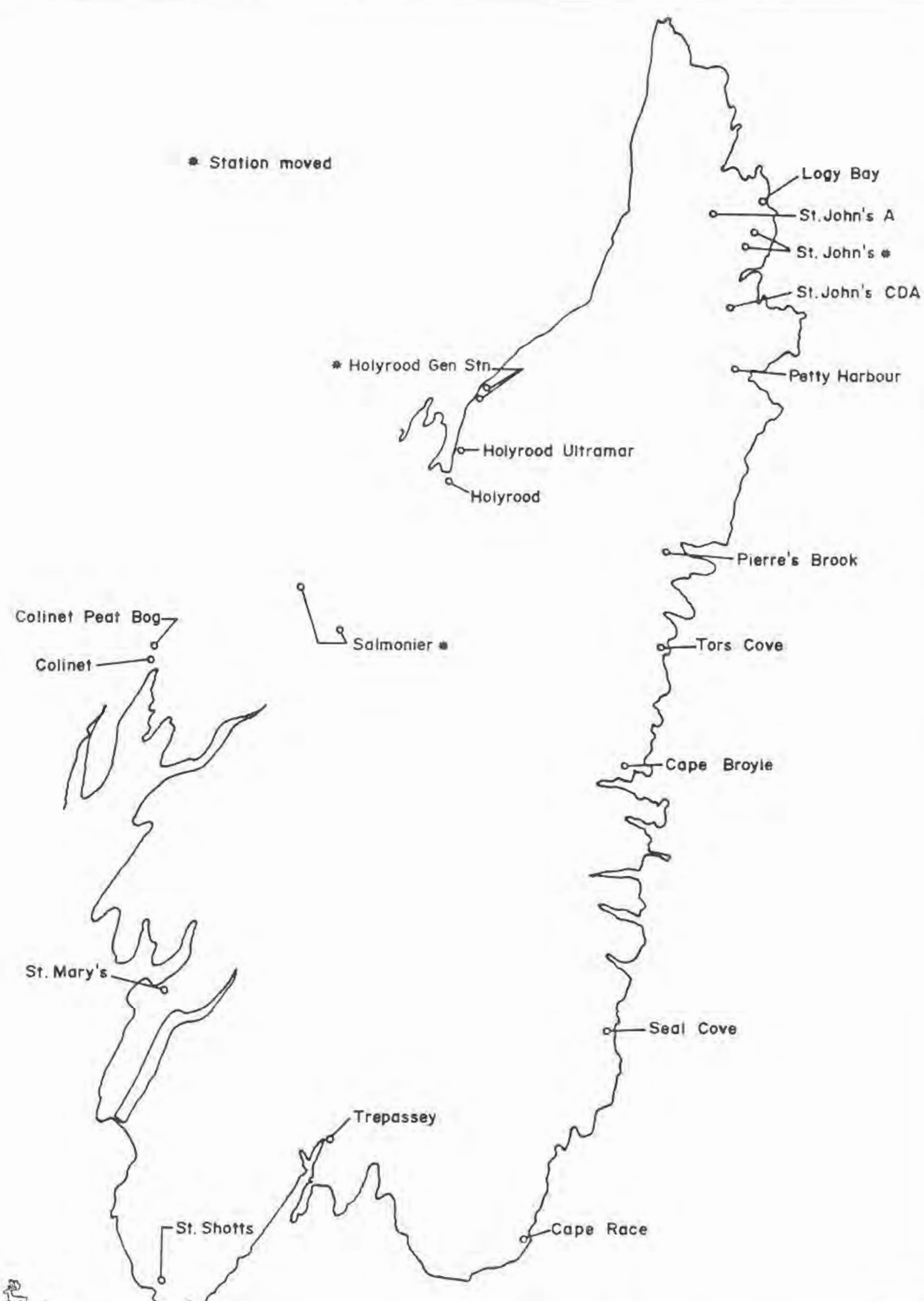

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FIG. 2.4

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Climatological Stations

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The section below describes the variation of the mean flow from one month to the next, and the range of flows which typically can be expected in each month.

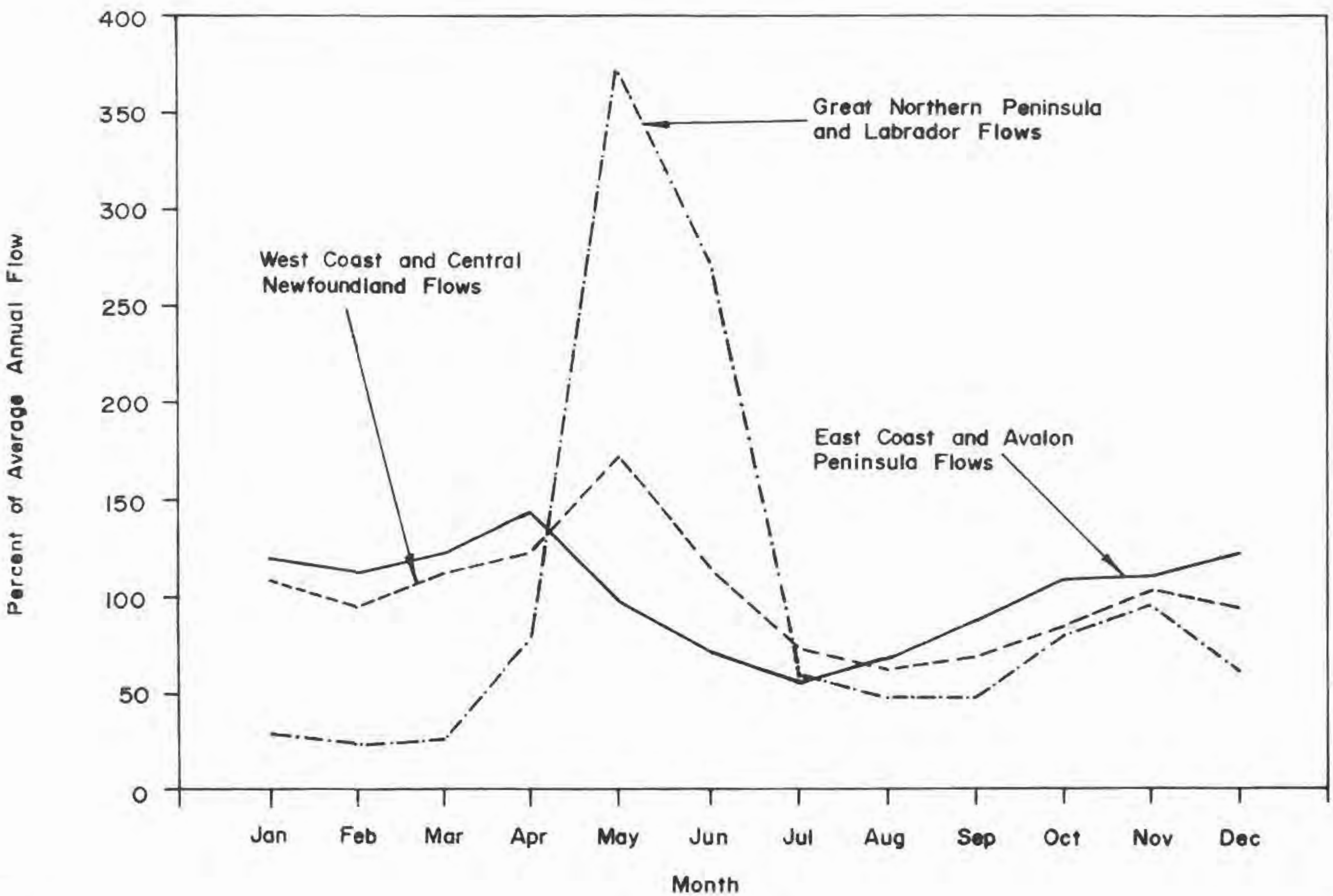
2.2.1 - Distribution of Mean Monthly Flows

The Avalon Peninsula is fortunate to have not only an abundant supply of water, but to have it fairly evenly distributed throughout the year. Figure 2.5 shows the annual variation in flow at three different locations on the island; the even distribution of flows on the Avalon Peninsula is apparent, particularly when compared with flows on the Northern Peninsula.

The chief reason for the even distribution of runoff on the Avalon Peninsula is that winters are milder than in many other locations on the island. Consequently, winter precipitation is often in the form of rain, rather than snow. In addition, snowmelt frequently occurs as several small events during the winter and spring, rather than as one large spring runoff event.

Mean value for the total precipitation and rainfall for each month at St. John's Airport is presented as an example in Figure 2.6. Even in February and March, the months with the most snow, on the average about 50 per cent of the precipitation falls as rain.

Table 2.1 presents the average monthly flows for the 4 gauges as a per cent of the mean flow. This same information is presented graphically in Figures 2.7 and 2.8. The pattern is very similar for all basins. Although it might be expected that the largest basin, Rocky River, would show the least variation from one month to another, in fact, it is an intermediate-sized basin, Northwest Brook (53 km^2) which is most consistent throughout the year. Northwest Brook is located in the southern part of the study area, a region of high annual runoff and abundant precipitation



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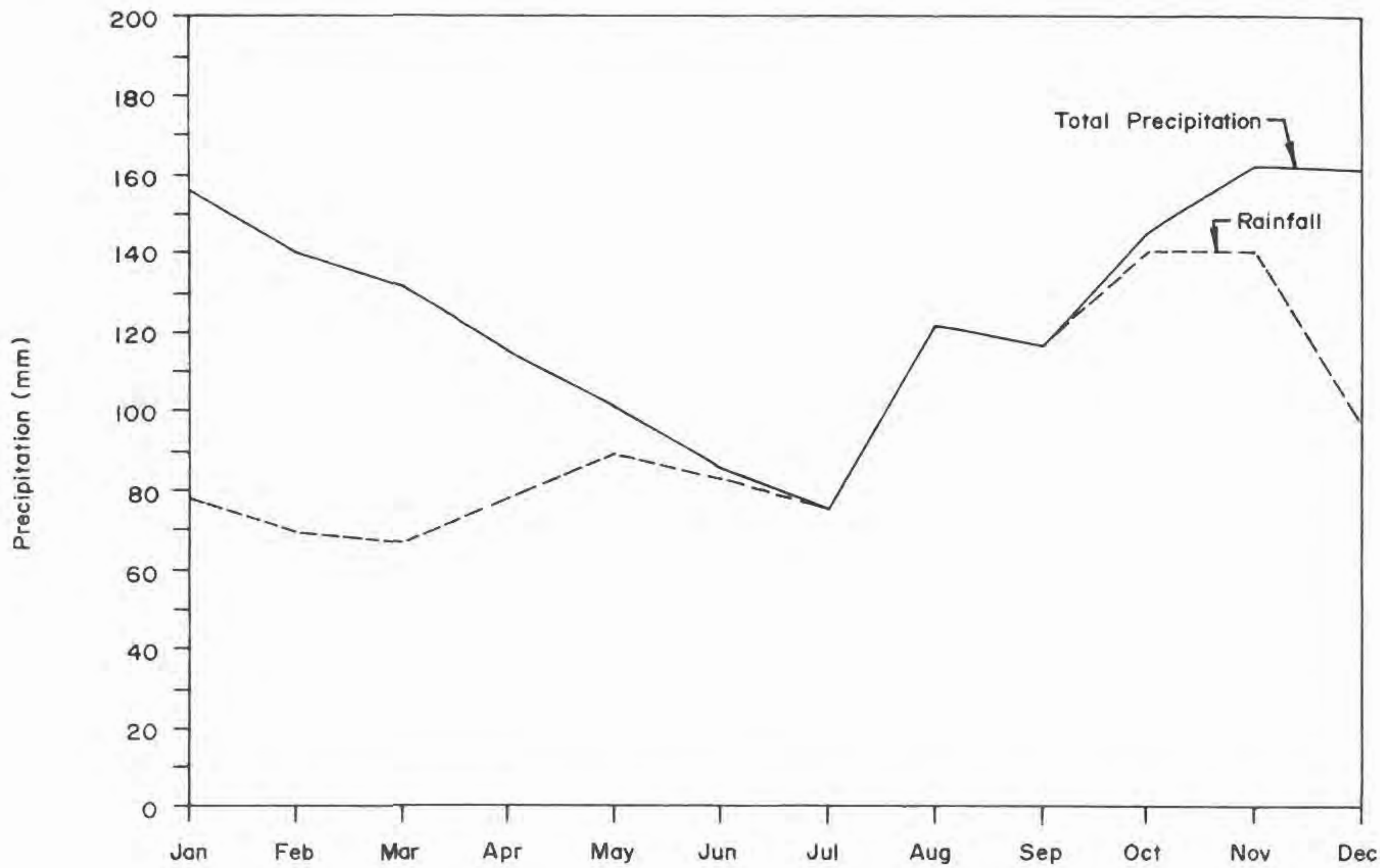
Mean Monthly Flow in Three Regions

FIG.2.5



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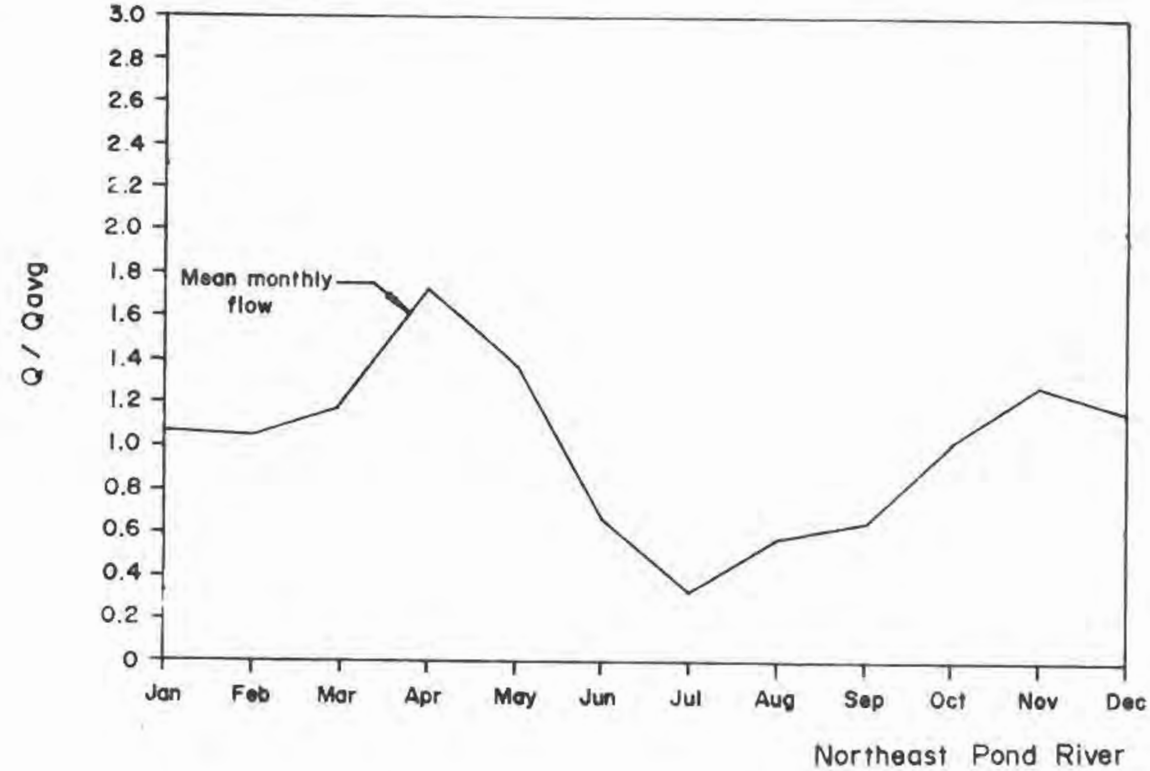
Rainfall and Total Precipitation at St. John's Airport

FIG.2.6

TABLE 2.1

SEASONAL DISTRIBUTION OF FLOWS AS PROPORTION OF MEAN ANNUAL FLOW

Month	Northeast Pond River 02ZM006	Northwest Brook 02ZN001	Waterford River at Kilbride 02ZM008	Rocky River 02ZK001	Mean
Drainage Area	3.9	53.0	52.7	285.0	
Jan	1.06	1.11	1.21	1.33	1.18
Feb	1.05	1.07	0.80	1.21	1.03
Mar	1.17	1.19	1.28	1.14	1.19
Apr	1.73	1.43	1.94	1.38	1.62
May	1.37	1.10	1.33	0.92	1.18
Jun	0.67	0.73	0.56	0.61	0.64
Jul	0.32	0.52	0.35	0.45	0.41
Aug	0.56	0.69	0.41	0.58	0.56
Sep	0.64	0.89	0.72	0.68	0.73
Oct	1.01	1.02	1.17	1.04	1.06
Nov	1.28	1.07	1.02	1.31	1.17
Dec	1.15	1.18	1.21	1.35	1.22



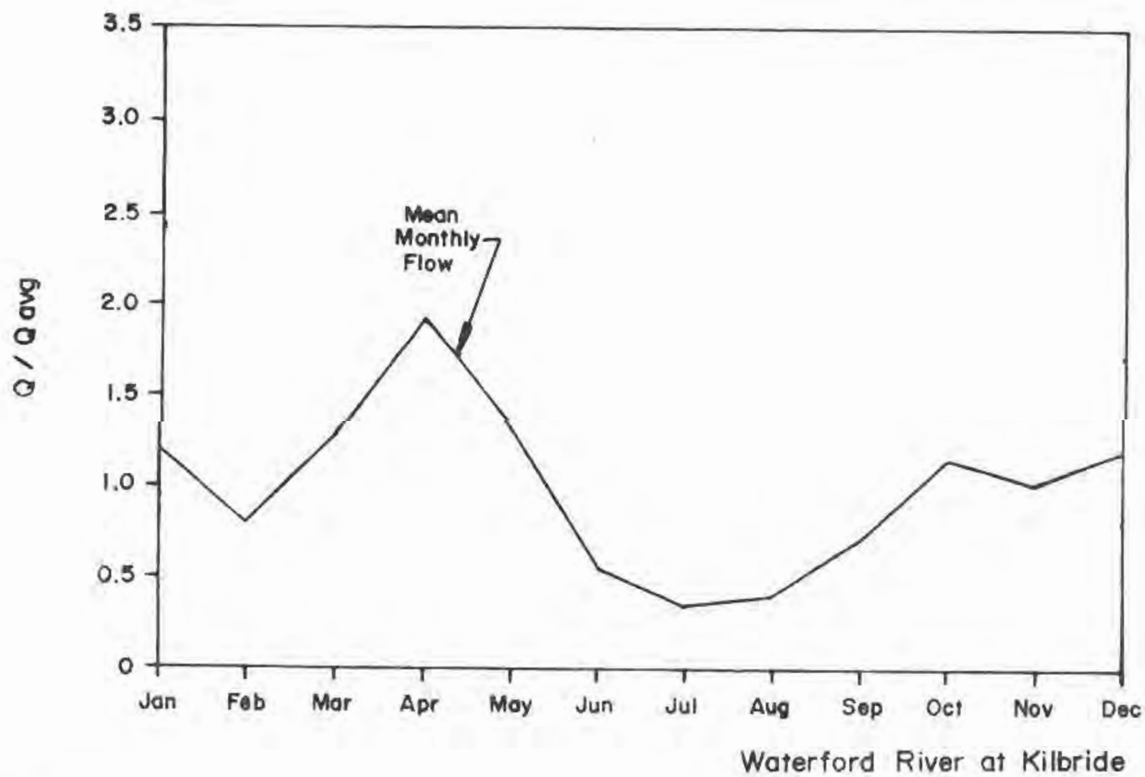


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FIG. 2.7

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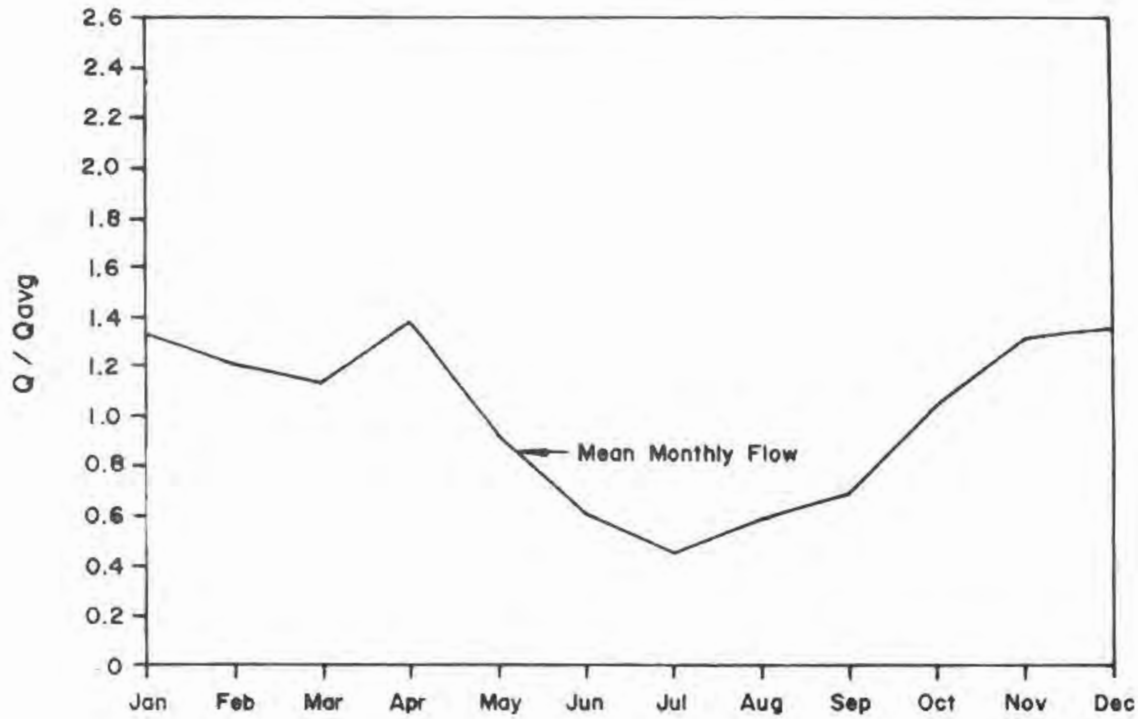
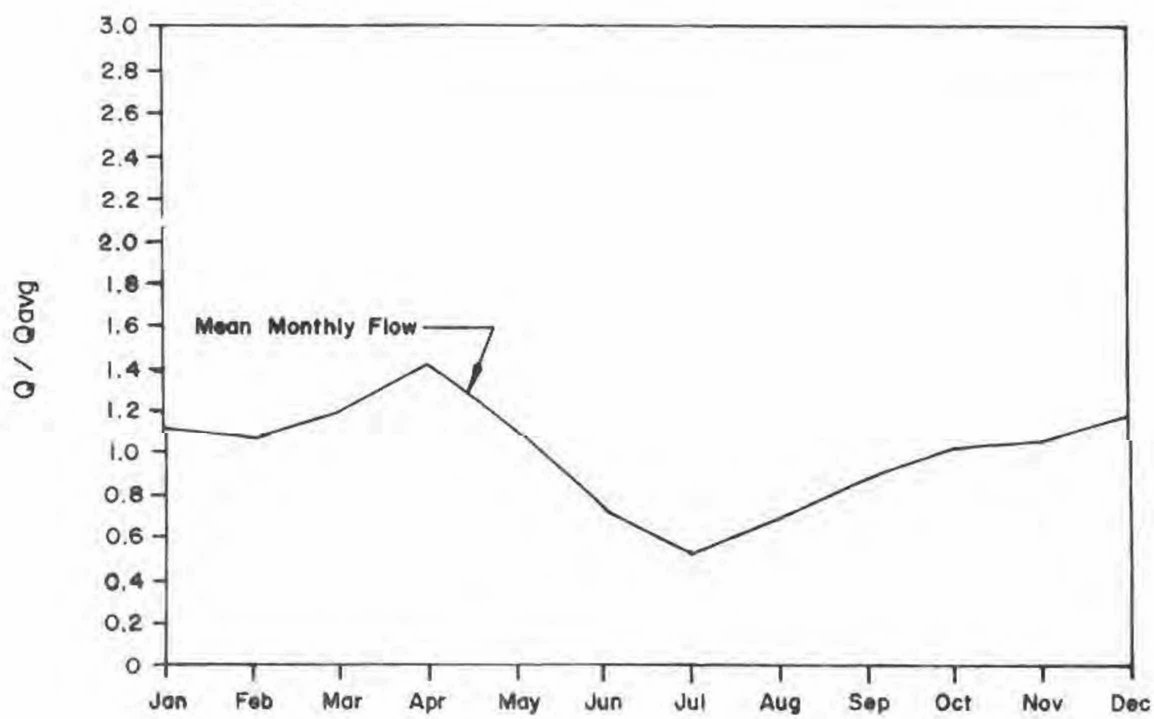
Mean Monthly Flow, Northeast Pond R. and Waterford R.



Rocky River



Northwest Brook

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FIG.2.8

Mean Monthly Flow, Rocky R. and Northwest Bk.

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year round. Rocky River's annual pattern is very similar to Northwest Brook's; the summer mean low flow is only slightly lower. It is a much larger basin (285 km^2), but is located in the slightly drier corridor along the western study boundary (Figure 2.2).

The basin with the most seasonal variation is the Waterford River at Kilbride, followed by Northeast Pond River. In the case of Northeast Pond River, a wide variation is expected because of the small size of the basin. The Waterford River shows more variation than the Northwest Brook, a basin of the same size (both are about 53 km^2), probably for several reasons. First, it has less storage than Northwest Brook (4.7 per cent lakes and swamps for the Waterford River basin, compared with 12.6 per cent for Northwest Brook). The lesser amount of storage is due partly to urbanization, and partly to a difference in the natural physiography.

A second important explanation is the distribution of precipitation through the year. Table 2.2 shows the mean monthly precipitation in the months which have the highest and lowest average precipitation. The stations are grouped into 3 regions. The stations in the south show less variation in (monthly) precipitation as a per cent of the mean than the northern stations. Since Northwest Brook is located in the south, it would be expected to have a more even distribution of runoff than Waterford River or Northeast Pond River in the north.

2.2.2 - **Distribution of High and Low Monthly Flows**

It is often useful to have an idea of the range of flows that can be expected through the year, in addition to the mean monthly values. The highest and lowest flows for a gauged basin can be obtained by inspection of the record. If the record is long, the range of expected flows will probably be reasonably represented

TABLE 2.2

MINIMUM AND MAXIMUM MONTHLY PRECIPITATION SELECTED CLIMATE STATIONS

Climate Station	Mean Precip. in Max. Month (mm)	Per cent of Mean Annual	Mean Precip. in Min. Month (mm)	Per cent of Mean Annual	Mean Annual Precip. (mm)
Southern					
Cape Race	146.3	127	80.5	70	1379
Salmonier	151.2	127	86.9	73	1425
St. Shott's	139.5	115	104.2	86	1453
Mean		123		76	1419
Central					
Petty Hbr	164.1	139	70.2	59	1420
Pierre's Brook	161.5	131	75.4	61	1484
Tors Cove	152.3	131	73.1	63	1390
Mean		134		61	1431
Northern					
Holyrood	131.4	153	46.7	54	1029
Holyrood Gen Stn	124.0	138	59.6	67	1075
Holyrood Ultramar	127.5	140	54.7	61	1084
St. John's	164.8	139	60.6	51	1421
St. John's A	163	129	75.3	60	1514
St. John's West	180.8	136	73.8	56	1595
Mean		139		58	1286

Note: Values taken from AES 1951-1980 climate summary. Maximum and minimum values are the mean values over the period of record for the month with the highest or lowest average precipitation.

by the historic sequence. For basins with a short record, or for ungauged basins, an alternative is required.

The 10 per cent and 90 per cent exceedance values for the flow duration curves (see Section 2.3.1) for each month for the four natural gauged streams with record lengths longer than 10 years were plotted, as shown in Figures 2.9 and 2.10. The mean monthly flow can be expected to be within this range 80 per cent of the time, on the average. As with mean monthly flow, the most variation is seen in the more northerly basins, Waterford River followed by Northeast Pond River. The least variation occurs at Northwest Brook, followed by Rocky River.

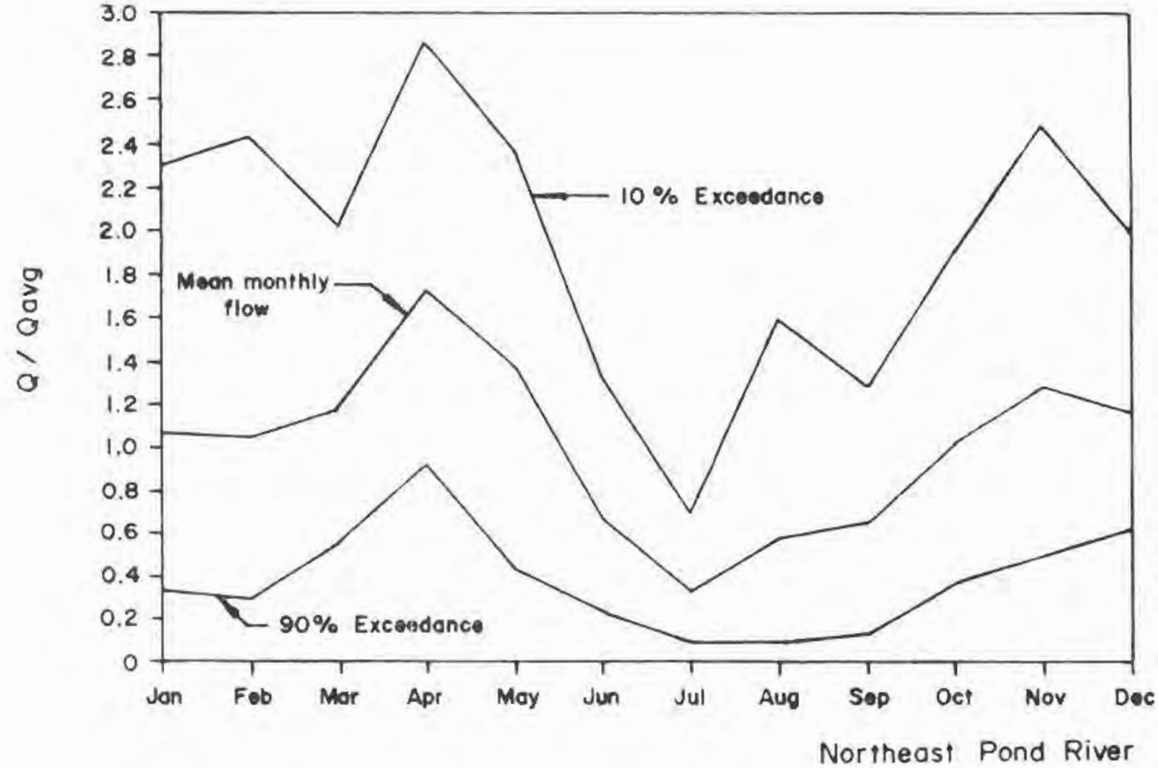
2.3 - Low Flow Analysis

Suitable low flow measures can be provided by both flow duration and low flow frequency analysis. The approach taken in this study was to provide estimates of several low flow measures for the four gauged basins from both these types of analyses. The estimated low flows were then non-dimensionalized using mean annual runoff and drainage area, and averaged.

The required low flows were then estimated for ungauged catchments using both the average value of the selected measure. This approach was relatively simple to apply, and gives a reasonable approximation of the low flow measure being estimated.

Although it is desirable to include other parameters besides mean annual runoff and drainage area to predict low flows, there are not enough gauges with long-term records to allow the required regression analysis.

The low flow measures referred to above apply only to natural streams. Most water supply projects incorporate some form of storage, and it is important to be able to estimate how much



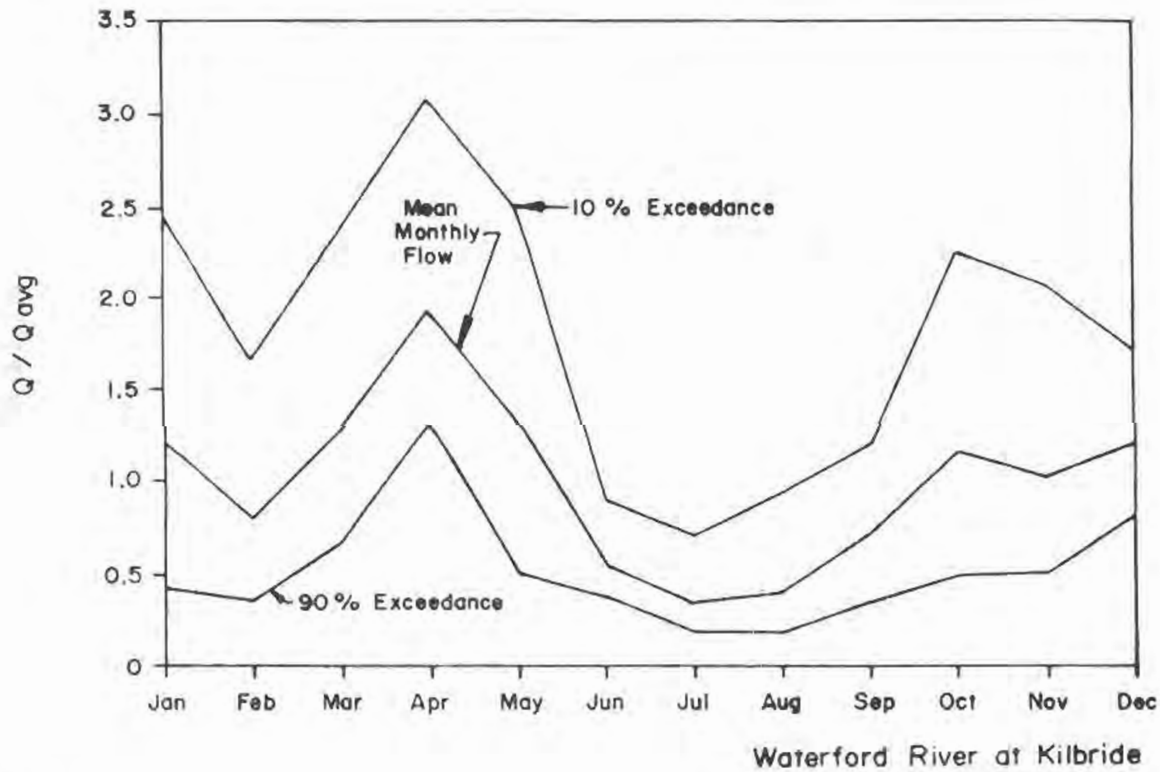


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FIG. 2.9

Monthly Flow Variation, Northeast Pond R. and Waterford R.

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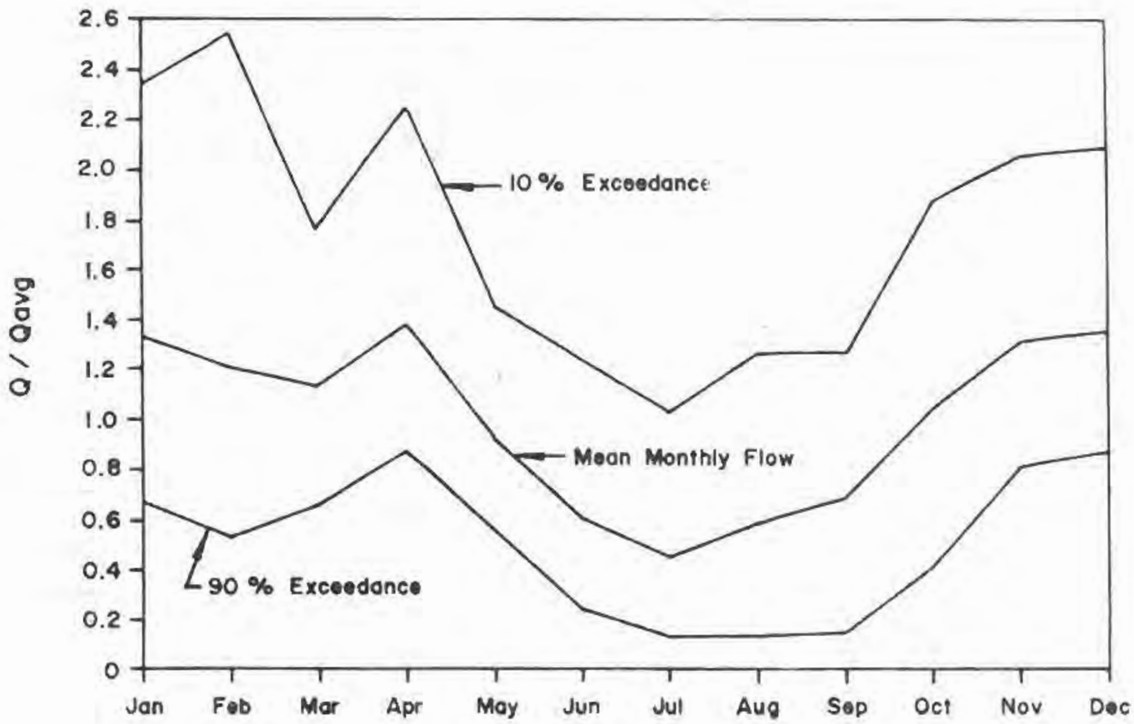
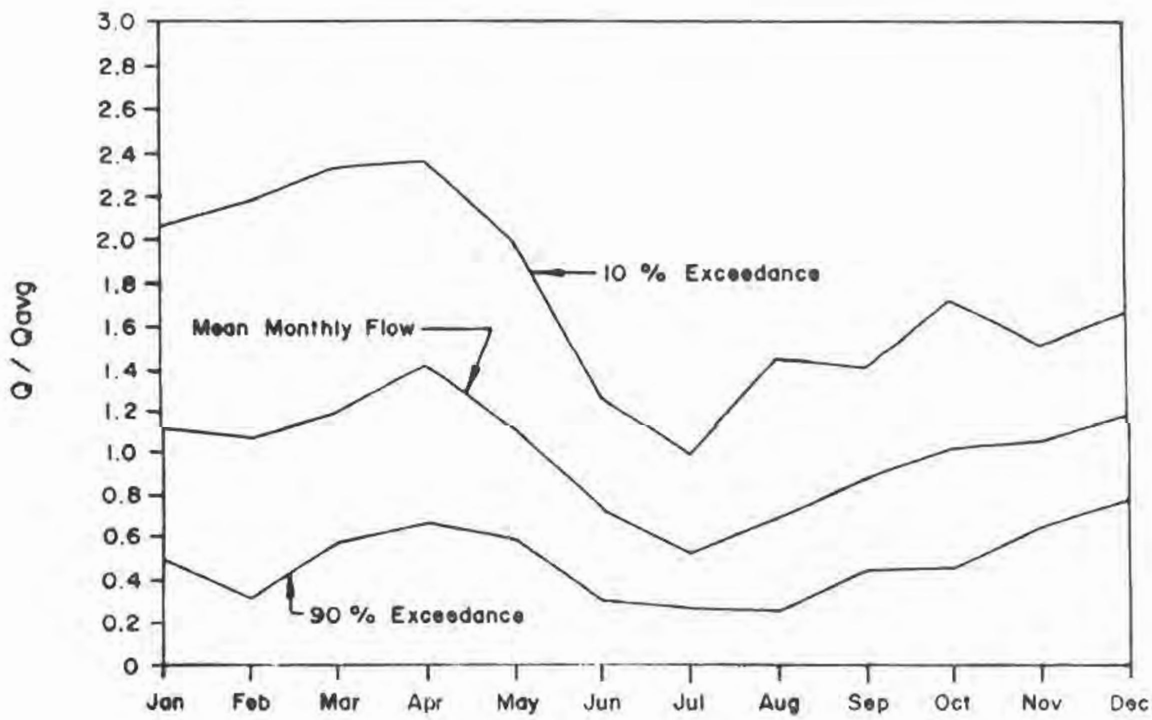


Rocky River



Northwest Brook

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FIG.2.10

Monthly Flow Variation, Rocky R. and Northwest Bk.

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storage is required to provide the necessary reliable yield. A method was therefore developed to enable the effects of storage to be quickly assessed in the supply/demand analysis.

Section 2.3.1 below presents a summary of the results of the low flow analyses, the flow duration and flow frequency. For both analyses the durations selected were 1 day and 1 month. These bracket the usual range of required low flow durations (e.g. 1 day, 3 day, 7 day, 15 day, 30 day); the 1 month low flow will be slightly higher than the 30 day low flow. Section 2.3.3 then describes the assessment of storage benefits.

2.3.1 - Low Flow Indices

Flow duration curve

Daily flow duration curves were prepared from all the gauge records in the study area, and monthly curves were prepared for the four natural long term records. These are presented in Appendix A.

The low flow indices used from the flow duration analysis are defined below.

Q95(1 day)	-	The daily flow having a probability of exceedance of 95 per cent (i.e. 1 day out of 20, on average)
Q95(1 month)	-	The monthly flow having a probability of exceedance of 95 per cent (i.e. 1 month out of 20, on average)

The indices were first developed for the gauged catchments, and non-dimensionalized. A mean value was then obtained for application to ungauged catchments. Results are presented in Table 2.3.

TABLE 2.3

Q95(1 DAY) AND Q95(1 MONTH) FOR SELECTED GAUGED BASINS

Gauge 02Z	Name	D.A. (km^2)	Q95 (1 Day) (m^3/s)	Q95 (1 Day) Non-dim*	Q95 (1 Month) (m^3/s)	Q95 (1 Month) Non-dim*
M006	N.E. Pond	3.90	0.008	0.065	0.016	0.118
M008	Waterford R.	52.7	0.294	0.140	0.424	0.201
N001	N.W. Brook	53.3	0.638	0.200	0.875	0.280
K001	Rocky R.	285.	1.35	0.120	1.95	0.174
	Mean			0.131		0.193
	Std Dev.			0.056		0.067

*Non-dimensionalized by dividing by mean annual flow

2.3.2 - Low Flow Frequency Analysis

Low flow frequency curves were also prepared from annual series of lowest days and lowest months for the 4 gauges, using the low flow frequency analysis program, LOFLOW, developed by R. Condie and L.C. Cheng of the Water Resources Branch of the Inland Waters Directorate of Environment Canada. A Gumbel III probability distribution (Weibull plotting position) is assumed. Results are similar if a log Gumbel distribution is assumed for the return periods considered in this study.

The two low flow indices selected from the frequency analysis are defined below.

Q1:10(1 day) - The daily low flow having a return period of one in ten years.

Q1:10(1 month) - The monthly low flow having a return period of one in ten years.

For the supply/demand analysis in Chapter 6, the low flow criterion selected was the Q1:10(1 month).

The indices were developed for the gauged catchments, and non-dimensionalized using average annual flow. A mean value was obtained for application to ungauged catchments. Results are presented in Table 2.4.

TABLE 2.4

Q1:10(1 DAY) AND Q1:10(1 MONTH) FOR SELECTED GAUGED BASINS

Gauge 02Z	Name	D.A. (km^2)	Q1:10(1 Day) (m^3/s)	Q1:10(1 Day) Non-dim*	Q1:10(1 Month) (m^3/s)	Q1:10(1 Month) Non-dim*
M006	N.E. Pond	3.90	0.002	0.015	0.006	0.044
M008	Waterford R.	52.7	0.151	0.073	0.324	0.156
N001	N.W. Brook	53.3	0.319	0.105	0.632	0.209
K001	Rocky R.	285.	0.404	0.036	1.175	0.104
	Mean			0.057		0.128
	Std Dev.			0.040		0.071

*Non-dimensionalized by dividing by mean annual flow

2.4 - Storage/Yield Analysis

Assessing the availability of water for any major use such as water supply or hydro power requires the estimation of the effect of storage. As soon as even a small dam is installed and some regulation is possible, the low flow analysis must be modified.

An assessment on benefits of storage usually requires a site-specific analysis. A daily or monthly series of inflows is obtained, from a long-term gauge record if possible. The characteristics of the project are defined, in particular the demand rate or draw on the reservoir, spillway (or other) outflows and the volume-elevation relationship for the pond. The operation of the system is then simulated on a daily or monthly basis over the period of the streamflow sequence.

A detailed analysis was carried out to allow the reliable yield to be estimated for any site, taking into account available storage based on three easily obtained parameters: mean annual runoff, area of pond/reservoir and drainage basin, and maximum water level fluctuation. If live storage is known from site data, then it can be used directly. The live storage is the volume of water between the lowest allowable water level and the maximum level at which the water is retained.

Daily operation for different live storage volumes was simulated for the four selected gauged catchments for the periods of record, for various withdrawal rates. The storage required for different withdrawal rates on the reservoir was obtained, for each location. The storages for which the withdrawal rate is guaranteed, i.e., no failures in simulation period, were then expressed as a per cent of annual flow volume. The results were similar for all 4 gauge records, and are summarized in Table 2.5. Using yields obtained from this table, the reservoir will fail less than once in ten years.

TABLE 2.5

YIELD/STORAGE RELATIONSHIP

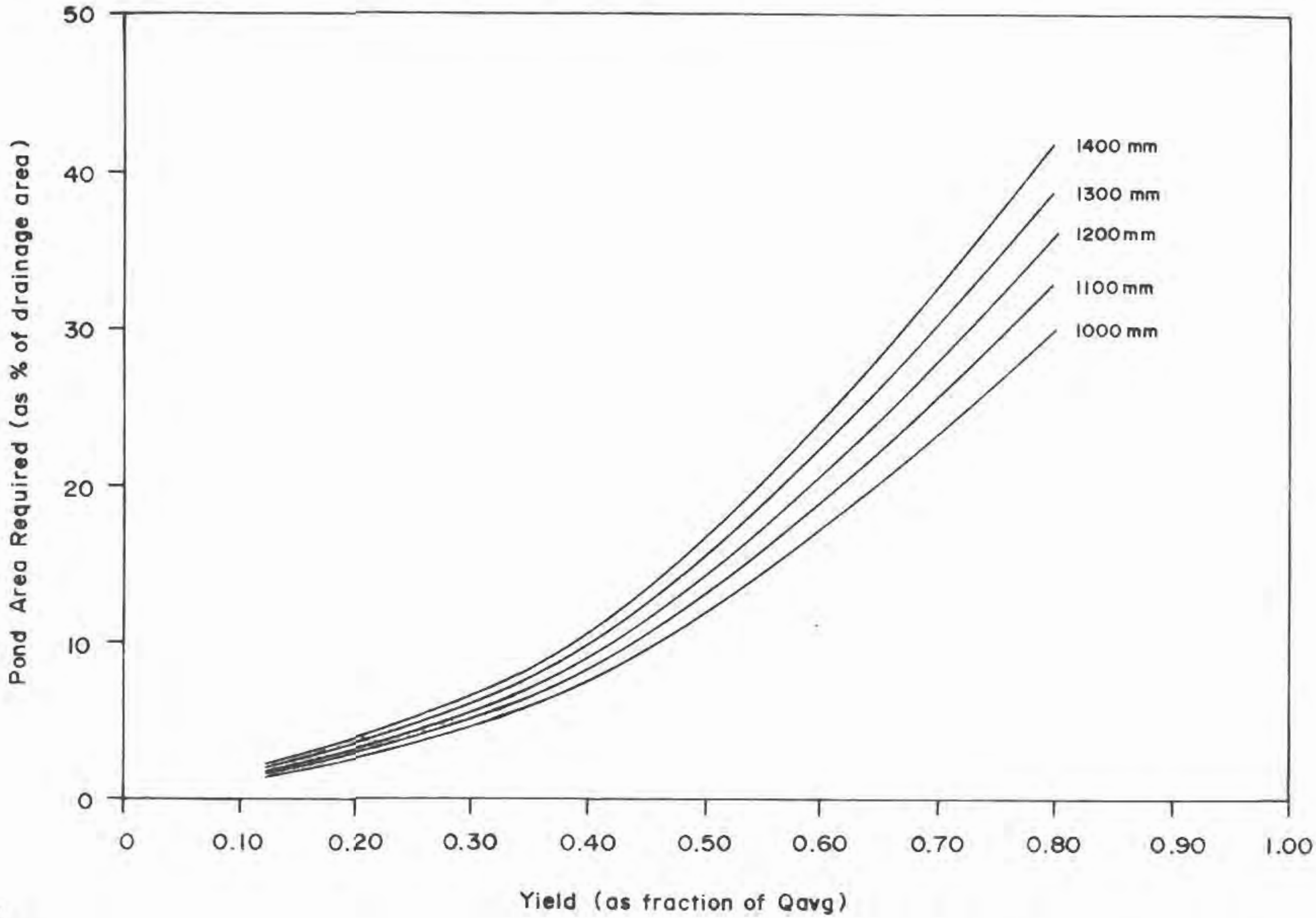
Yield (Fraction of Average Flow)	Storage (Fraction of Average Annual Volume)
0.2	0.025
0.4	0.075
0.6	0.200
0.8	0.300

The results in Table 2.4 were converted to the plot given in Figure 2.11, assuming 1 m of live storage in the pond. An equivalent pond area can be calculated for other heights. These curves were used extensively in this supply/demand analysis in Section 6 to estimate reliable yield for the communities with surface supplies in the study area, since reliable yields are generally not otherwise available, except for the regional water supply system reservoirs.

2.5 - Natural Surface Water Availability

To estimate natural surface water availability, the study area was divided into natural drainage basins. Each basin was defined from the mouth of the river to its most upstream limit. Some 73 such major basins were outlined. In addition, some 42 coastal areas drained by surface runoff or small brooks were identified. Occasionally, where one of these contained a small municipal water supply source, the water supply watershed was separately identified.

These were grouped into four regions - north, south, east and west. For each of these basins, the average flow and Q1:10 (1 month) were calculated. The Q1:10(1 month) was chosen for



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Water Resources Division

Regional Water Resources Study
Eastern Avalon Peninsula

Area / Yield / Runoff Relationships

FIG.2.11

this study. Alternatively one of the flow duration curve measures could be used.

The procedure used was as follows.

- Identify all the major streams draining to the sea.
- Mark their watershed boundaries.
- Locate centroid of each basin.
- Select appropriate mean annual runoff from Figure 2.2.
- Calculate mean annual flow, using Figure 2.2 and the drainage basin area
- Calculate Q1:10(1 month) from Table 2.4.

Plate 1 shows the location of the identified watersheds, and Table 2.6 lists all the basins identified in the study area, together with their estimated average and low flows.

The total mean annual flow volume is nearly 6100 Mm^3 in the study area, and the average annual runoff is nearly 1280 mm/a.

TABLE 2.6

DRAINAGE BASIN DATA

REF. NO.	Drainage Basin	Drainage Area (km2)	Avg. Annual Runoff (mm)	Mean Ann. Flow (m3/s)	Q1:10 1 month (m3/s)
S 1	Peter's River	141.4	1400	6.27	0.809
S 2	Northwest Brook	169.5	1600	8.59	1.109
S 3	St. Shott's River	94.6	1200	3.60	0.464
S 4	Tartan Lake River	4.7	1050	0.16	0.020
S 5	Northeast Brook	20.9	1350	0.89	0.115
S 6	Back Brook	26.7	1350	1.14	0.147
S 7	Portugal Cove Brook	40.6	1350	1.74	0.224
S 8	Chance Cove Brook	98.8	1300	4.07	0.525
S 9	Clam Cove	35.4	1200	1.35	0.174
S10	Wrights River	6.7	1100	0.23	0.030
S11	Bristy Cove River	40.0	1150	1.46	0.188
S12	Long River	16.1	1100	0.56	0.072
S13	Freshwater River	15.5	1100	0.54	0.070
S14	Biscay Bay River	244.9	1700	13.19	1.702
SC 1	Cape Race Coastal	57.4	900	1.64	0.211
SC 2	Mutton Bay Coastal	44.2	1000	1.40	0.181
SC 3	Trepassey Coastal	38.9	1150	2.51	0.324
SC 4	Shoal Point Coastal	5.2	1150	0.19	0.024
SC 5	Daniel's Point Coastal	29.4	1700	1.58	0.204
SC 6	St. Shott's Coastal	45.2	1300	1.86	0.240
SC 7	Gull Island Coastal	144.0	1100	5.02	0.648

TABLE 2.6

DRAINAGE BASIN DATA

REF. NO.	Drainage Basin	Drainage Area (km2)	Avg. Annual Runoff (mm)	Mean Ann. Flow (m3/s)	Q1:10 1 Month (m3/s)
NC 1	Cape St. Francis West	5.9	800	0.15	0.019
NC 2	Cape St. Francis East	4.3	900	0.12	0.016
NC 3	Pouch Cove Coastal	3.1	900	0.09	0.011
NC 4	Blackhead N Coastal	2.5	900	0.07	0.009
NC 5	Red Head	3.6	900	0.10	0.013
NC 6	Cove Pond Brook	1.2	1000	0.04	0.005
NC 7	Bauline Coastal	1.5	800	0.04	0.005
NC 8	Flatrock Coastal	4.6	900	0.13	0.017
NC 9	Torbay Coastal	4.8	900	0.14	0.018
NC10	Freshwater Pond	13.8	950	0.42	0.054
NC11	Torbay Coastal	0.9	900	0.03	0.003
NC12	Logy Bay Coastal	11.4	900	0.33	0.042
NC13	Sugarloaf Coastal	3.1	900	0.09	0.011
NC14	St. John's Coastal	8.1	900	0.23	0.030
NC15	Freshwater Coastal	19.3	900	0.55	0.071
NC16	Cape Spear Coastal	24.4	900	0.70	0.090
NC17	St. Phillips Coastal	2.2	900	0.06	0.008

TABLE 2.6

DRAINAGE BASIN DATA

REF. NO.	Drainage Basin	Drainage Area (km2)	Avg. Annual Runoff (mm)	Mean Ann. Flow (m3/s)	Q1:10 1 month (m3/s)
N 1	Northeast Pond	4.0	1000	0.13	0.016
N 2	Pouch Cove Brook	15.2	1000	0.48	0.062
N 3	Brook at Small Point	2.5	1000	0.08	0.010
N 4	Shoe Cove Brook	13.3	1050	0.44	0.057
N 5	Bauline Brook	8.7	1050	0.29	0.037
N 6	Half Moon Pond	6.5	1000	0.21	0.027
N 7	Piccos Brook	31.9	1100	1.11	0.143
N 8	Island Pond Brook	17.5	1100	0.61	0.079
N 9	North Pond Brook	6.9	1050	0.23	0.030
N10	Jones Pond Brook	1.0	1050	0.03	0.004
N11	Kennedys / Soldiers Brook	6.4	1050	0.21	0.027
N12	Outer Cove Brook	12.0	1050	0.40	0.052
N13	Main Northeast Pond River	18.1	1050	0.60	0.078
N14	Virginia River	15.5	900	0.44	0.057
N15	Windsor Lake	17.3	1200	0.66	0.085
N16	Rennie's River	29.1	1100	1.01	0.131
N17	Beachy Cove Brook	7.6	1050	0.25	0.033
N18	Goat Cove Brook	2.7	1050	0.09	0.012
N19	Horse Cove Brook	5.0	1050	0.17	0.021
N20	Broad Cove River	23.3	1100	0.81	0.105
N21	Waterford River	63.8	1100	2.22	0.287
N22	Petty Harbour Coastal	10.1	900	0.29	0.037
N23	Fowlers Brook	2.5	1050	0.08	0.011
N24	Manuels River	18.0	1100	0.63	0.081
N25	Topsail River	36.9	1100	1.29	0.166
N26	Conway Brook	13.2	1100	0.46	0.059
N27	Steadywater Brook	6.5	1050	0.22	0.028
N28	Foxtrap River	4.4	1000	0.14	0.018
N29	Kelligrews River	15.5	1050	0.52	0.067
N30	Lower Gullies River	21.1	1100	0.74	0.095
N31	Upper Gullies River	4.1	1000	0.13	0.017
N32	Billy Brook	3.8	1000	0.12	0.016
N33	Quarry Brook	13.9	1150	0.51	0.065
N34	Seal Cove River	78.0	1200	2.97	0.383
N35	Mahers River	43.7	1400	1.94	0.250
N36	Daniels / North Arm River	93.1	1200	4.43	0.571
N37	Petty Harbour	134.0	1360	5.78	0.745
N38	Petty Harbour Long Pond	7.8	1050	0.26	0.033

TABLE 2.6

DRAINAGE BASIN DATA

REF. NO.	Drainage Basin	Drainage Area (km2)	Avg. Annual Runoff (mm)	Mean Ann. Flow (m3/s)	Q1:10 1 month (m3/s)
E 1	Bay Bulls River	40.6	1200	1.54	0.199
E 2	Pierre's Brook (Gull Pond)	117.0	1350	5.01	0.646
E 3	Mobile (Mobile First Pond)	112.0	1670	5.93	0.765
E 4	Tors Cove	208.0	1500	9.89	1.275
E 5	Horse Chops	191.4	1600	9.70	1.252
E 6	Cape Broyle River	51.8	1300	2.13	0.275
E 7	Spout River	97.2	1550	4.77	0.616
E 8	Aquaforte River	62.9	1450	2.89	0.373
E 9	Little River	3.9	1200	0.15	0.019
E10	Chance Pond River	5.3	1000	0.17	0.022
E11	Bear Cove Pond	3.6	1000	0.12	0.015
E12	Renews River	83.2	1350	3.56	0.459
E13	Old Women's Brook	17.1	1200	0.65	0.084
E14	Cappahayden	59.3	1200	2.26	0.291
EC 1	Motion Head Coastal	42.1	900	1.20	0.155
EC 2	Bull Head Coastal	22.8	900	0.65	0.084
EC 3	Witless Bay Coastal	18.8	1000	0.60	0.077
EC 4	Witless Bay Brook Coastal	26.9	1000	0.85	0.110
EC 5	Tors Cove Coastal	12.7	1000	0.40	0.052
EC 6	La Manche Coastal	95.4	1100	3.33	0.429
EC 7	Ferryland Coastal	52.8	900	1.51	0.194
EC 8	Fermeuse Coastal	35.5	1100	1.24	0.160
EC 9	Renews Coastal	13.7	900	0.39	0.050
EC10	Cappayhayden Coastal	36.6	1100	1.28	0.165
EC11	Chance Cove Coastal	39.1	900	1.12	0.144

TABLE 2.6

DRAINAGE BASIN DATA

REF. NO.	Drainage Basin	Drainage Area (km2)	Avg. Annual Runoff (mm)	Mean Ann. Flow (m3/s)	Q1:10 1 month (m3/s)
W 1	Salmonier River	255.3	1100	8.90	1.148
W 2	Little Harbour River	242.3	1300	9.98	1.288
W 3	Crossing Place River	150.3	1550	7.38	0.952
W 4	Holyrood Pond	31.5	1550	1.55	0.200
W 5	Path End	15.4	1150	0.56	0.072
W 6	Riverhead River	21.1	1200	0.80	0.104
W 7	Mall Bay Brook	23.7	1200	0.90	0.116
W 8	St. Josephs Pond	13.8	1000	0.44	0.056
WC 1	St. Stephen Coastal	62.9	1000	1.99	0.257
WC 2	Upper Holyrood Pond Coastal	11.2	1100	0.39	0.050
WC 3	St. Mary's Coastal	50.8	1000	1.61	0.208
WC 4	Riverhead Coastal	30.5	1100	1.06	0.137
WC 5	Mall Bay Coastal	25.4	1000	0.80	0.104
WC 6	Shoal Bay R. Coastal	20.3	900	0.58	0.075
WC 7	Salmon Brook Coastal	64.0	900	1.83	0.235
WC 8	St. Joseph's Coastal	16.8	900	0.48	0.062

3 - GROUNDWATER AVAILABILITY

3 - GROUNDWATER AVAILABILITY

The geology and hydrogeology have been described in detail in Report 2-6 of the Department of Environment Groundwater Report series(25), on which much of the material in this section is based.

The study area is characterized by a mantle of glacially derived overburden material, overlying fractured sedimentary bedrock of Precambrian origin. The till mantle is thin, typically less than 5 m in depth, and bedrock outcroppings are frequent. Thick till deposits do occur, however, particularly at the heads of bays, such as Bay Bulls, Witless Bay, Middle Cove, Seal Cove, Holyrood Pond, and Peter's River. At St. Shott's, one drift section is 30 m thick, but such depths are rare.

As a result of this geology, groundwater flow systems are closely tied to surface water systems. Wells are dug or drilled in both overburden and bedrock. The flow systems are faster in the till than in the bedrock, but both are closely connected with surface water. Lakes and ponds serve as both local and regional discharge points. The implication of the close surface water/-groundwater connection is that wells are very sensitive to dry periods, unless some storage is available in the well or in a reservoir.

3.1 - Surficial Hydrogeology

Most wells are developed in overburden, but little information is available, and as a result, groundwater potential cannot be properly assessed. Two major hydrostratigraphic units have been identified in the surficial layer, moraine deposits and outwash deposits.

The eskers and meltwater channels occurring in the coastal areas in the southern part of the study region have been identified as possibly significant aquifers, but no data are available.

The moraine deposits have low permeability; average yields are less than 9 L/min. The outwash deposits have a greater groundwater potential; the mean yield of the outwash deposit wells examined in the Groundwater Report was 40.6 L/min. No data are available on reliable yields.

3.2 - Bedrock Hydrogeology

In the bedrock, fractures are the primary groundwater conduits; the main fracture features are joints, fracture zones, and shear zones. The best yield comes from wells located in highly fractured areas, but these areas are difficult to identify. The larger amount of fracturing means that often they have been eroded more than adjacent rock, resulting in depressions filled with overburden.

Four bedrock hydrostratigraphic units were identified in the study region; Bell Island is a unique fifth unit. The average yields and range of yields of wells with data are given in Table 3.1. The range of yields is very wide. Yield does not improve *significantly with depth. If increased yields are required,* improved development practices are probably more promising than deeper drilling.

TABLE 3.1

BEDROCK HYDROSTRATIGRAPHIC UNITS, YIELDS AND DEPTHS

Bedrock Hydrostratigraphic Unit	Well Yield (L/m) Mean	Range	Well Depth (m) Mean	Range
Unit A Moderate Yield	25.2	1.1-136.5	43.7	7.0-154.5
Unit B Low to Moderate Yield	20.1	0.6-136.5	51.7	9.8-152.4
Unit C Moderate to High Yield	43.0	1.1-273	49.7	12.2-111.3
Unit D Moderate Yield	27.4	1.1-364	47.7	7.0-121.9
Unit E High Yield	73.5	68-273	77.2	21.3-201.2

Unit A includes	Harbour Main Group, Holyrood Granite (Volcanics, Sedimentary, Intrusive granitic rocks)
Unit B includes	Conception, Dildo Groups (Siliceous sandstone, shale, siltstone, tuff, tillite, volcaniclastics conglomerate)
Unit C includes	Signal Hill Group (Breccia, conglomerate, sandstone, siltstone, shale, tuff)
Unit D includes	St. John's, Random, Bonavista, Smith Point, Brigus, Chamberlains Brook, Manuels River, Elliot Cove Formations (Shale, slate, limestone, quartzite, conglomerate, arkose, siltstone sandstone)
Unit E includes	Wabana and Bell Island Groups (Sandstone, siltstone, shale)

Information from Water Resources Report 2.6, Groundwater Series (Reference 25).

Reliable yield, or long term safe yield, is a more important characteristic of a well. Reliable yield is determined by controlled aquifer testing, but such tests are infrequently undertaken. Results are available for 6 tests in the Conception Group (Hydrostratigraphic Unit B) and for 9 tests in the St. John's Group (Unit D). Results are given in Table 3.2.

TABLE 3.2

RESULTS OF AQUIFER TESTS

	Avg Reliable Yield (L/min)	Range (L/min)
Conception Group (Unit B)	26	14.5 to 50
St. John's Group (Unit D)	10.4	1 to 25

3.3 - Relationship of Surface and Groundwater Flow

No information is available on whether reliable yield as determined by aquifer testing varies seasonally or annually (i.e., as a function of precipitation or streamflow). Given the close interconnection of surface and groundwater flow, such a variation might be expected.

Data from observation wells in the Waterford River Basin and the streamflow gauge on the Waterford River at Kilbride show a strong correlation. This relationship indicates relatively high soil moisture content and overburden permeability. Given the numerous bogs and ponds throughout the study area, and the close connection between them and the surficial material, it is difficult to separate groundwater and surface storage in determining base flow contribution.

Wells are an important source of water in small communities and rural areas in the study region. Properly located and developed, they can continue to supply domestic users. The close connections with surface water suggests that there is little groundwater reserve during dry periods.

4 - WATER QUALITY

4 - WATER QUALITY

4.1 - Introduction

A review of the water quality data, presented in the following sections and in Appendix C indicates that the present water quality in the study area is generally good.

The relatively pure state of the water can be explained by two principal factors. First, most of the rivers are short, and water is not required for reuse; consequently effluents are usually discharged directly to the sea. Second, the industries located in the study area are not typically heavy polluters. Primary industries in the region consists of agriculture and the fishery; the amount of land under cultivation is small, and consequently the contribution of pesticides and fertilizers to runoff is small. Secondary and tertiary industries include the service industries, food and beverage processing, and light manufacturing. No pulp and paper or chemical processors are located here.

Notwithstanding the generally good water quality, three major concerns have been identified in this study.

1. Local instances of freshwater degradation.
2. Non-local sources of pollution (airborne pollutants, and rain).
3. Coastal and estuarine pollution.

The first two are discussed in this report. The third, coastal pollution, is beyond the scope of the study. Nevertheless, one of the reasons that surface waters are of good quality is that most wastes are discharged directly to the sea. The effects of such discharges on coastal waters should be examined.

Section 4.2 describes the present quality of the water in the study region. Section 4.3 then outlines the water quality requirements for the major water uses and Section 4.4 discusses possible degradation resulting from both local and non-local sources of pollutants.

4.2 - Present Water Quality

The present water quality of most of the surface water ponds and streams in the area is good, with the exception of those in developed areas. Naturally occurring surface waters are soft, acidic, coloured, and occasionally turbid. Concentrations of major ions are low, with the exceptions of sodium and chloride from airborne sea salts. Metal concentrations also tend to be low, with the exception of iron and manganese, reflecting the composition of the sedimentary bedrock.

Tables 4.1 to 4.6 present surface water quality data for six rivers in or adjacent to the study area. These rivers are monitored by the Department of Environment, Province of Newfoundland, under a joint program with Environment Canada. The information presented here is from the summary of 1965-80 data (13), combined with additional data for the period 1981-85 from the National Water Quality Data Base (NAQUADAT) of Environment Canada.

The monitored rivers are

- Broad Cove River
- Mobile River
- Northeast Pond River
- Northwest Brook
- Rocky River
- Seal Cove Brook (near Cappahayden)

The locations of these watersheds are shown on Plate 1.

TABLE 4.1

WATER QUALITY DATA : BROAD COVE RIVER (00NF02M0010)

(1965-1885)

		Samples	Flags	Low	High	Mean
Specific Conduct.	USIE/CM	75	0	11	100	46.16
Turbidity	JTU	96	0	0.1	9	1.09
Colour Apparent	Rel. units	94	0	5	65	23.70
PH	PH Units	94	0	3.7	7	-
Alkalinity Total	mg/l	95	25	0.1	13	1.93
Alkalinity Phenol	mg/l					
Total Dissolved Solids	mg/l	5	0	28	68	42.00
Hardness Total	mg/l	13	0	5.6	78.1	8.10
Sodium Dissolved	mg/l	40	0	5.6	195	12.88
Potassium Dissolved	mg/l	59	0	0.1	27.2	0.92
Calcium Dissolved	mg/l	47	0	1.14	29.5	2.41
Magnesium Dissolved	mg/l	56	0	0.6	1.3	0.80
Carbonate	mg/l	27	5	0	0	0.00
Bicarbonate	mg/l	27	5	0	10	2.00
Chloride Dissolved	mg/l	93	0	8.2	45	14.51
Sulphate Dissolved	mg/l	78	5	1.1	8	4.03
Saturation Index	PH Units	11	2	-5.6	-3.6	-5.10
Stability Index	PH Units	11	2	13.2	16.7	15.90
Sodium Adsorption Ratio	Rel. units	9	0	0.51	1.68	1.22
Silica Reactive	mg/l					
Oxygen Dissolved	mg/l	86	0	5	14.3	10.05
Oxygen Total COD	mg/l	24	0	1	62	17
Carbon Total Inorganic	mg/l					
Carbon Total Organic	mg/l					
Nitrogen Dsolv. NO3&NO2	mg/l					
Nitrogen Dsolv. Nitrate	mg/l	58	6	0.002	0.702	0.05
Nitrogen Dsolv. Ammonia	mg/l					
Nitrogen Total Ammonia	mg/l	60	29	0.004	0.07	0.01
Nitrogen Total Kjeldahl	mg/l	80	2	0	1.3	0.26
Phosphorus Dsolv. PO4	mg/l					
Phosphorus Total	mg/l	66	8	0.005	4.3	0.10
Fluoride Dissolved	mg/l					
Chromium Total	mg/l	3	3	0.01	0.01	0.01
Manganese Total	mg/l	49	3	0.01	0.12	0.05
Iron Total	mg/l	96	2	0.01	0.74	0.24
Nickel Total	mg/l	3	2	0.01	0.01	0.01
Copper Total	mg/l	29	15	0.01	0.14	0.02
Zinc Total	mg/l	47	24	0.01	0.14	0.02
Cadmium Total	mg/l	25	16	0	0.02	0.00
Lead Total	mg/l	29	18	0.01	0.02	0.01
Residue Nonfilterable	mg/l	96	62	1	42	4.31
Residue Filterable	mg/l	96	1	4	333	47.81
Coliforms Total	NO/DL	93	18	20	780	165.39
Coliforms Fecal	NO/DL	28	11	0	310	10.00

TABLE 4.2

WATER QUALITY DATA : MOBILE RIVER (00NF02M0011)

(1965-1980)

		Samples	Flags	Low	High	Mean
Specific Conduct.	USIE/CM	80	0	0	50	26.81
Turbidity	JTU	93	0	0.1	6.3	0.95
Colour Apparent	Rel. units	95	18	15	135	53.92
PH	PH Units	99	0	4.5	6.8	-
Alkalinity Total	mg/l	96	36	0.2	6	1.48
Alkalinity Phenol	mg/l					
Total Dissolved Solids	mg/l	7	4	19	31	24.00
Hardness Total	mg/l	13	0	3.9	36.6	5.60
Sodium Dissolved	mg/l	33	0	3.5	38.3	5.90
Potassium Dissolved	mg/l	59	0	0	1.5	0.30
Calcium Dissolved	mg/l	51	0	0.77	12.67	1.77
Magnesium Dissolved	mg/l	54	0	0.4	1.2	0.60
Carbonate	mg/l	27	0	0	0	0.00
Bicarbonate	mg/l	27	10	0	7	1.00
Chloride Dissolved	mg/l	98	0	4.7	19	9.07
Sulphate Dissolved	mg/l	85	6	1	9	3.06
Saturation Index	PH Units	12	8	-6.8	-4.2	-5.90
Stability Index	PH Units	12	8	14.6	18.1	17.10
Sodium Adsorption Ratio	Rel. units	8	0	0.72	1.55	0.83
Silica Reactive	mg/l					
Oxygen Dissolved	mg/l	82	0	4	16.6	10.45
Oxygen Total COD	mg/l	18	0	7	89	22.00
Carbon Total Inorganic	mg/l					
Carbon Total Organic	mg/l					
Nitrogen Dsolv. NO3&NO2	mg/l					
Nitrogen Dsolv. Nitrate	mg/l	59	28	0.002	1.32	0.03
Nitrogen Dsolv. Ammonia	mg/l					
Nitrogen Total Ammonia	mg/l	60	31	0.004	0.07	0.01
Nitrogen Total Kjeldahl	mg/l	83	0	0	1.1	0.26
Phosphorus Dsolv. PO4	mg/l					
Phosphorus Total	mg/l	69	11	0.005	0.26	0.05
Fluoride Dissolved	mg/l					
Chromium Total	mg/l	2	2	0.01	0.01	0.01
Manganese Total	mg/l	52	7	0.01	0.237	0.06
Iron Total	mg/l	99	0	0.08	3.1	0.45
Nickel Total	mg/l	2	1	0.01	0.13	0.07
Copper Total	mg/l	26	17	0.01	0.1	0.01
Zinc Total	mg/l	20	7	0.01	4.42	0.01
Cadmium Total	mg/l	24	20	0	0.01	0.00
Lead Total	mg/l	30	22	0.001	0.01	-
Residue Nonfilterable	mg/l	99	63	1	41	5.61
Residue Filterable	mg/l	98	0	4	198	43.37
Coliforms Total	NO/DL	94	16	11	1600	268.35
Coliforms Fecal	NO/DL	27	6	0	210	13.00

TABLE 4.3

WATER QUALITY DATA : NORTHEAST POND RIVER (00NF02M0002)

(1965-1980)

		Samples	Flags	Low	High	Median	Mean
Specific Conduct.	USIE/CM	109	0	31	158	50	52
Turbidity	JTU	110	6	0.1	2	0.6	0.6
Colour Apparent	Rel. units	111	1	5	70	20	24
PH	PH Units	112	0	3.9	7.8	5.7	-
Alkalinity Total	mg/l	109	25	0.4	6.4	1.5	1.8
Alkalinity Phenol	mg/l	86	0	0	0	0	0
Total Dissolved Solids	mg/l	105	24	16	40	24	25
Hardness Total	mg/l	109	0	3.6	11.5	6.2	6.2
Sodium Dissolved	mg/l	111	0	3.9	10	6.4	6.5
Potassium Dissolved	mg/l	111	0	0.2	0.9	0.4	0.5
Calcium Dissolved	mg/l	111	0	0.5	1.8	1	1.01
Magnesium Dissolved	mg/l	109	0	0.5	1.8	0.9	0.9
Carbonate	mg/l	109	25	0	0	0	0
Bicarbonate	mg/l	109	25	0	8	2	2
Chloride Dissolved	mg/l	112	0	6	21.6	10.7	11.3
Sulphate Dissolved	mg/l	110	1	1	7	3.5	3.6
Saturation Index	PH Units	105	24	-7.6	-3.3	-5.6	-
Stability Index	PH Units	105	24	14.2	19.2	16.8	-
Sodium Adsorption Ratio	Rel. units	110	0	0.86	1.45	1.13	1.13
Silica Reactive	mg/l	70	6	0.1	5.5	2.1	2.207
Oxygen Dissolved	mg/l	2	0	5.8	9.3	7.5	7.5
Oxygen Total COD	mg/l	1	0	33	33	-	-
Carbon Total Inorganic	mg/l						
Carbon Total Organic	mg/l	1	0	6.2	6.2	-	-
Nitrogen Dsolv. NO3&NO2	mg/l	84	30	0.001	0.48	0.01	0.038
Nitrogen Dsolv. Nitrate	mg/l	1	0	0.44	0.44	-	-
Nitrogen Dsolv. Ammonia	mg/l	32	5	0.005	0.5	0.04	0.118
Nitrogen Total Ammonia	mg/l	5	0	0.005	0.05	0.018	0.025
Nitrogen Total Kjeldahl	mg/l	1	0	0.1	0.1	-	-
Phosphorus Dsolv. PO4	mg/l	19	6	0.002	0.09	0.005	0.013
Phosphorus Total	mg/l	43	0	0.001	0.061	0.007	0.0079
Fluoride Dissolved	mg/l	34	30	0.02	0.3	0.07	0.08
Aluminum Dissolved	mg/l						
Chocmium Extrble	mg/l	5	3	0.0005	0.004	0.0005	0.0012
Manganese Dissolved	mg/l	10	4	0.01	0.07	0.01	0.018
Manganese Extrble	mg/l	31	1	0.01	0.12	0.04	0.04
Iron Dissolved	mg/l	9	0	0.01	0.13	0.05	0.058
Iron Extrble	mg/l	36	0	0.05	0.66	0.23	0.232
Nickel Extrble	mg/l						
Copper Extrble	mg/l	28	11	0.001	0.1	0.003	0.01
Zinc Extrble	mg/l	29	9	0.001	0.25	0.004	0.017
Arsenic Total	mg/l	17	16	0.005	0.008	0.005	0.005
Arsenic Dissolved	mg/l	4	2	0.005	0.01	0.005	0.006
Cadmium Extrble	mg/l	33	27	0.001	0.002	0.001	0.001
Mercury Extrble	+g/l	45	38	0.05	0.13	0.050	0.060
Lead Extrble	mg/l	28	18	0.001	0.01	0.002	0.003
Chromium Total	mg/l	1	1	0.01	0.01	-	-
Manganese Total	mg/l	1	0	0.061	0.061	-	-
Iron Total	mg/l	1	0	0.388	0.388	-	-
Nickel Total	mg/l	1	1	0.01	0.01	-	-
Copper Total	mg/l	1	1	0.01	0.01	-	-
Zinc Total	mg/l	1	1	0.01	0.01	-	-
Cadmium Total	mg/l	1	1	0.01	0.01	-	-
Lead Total	mg/l	1	1	0.01	0.01	-	-
Residue Nonfilterable	mg/l	1	0	2	2	-	-
Residue Filterable	mg/l	1	0	52	52	-	-
Coliforms Total	NO/DL	1	0	20	20	-	-
Coliforms Fecal	NO/DL	1	0	10	10	-	-

TABLE 4.4

WATER QUALITY DATA : NORTHWEST BROOK (00NF02N0001)

(1965-1985)

		Samples	Flags	Low	High	Median
Specific Conduct.	USIE/CM	77	0	10	170	27.62
Turbidity	JTU	91	0	0.1	2.9	0.85
Colour Apparent	Rel. units	91	2	10	300	39.27
PH	PH Units	96	0	4.4	8	
Alkalinity Total	mg/l	95	35	0.6	36	2.08
Alkalinity Phenol	mg/l					
Total Dissolved Solids	mg/l	7	2	16	28	21.00
Hardness Total	mg/l	13	0	3.1	8.9	4.70
Sodium Dissolved	mg/l	30	0	2.1	10	4.37
Potassium Dissolved	mg/l	58	0	0	1.6	0.26
Calcium Dissolved	mg/l	48	0	0.45	2.5	1.07
Magnesium Dissolved	mg/l	54	0	0.4	2	0.55
Carbonate	mg/l	29	5	0	0	0.00
Bicarbonate	mg/l	29	5	1	44	2.00
Chloride Dissolved	mg/l	96	0	4.4	68	9.52
Sulphate Dissolved	mg/l	83	8	1	9	3.04
Saturation Index	PH Units	12	5	-6.5	-4	-5.80
Stability Index	PH Units	12	5	14.7	18.1	16.90
Sodium Adsorption Ratio	Rel. units	7	0	0.46	0.97	0.80
Silica Reactive	mg/l					
Oxygen Dissolved	mg/l	80	0	4	15.2	10.65
Oxygen Total COD	mg/l	18	0	7	121	16.00
Carbon Total Inorganic	mg/l					
Carbon Total Organic	mg/l					
Nitrogen Dsolv. NO3&NO2	mg/l					
Nitrogen Dsolv. Nitrate	mg/l	57	22	0.002	0.074	0.01
Nitrogen Dsolv. Ammonia	mg/l					
Nitrogen Total Ammonia	mg/l	54	24	0.005	0.08	0.01
Nitrogen Total Kjeldahl	mg/l	80	3	0	2.1	0.26
Phosphorus Dsolv. PO4	mg/l					
Phosphorus Total	mg/l	67	13	0	0.21	0.04
Fluoride Dissolved	mg/l					
Chromium Total	mg/l	2	2	0.01	0.01	0.01
Manganese Total	mg/l	48	16	0.005	0.08	0.02
Iron Total	mg/l	97	1	0.02	1.07	0.16
Nickel Total	mg/l	2	2	0.01	0.01	0.01
Copper Total	mg/l	24	15	0	0.05	0.02
Zinc Total	mg/l	40	23	0	0.16	0.02
Cadmium Total	mg/l	23	18	0	0.01	0.00
Lead Total	mg/l	28	17	0.001	0.054	0.01
Residue Nonfilterable	mg/l	97	62	0	48	5.31
Residue Filterable	mg/l	97	0	6	813	57.66
Coliforms Total	NO/DL	91	21	5	1600	238.86
Coliforms Fecal	NO/DL	26	4	0	830	25.00

TABLE 4.5

WATER QUALITY DATA : ROCKY RIVER (00NF02K0001)

(1965-1980)

		Samples	Flags	Low	High	Median	Mean
Specific Conduct.	USIE/CM	159	0	26	144	38	41
Turbidity	JTU	157	3	0.1	5	0.8	1.1
Colour Apparent	Rel. units	159	18	10	450	60	71
PH	PH Units	158	0	3.6	8.2	6.2	-
Alkalinity Total	mg/l	157	4	0	9.4	3.2	3.5
Alkalinity Phenol	mg/l	133	0	0	0	0	0
Total Dissolved Solids	mg/l	144	5	13	32	20	21
Hardness Total	mg/l	128	0	2.8	21.5	7.2	7.6
Sodium Dissolved	mg/l	158	0	1.9	23	4.2	4.6
Potassium Dissolved	mg/l	158	2	0	2.4	0.4	0.4
Calcium Dissolved	mg/l	153	0	0.8	7.3	1.6	1.71
Magnesium Dissolved	mg/l	128	0	0.1	1.5	0.8	0.8
Carbonate	mg/l	157	4	0	0	0	0
Bicarbonate	mg/l	157	4	0	12	4	4
Chloride Dissolved	mg/l	158	0	1.1	37.6	7	7.7
Sulphate Dissolved	mg/l	156	0	1.6	19	3.2	3.7
Saturation Index	PH Units	141	5	-7.7	-2.3	-4.5	-
Stability Index	PH Units	141	5	12.8	18.9	15.2	-
Sodium Adsorption Ratio	Rel. units	147	0	0.25	2.53	0.71	0.73
Silica Reactive	mg/l	124	1	0.1	18	1.6	1.755
Oxygen Dissolved	mg/l	1	0	10.2	10.2	-	-
Oxygen Total COD	mg/l						
Carbon Total Inorganic	mg/l	10	1	0.5	2	1	1
Carbon Total Organic	mg/l	11	0	1	18	13	12.1
Nitrogen Dsolv. NO3&NO2	mg/l	124	66	0.001	2.2	0.01	0.059
Nitrogen Dsolv. Nitrate	mg/l						
Nitrogen Dsolv. Ammonia	mg/l	45	9	0.005	0.8	0.025	0.0175
Nitrogen Total Ammonia	mg/l	3	1	0.005	0.02	0.02	0.015
Nitrogen Total Kjeldahl	mg/l						
Phosphorus Dsolv. PO4	mg/l	25	4	0.002	0.029	0.01	0.011
Phosphorus Total	mg/l	38	0	0.001	0.08	0.009	0.0117
Fluoride Dissolved	mg/l	58	42	0.01	6.9	0.05	0.2
Aluminum Dissolved	mg/l	1	0	0.07	0.07	-	-
Chocmium Extrble	mg/l	2	1	0.0005	0.0005	0.0005	0.0005
Manganese Dissolved	mg/l	17	14	0.01	0.05	0.01	0.013
Manganese Extrble	mg/l	43	4	0.01	0.16	0.02	0.03
Iron Dissolved	mg/l	19	0	0.02	0.24	0.07	0.087
Iron Extrble	mg/l	35	0	0.051	0.59	0.29	0.279
Nickel Extrble	mg/l						
Copper Extrble	mg/l	44	27	0.001	0.07	0.002	0.01
Zinc Extrble	mg/l	44	21	0.001	0.034	0.002	0.007
Arsenic Total	mg/l	14	13	0.005	0.008	0.005	0.005
Arsenic Dissolved	mg/l	2	0	0.01	0.033	0.022	0.022
Cadmium Extrble	mg/l	43	37	0.001	0.01	0.001	0.001
Mercury Extrble	fg/l	61	50	0.05	0.9	0.05	0.08
Lead Extrble	mg/l	36	23	0.001	0.006	0.002	0.002
Residue Nonfilterable	mg/l	2	0	3	28	16	16
Residue Filterable	mg/l	1	0	36	36	-	-
Coliforms Total	NO/DL						
Coliforms Fecal	NO/DL						

TABLE 4.6

WATER QUALITY DATA : SEAL COVE RIVER NEAR CAPPAHAYDEN (00NL02ZM0013)

(1980-1985)

		Samples	Flags	Low	High	Median	Mean
Specific Conduct.	USIE/CM	55	0	10	70	25	28
Turbidity	JTU	55	0	0.3	1.5	0.7	0.8
Colour Apparent	Rel. units	55	10	10	70	50	47
PH	PH Units	55	0	4.1	6.8	6.1	6
Alkalinity Total	mg/l	55	16	0.7	7	1.4	1.9
Alkalinity Phenol	mg/l						
Total Dissolved Solids	mg/l						
Hardness Total	mg/l						
Sodium Dissolved	mg/l	17	0	3.4	10	4.9	5.1
Potassium Dissolved	mg/l	27	0	0.2	0.6	0.3	0.3
Calcium Dissolved	mg/l	27	0	0.68	2.76	1.41	1.47
Magnesium Dissolved	mg/l	21	0	0.6	2	0.8	0.9
Carbonate	mg/l						
Bicarbonate	mg/l						
Chloride Dissolved	mg/l	55	0	4.3	23	7.7	8.4
Sulphate Dissolved	mg/l	54	0	2	20	3	3
Saturation Index	PH Units						
Stability Index	PH Units						
Sodium Adsorption Ratio	Rel. units						
Silica Reactive	mg/l						
Oxygen Dissolved	mg/l	53	0	3.9	14.6	11.9	11.1
Oxygen Total COD	mg/l						
Carbon Total Inorganic	mg/l						
Carbon Total Organic	mg/l						
Nitrogen Dsolv. NO3&NO2	mg/l						
Nitrogen Dsolv. Nitrate	mg/l	36	14	0.002	0.149	0.005	0.014
Nitrogen Dsolv. Ammonia	mg/l						
Nitrogen Total Ammonia	mg/l	26	16	0.005	0.03	0.005	0.008
Nitrogen Total Kjeldahl	mg/l	39	0	0.1	0.8	0.3	0.3
Phosphorus Dsolv. PO4	mg/l						
Phosphorus Total	mg/l	39	6	0.01	0.11	0.02	0.03
Fluoride Dissolved	mg/l						
Chromium Total	mg/l						
Manganese Total	mg/l	28	9	0.005	0.08	0.02	0.023
Iron Total	mg/l	55	0	0.004	1.7	0.16	0.225
Nickel Total	mg/l						
Copper Total	mg/l	12	10	0	0.05	0.01	0.01
Zinc Total	mg/l	17	14	0.01	0.02	0.01	0.01
Cadmium Total	mg/l	12	7	0	0	0	0
Lead Total	mg/l	17	10	0.001	0.02	0.002	0.004
Residue Nonfilterable	mg/l						
Residue Filterable	mg/l						
Coliforms Total	NO/DL						
Coliforms Fecal	NO/DL						
Mercury Extrble	fg/l						
Lead Extrble	mg/l						
Residue Nonfilterable	mg/l	55	44	2	18	4	5
Residue Filterable	mg/l	55	0	21	445	39	48
Coliforms Total	NO/DL	53	15	20	1180	20	176
Coliforms Fecal	NO/DL						

The results of four other sampling programs are used in this report. These include

- two major surveys in insular Newfoundland by the Department of Fisheries (DFO), one of headwater lakes, the other of Atlantic salmon rivers (50 and 51)

- an extensive monitoring program of the Waterford River carried out over a three year period as part of the Waterford River Basin Urban Hydrology Study (24)

- a survey of toxic chemicals in water supply systems in Atlantic Canada in 1985, including St. John's and Trepassey.

A detailed discussion of each of the parameters, together with values obtained in the study region and comparison with values found elsewhere, is contained in Appendix B.

4.3 - Water Quality Requirements for Various Uses

The primary uses of concern in the study area are

- drinking water supply
- industrial water supply
- maintenance of aquatic life
- recreation.

Guideline values for various parameters and for various uses are given in Canadian Water Quality Guildlines (56). Table 4.7 presents values for which local water quality data are available. Guidelines for recreational water use quality are presented separately in Table 4.9.

TABLE 4.7

GUIDELINE VALUES FOR VARIOUS USES

Parameter	Drinking Water Max Acc mg/l	Aquatic Life Guide mg/l (1)	Once Through Cooling Water Guide mg/l	Food & Bev Proc Guideline mg/l (3)	Feed & Boiler Water (4)	Typical Median Value mg/l (5)
Inorganic						
Alkalinity	-	-	<500	<85	<700	1 - 3.2
Aluminum	-	0.005	-	-		
Arsenic	0.05	0.05	-	-		<.02
Bicarbonate	-	-	<600	ND		1-4
Cadmium	0.005	0.002	-	-		<.01
Calcium	-	-	-	<100		0.9-1.6
Carbonate	-	-	<200	<5		0
Chloride	250	-	-	<30		10-17
Chromium	0.05	0.02	<600	-		<0.01
COD	-	-	-	-		16-33
Copper	1	0.002	<75	ND	<0.05	<0.01
Dissolved Oxygen	-	9.5	-	-	<0.04	7.5-10.2
Fluoride	1.5	-	-	<1.0		4.7-8.1
Hardness	-	-	-	<180	<1	0.05-0.49
Iron	0.3	0.3	<850	<0.1	<0.1	<0.01
Lead	0.05	0.001	-	-		0.5-0.9
Magnesium	-	-	-	<30		0.01-0.07
Manganese	0.05	-	-	0.03-0.1		<0.0005
Mercury	0.001	0.0001	-	-		<0.01
Nickel	-	0.0025	-	-		0.005-0.03
Nitrate	10	-	-	<10		-
Nitrite	1	0.06	-	-		0.01-0.04
N-Ammonia	0.5	2.2	-	ND		5.4-6.2
pH (pH units)	6.5-8.5	6.5-9.0	5.0-8.3	6.5-7.0	7.0-10.	1.6-2.1
Silica	-	-	<50	ND	<150	3-4.7
Sulphate	500	-	<680	<60		20-40
TDS	500	-	<1000	50-100		<0.01
Zinc	5	0.03	-	-		
Physical						20-60
Colour	15 NCU	-	-	<5 HU		0.6-0.9
Turbidity	5 NTU	-	-	1-2		
Temperature	15	Ltd Change	-	-		
TSS		from Nat'l	<5000	<10		
Microbiological						
Total Coliforms(2)	10/100ml		-	Sterile		10-230
Faecal Coliforms	0/100ml		-			0-25

NOTES :

(1) A number of these guidelines vary with other parameters. Guideline given is for typical value.
(2) Other conditions apply.
(3) Minimum of guidelines for industries in study area (see text).
(4) Industrial firetube steam generator without superheater, turbine drives or process restriction on steam purity.
(5) Of five regularly sampled rivers, Table 6.1.

For all uses except drinking water, the values given are guidelines, i.e. recommended values to support and maintain a designated water use. For drinking water, the guideline values presented in Table 4.7 are the recommended limits established by Health and Welfare Canada. Drinking water that contains substances in excess of these maximum acceptable concentrations is capable of producing deleterious health effects or is aesthetically objectionable.

The water quality parameters of concern to each use are discussed in the following sections.

4.3.1 - Drinking Water Supply

As Table 4.7 shows, raw water supplies come very close to meeting all the maximum acceptable limits for drinking water supplies. The natural surface waters are generally acceptable for drinking water, with pH adjustment and disinfection to ensure bacteriological control. Table 4.8 compares results of the most recent available chemical analyses from the three major water regional system supplies with the drinking water guidelines. Often only pH adjustment and disinfection are required to bring the raw water within acceptable limits.

Occasionally, however, the natural surface waters in the area may have elevated colour, turbidity, iron and manganese levels. These limits are set for aesthetic considerations, not health. The water may have an unattractive appearance or taste, and may stain clothes and porcelain or enamel plumbing fixtures. Filtration, or similar treatment, of almost all sources in the study area, would be beneficial. It will remove turbidity, and often iron as well; manganese and colour are less amenable to treatment. The treatment processes used at the Bay Bulls plant are very effective, but are also very expensive.

TABLE 4.8

RESULTS OF CHEMICAL ANALYSIS OF REGIONAL WATER SUPPLY SOURCES

Parameter	Drinking Water Standard mg/L	Petty Harbour Long Pond (Aug/1986) mg/L	Windsor Lake (Aug/1986) mg/L	Bay Bulls (May/1986)
Alkalinity	-	0.5	1.2	1.7
Cadmium	0.005	.0008	<0.0005	<0.0005
Calcium	200(1)	0.8	1.28	1.26
COD	-	11	14	-
Copper	1.0	<0.05	<0.05	<0.01
Hardness	-(2)	4.4	6.0	5.2
Iron	0.3	0.07	<0.05	0.10
Lead	0.05	<0.002	<0.002	<0.002
Magnesium	150*	0.59	0.68	0.50
Manganese	0.05	0.03	0.01	0.05
Nitrate	10.0	<0.002	<0.002	0.017
pH	6.5-8.5	5.98	6.2	6.08
Zinc	5.0	0.03	<0.01	<0.01
Colour	15 TCU	5 ACU	5 ACU	15 TCU
Turbidity	5 NTU	0.4 JTU	0.42 JTU	0.44 NTU

(1) A suggested guideline, not established in Canadian Water Quality Guidelines(56).

(2) No guidelines set; <30 is very soft.

The naturally soft waters in the region are desirable for domestic water supply because of the ease of lathering. Local natural waters generally have a pleasing taste, due to the low levels of soluble ions of many substances. Levels of total dissolved solids as well as metals other than iron and manganese are generally low.

There is very little information on water quality at the end of the distribution system i.e. in homes and businesses. In addition to bacteriological contamination, soft, low pH water could cause some of the copper and lead in pipes and plumbing to come into solution. Limited testing shows no evidence of high lead or copper levels in the principal conduits of the St. John's regional system, but there may be local occurrences of elevated levels.

4.3.2 - Industrial Water Supply

Most of the industrial users in the study region use municipal water supplies, with the exception of some of the fish plants. The chief industrial consumers with water quality concerns are those which use hot water and steam for environmental and process heating (and cooling), and food and beverage processors. The requirements for these two user groups are discussed below, and their requirements are included in Table 4.7. In the food and beverage industry, each process (baking, brewing, carbonate beverages, confectionery, canning, freezing, drying, and sugar manufacturing) has its own guidelines. In the preparation of Table 4.7, the most stringent criterion was chosen for each parameter from among the guidelines for all the processes. Sugar manufacturing was excluded because it does not take place in the region.

The softness and low solids and metal content of local waters are assets to most manufacturing processes, because scaling is not likely to occur. When hot water and steam are used for environmental and process heat, deposits and scale on pipes and boiler walls can be a serious problem. The indicators of potential problems include high alkalinity, high hardness, high calcium, high TDS, and high silica. Values for all these parameters in the natural waters of the area are typically low. The natural softness, together with low pH, may cause corrosion problems, however.

Food and beverage processes incorporating water into the final product, such as beer and soft drink manufacturing, have very strict requirements. Natural waters in the study area may exceed required values for iron, manganese, pH, turbidity, colour, and sterility, and additional treatment is normally provided by the processor. Other food industries, such as fish processing, use water only for such general purposes as washing and transporting the product. These processors use either a municipal water supply, or provide their own fresh or salt water supply with filtering and chlorination before use.

4.3.3 - Maintenance of Aquatic Life

Aquatic life is naturally adapted to the characteristics of local waters, and the guidelines are required when human activity changes the natural quality. The guidelines can be used as objectives in a rehabilitation program for degraded waters, for example, as standards to measure the effect of a proposed project, or to monitor the effect of existing developments.

As expected, Table 4.7 shows that the natural waters in the study region are within the guidelines for aquatic life, with the exception of pH. Local fish populations and other forms of aquatic life can be assumed to be acclimated to a naturally low pH; however, any decrease such as might result from acid rain or other anthropogenic sources may well cause chronic effects, such as spawning failure and diminished hatching success.

4.3.4 - Recreational Water Use

The water quality in the study area is very good for recreational water use, with the exception of the urban areas. In St. John's, the major population centre, a number of the ponds are no longer safe for swimming. Although the urban rivers support fish and water fowl populations, and riverside walks and parks provide recreational opportunities for local residents, considerable degradation has occurred.

The surface waters in less developed areas meet all required guidelines. Table 4.9 lists the recreational parameters and guidelines and compares them with median values from the five regularly sampled rivers, where available. The microbiological parameters are most important when users are frequently immersed in water, i.e., swimming or certain types of boating. For scenic pleasure, the appearance of the water and the overall setting is as important as the quality of the water itself.

4.4 - Types of Degradation

A number of types of degradation of surface waters can occur as a result of human activity. These can be categorized as increased loadings of

- sediment and other solids
- microorganisms
- nutrients
- toxic chemicals
- atmospheric pollutants.

TABLE 4.9

GUIDELINES FOR RECREATIONAL WATER QUALITY

Parameter	Typical Guideline	Natural Value in Study Area
Bacteriological Faecal coliforms	The geometric mean of not less than 5 samples taken over a 30-d period should be less than 200 faecal coliforms per 100 mL. Resampling should be performed when any sample exceeds 400 faecal coliforms per 100 mL.	0 - 810*
Pathogens Coliphages Enterococci E. coli P. aeruginosa G. lamblia	) No guidelines set. May be) indicators, or monitoring) may be required.)))	-
Clarity	The water should be sufficiently clear that a Secchi disc is visible at a minimum of 1.2 m.	-
pH	5.0-9.0	5.4 - 6.2
Turbidity	The turbidity of water should not be increased more than 5.0 NTU over natural turbidity when this is low (< 50 NTU).	0.6 - 1.3
Aesthetics	All water should be free from - materials that will settle to form objectionable deposits: - floating debris, oil, scum and other matter; - substances producing objectionable colour, odour, taste or turbidity; and - substances and conditions or combinations thereof in concentrations which produce undesirable aquatic life.	- (Pollen may occasionally form an oil-like sheen for a brief period)

*The highest value reported from the six monitored rivers was 810. Values in the hundreds of thousands have been reported from the Waterford River.

TABLE 4.9

GUIDELINES FOR RECREATIONAL WATER QUALITY (continued)

Parameter	Guideline	Typical Median Value
Oil and grease	Oil or petrochemicals should not be present in concentrations that - can be detected as a visible film, sheen or discoloration on the surface; - can be detected by odour; or - can form deposits on shorelines and bottom deposits that are detectable by sight and odour.	-
Aquatic plants	Rooted or floating plants which could entangle bathers should be absent; very dense growths could affect other activities such as boating and fishing.	-

Source: Canadian Water Quality Guidelines (56).

The types of degradation and their significance in the study area are briefly discussed in the following sections; additional discussion and data are provided in Appendix B.

4.4.1 - Sediment

Increased loadings of sediments and other solids generally arise from changed land use or drainage regimes. Any activity which removes vegetation or protective cover, such as construction, quarrying, road building, and many farming activities will increase erosion and resulting sediment loads. In addition, changed flow patterns, particularly channeling of flows for drainage in urban areas or bogs, will usually increase flow velocities and consequently scouring potential.

The principal adverse affect of increased sediment is on fish habitat and food supply. In addition, silt-laden rivers are aesthetically unattractive. High turbidity levels during the spawning season will seriously disrupt spawning activities, because visual stimuli are required for successful reproduction. Sediments settling on the bottom will fill in rearing pools, reduce intra-gravel flow in spawning areas, and suffocate eggs (32).

Of continuing concern are developed areas, in particular St. John's and surroundings. Waterford River, Rennie's River and Virginia River all have a large recreational potential including fly-fishing. Channelization, development along the banks, and concentration of pollutants in episodic events have degraded their quality. Outside developed areas, impacts are usually local, although often serious. The construction of Highway 100 to Argentia, for example, resulted in loss of the best spawning beds on an important salmon river (14).

The deleterious effects of sediment loading can be substantially mitigated by simple measures, including

- Minimizing amount of unvegetated soil and reducing the length of time that ground is bare (e.g., during construction).
- Using settling pools at outflow of quarries and construction sites.
- Avoiding straightening of natural streams.
- Maintaining streambank vegetation.

The problems of increased sediment are generally recognized, and environmental agencies are attempting to reduce the negative impacts of human activities on siltation and erosion. Since these activities are very widespread and increase with development, however, constant attention is required to minimize or prevent deterioration.

4.4.2 - <u>Microorganisms</u>

The surface waters in the study area are naturally very low in pathogenic organisms. In inhabited areas, whether urban, rural residential, or agricultural, some contamination from human and animal sources often occurs.

Table 4.10 shows bacteriological counts in the six non-urban monitored rivers of the study area. Although the rivers are not pristine, coliform counts are quite low, generally well within swimming limits, for example.

TABLE 4.10

BACTERIOLOGICAL DATA: NON-URBAN RIVERS

Location	Total Coliforms (no./100 mL) Low	High	Faecal Coliforms (no./100 mL) Low	High
Broad Cove Brook	20	780	0	310
Mobile River	11	1600	0	210
Northeast Pond River	20	20	10	10
Northwest Brook	5	1600	0	830
Rocky River	-	-	-	-
Seal Cove River	-	-	-	-
Guidelines				
Drinking water		10		0
Swimming(1)		1000		100
Swimming(2)				200

(1) Ontario Ministry of the Environment(29)

(2) Canadian Water Quality Guidelines(56)

In urban areas, with piped sewerage systems, bacteriological pollution has occurred from cross-connections of storm water and sanitary sewers, from leaking sanitary sewers, and from animal wastes washing into storm sewers. This has been particularly well-documented on the Waterford River, but also happens elsewhere. In rural residential areas, well-placed and well-maintained septic tanks control bacteriological pollution, but occasionally malfunctions or leaks can occur, causing local increases in bacteriological loadings. Animal husbandry (chiefly dairy cattle, swine, and chickens in the study area) can result in increased loads of microorganisms through pasture runoff, manure spreading, and manure lagoons.

A number of sampling programs have been undertaken in the City of St. John's and environs, to determine the extent of contamination. Results are presented in Appendix B.

4.4.3 - Nutrients

Developed Areas

As discussed in Appendix B, levels of nutrients are naturally low in surface waters in the study area. Degradation of water quality due to excess nutrients appears to occur chiefly in developed areas, as a result of

- human and animal waste
- agricultural residues, particularly fertilizers.

The principal source of data for increased nutrient loadings in developed areas is the Waterford River Study(24). This study reported that although the developed parts of the watershed contributed extra nutrients, the flowing waters of the river did not permit accumulation of these nutrients except at some sites in low discharge periods.

Rural Areas

Outside urban areas, the principal source of excess nutrients is agricultural runoff. Although farming is not a major economic activity in the study area, the potential exists for local pollution from animal wastes, and non-point pollution from fertilizer runoff.

Disposal locations and procedures for animal wastes (e.g. manure spreading, manure lagoons) are occasionally the source of complaints. Disposal practices must be approved by the provincial Department of Environment. The most common applications of fertilizer are of lime, to counteract the natural acidity of the soil, and an all-purpose fertilizer, containing nitrogen, phosphorus, and potassium, often in a mixture with a variety of trace elements. Boron is also added where certain crops such as turnips are grown. Again, the small scale of the farming, together with the natural dearth of nutrients in the environment, has generally prevented problems.

Appendix B contains detailed information on locations of farming areas, indicating where high nutrient loading might occur.

4.4.4 - Toxic Substances

No chronic pollution by toxic substances has been reported in the surface waters of the study area. Nonetheless, the use of many relatively new chemical substances is widespread, and they have the potential for serious adverse effects due to their persistence in the environment and accumulation in living tissues. Appendix B provides more detail on these substances, including a list of the major chemicals (including metals) of concern and possible sources.

4.4.5 - **Atmospheric Pollutants and Deposition: Acid Rain**

A fourth type of potential water quality degradation results from the long range atmospheric transport and subsequent deposition of pollutants. As defined by Environment Canada(#), acid precipitation includes rain, snow, freezing rain, hail and fog with a pH below 5.6 (the pH of normal rain). Acid rain is formed in the atmosphere as a result of emissions of sulphur dioxide (SO_2) and oxides of nitrogen (NO_x) from the combustion of fossil fuels. These substances can be further oxidized in the atmosphere to form sulfuric and nitric acids. In addition to the acid rain itself, other pollutants, such as toxic chemicals and metals, can be transported and deposited.

The implications of acid rain, from experience in Europe and other parts of North America, are the decline and disappearance of fish in freshwater lakes and rivers, and the serious deterioration of forests. These effects are due not only to the low pH, but also to the increased mobilization of minerals in rock.

The federal Department of Fisheries and Oceans has conducted several major studies to assess the effects of acid rain in Newfoundland(50). The conclusions of their work to date are that lakes and streams in the study area are extremely sensitive, and with current or increasing rates of deposition, may be on the threshold of acidification. Although chronic acidification is not a widespread problem at present, pH excursions below 5.0 occur (as shown in Appendix B, Table B1.2), which are of sufficient magnitude to affect fish. The lowest recorded annual pH of rainfall on the Avalon peninsula is about 4.5 to 4.7. A rainfall pH of 4.6 has been considered a threshold level for acidification, suggesting that many of Newfoundland's freshwaters may be at the edge of a potential acidification problem.

Newfoundland is vulnerable for several reasons. First, it is in the path of weather systems carrying substantial pollutant loads from the industrialized east coast of the United States and Canada. Analysis of storm trajectories by researchers at Memorial University of Newfoundland indicates that most of the sulphate deposited in Newfoundland originates in the Ohio Valley, the eastern seaboard of the United States, or southern Ontario. Second, Newfoundland is an area of high precipitation, and the total deposition of sulphates and nitrogen oxides is a function of total precipitation as well as the concentration of these pollutants in the atmosphere. Third, the rocks and soils of the island have very little natural buffering capacity.

Most of Newfoundland is highly sensitive, with the exception of some area of rocks such as limestones and dolomites on the west coast. Soils, a potentially important provider of buffering agents, are generally thin to non-existent. Table 4.11 presents values for four other criteria for determining sensitivity. These also indicate the high sensitivity of the surface waters of the Avalon Peninsula to acid precipitation.

4.5 - Groundwater Quality

The report on Hydrogeology of the Avalon Peninsula contains a discussion of groundwater quality(25). The following section summarizes the information in that report, supplemented with recent data.

Overburden groundwater quality is similar to surface water quality, with low values of total dissolved solids and low pH (5 to 6). High iron and manganese levels are also common. Bedrock groundwater quality depends on which of the three groundwater group is its source. Typical water quality for each of the groups is as follows.

TABLE 4.11

SENSITIVITY OF AVALON PENINSULA RIVERS TO ACID PRECIPITATION

River	Alka-linity ueq/L	Cal-cium ueq/L	Conduc-tivity uS/cm	CSI	pH
Biscay Bay (Back) Brook	23	51	22	-5.41	5.75
Colinet River	51	86	20	-4.51	6.08
Rocky River	30	81	21	-5.12 (-4.3*)	5.71

*Long-term avg.

Interpretation Key

Alkalinity	0- 40	extremely sensitive
	40-200	highly sensitive
Calcium	0-200	highly sensitive
Conductivity	0- 35	highly sensitive
Calcite Saturation Index (CSI)	(<-3	deleterious effects possible
	(-2 to -3	danger
	(-1 to -2	moderate sensitivity
	(>-1	low sensitivity

The CSI is employed as an index of freshwater sensitivity to acidification. The CSI of water is the logarithm of its degree of saturation with respect to calcium carbonate. High negative values indicate extreme sensitivity to acidification.

Source: Scruton(52)

Group I - Calcium bicarbonate type waters, having higher hardness and pH than is typical of the surface waters (> 50 mg/L as $CaCO_3$ and pH between 6.5 and 9).

Group II - Sodium bicarbonate type waters having high pH (>8), high alkalinity, and low hardness.

Group III - Soft, acidic water, with low total dissolved solids, much like the waters from overburden wells.

Almost 50 per cent of wells are reported to have one or more parameters whose values exceed acceptable limits for drinking water. The exceedances are usually of aesthetic or domestic use parameters, rather than health-related, i.e. parameters exceeded include pH, hardness, manganese, iron, sodium and chloride.

The high sodium and chloride concentrations are attributed to sea water intrusion, or less often to contaminated sources such as road salt. A report on the effects of road icing salt on groundwater in the Airport Heights area of St. John's concluded that the application of road salt has been responsible for the contamination of shallow wells in the area.

5 - INSTREAM USES

5 - INSTREAM USES

The demands for fresh water can be classified as either instream requirements or withdrawal demands.

Instream uses include

- hydro electric power
- fisheries
- recreation and tourism
- log driving
- inland navigation
- waste disposal.

Withdrawal demands include

- municipal water supply
- rural residential water supply
- industrial water supply
- mine water supply
- agriculture
- thermoelectric power (cooling)

Instream requirements are discussed in this section, and withdrawal demands in Section 6.

5.1 - Hydro Power

5.1.1 - Existing Developments

The drainage areas developed for hydro power by Newfoundland Light and Power covers over 25 percent of the study area. The plants are listed in Table 5.1, together with their capacities, present values and spills. The locations of the plants and

TABLE 5.1

HYDRO POWER PLANT INFORMATION

PLANT	CAPACITY (kW)	PRESENT VALUE (per kW)	AVG. ANNUAL FLOW (1) (m^3/s)	AVG. ANNUAL SPILL (m^3/s)
Petty Harbour	5,000	$2,000	5.80 (2)	0.2900
Pierre's Brook	4,000	$4,200	4.96 (2)	0.0900
Topsail	2,250	$3,100	1.75	0.0000
Mobile	10,000	$2,200	6.01 (2)	0.0002
Morris	1,100	$4,400	-	-
Cape Broyle	6,000	$2,900	9.70	0.0100
Horse Chops	7,650	$2,900	-	-
Tors Cove	6,300	$2,100	9.89	0.0100
Rocky Pond	3,200	$2,200	-	-
Seal Cove	3,300	$1,500	2.97	0.0460

NOTES:

(1)Estimated using methods of Section 2 unless noted.
(2)From NLP records as reported to WSC.

drainage basins are shown on Plate 1 and in Figure 5.1. Plate 1 also shows the locations on the dams and canals.

The total water use by hydro power plants averages about 1300 Mm^3/a, about 23 per cent of the total water available in the study area. The plants have high utilization rates, as indicated by the low average spills (Table 5.1). The spill ranges from an average of none at Topsail and near zero at Mobile to about 5 per cent at Petty Harbour. Average annual energy generation is 165 million kWh. The plant with the highest installed capacity is Mobile, at 10,000 kW. It also has the highest head, at 115 m.

Three basins have additional plants; Morris, upstream of the Mobile plant, Rocky Pond, upstream of Tors Cove, and Horse Chops, upstream of Cape Broyle.

Several of the reservoirs serve multiple uses. Bay Bulls Big Pond, a major reservoir for the Petty Harbour plant, already serves as a reservoir for the St. John's regional water supply system. In addition, Bay Bulls Big Pond is a highly desirable recreational area, although recreational activities are restricted because of the necessity for watershed protection. Two other basins supplying hydro power plants, Topsail and Pierre's Brook, have also been designated as protected watersheds, to protect future municipal supplies to the St. John's regional water supply system.

5.1.2 - Future Developments

Because of the hilly topography and high runoff in the study area, there is some potential for development of small scale hydro projects (< 20 MW).

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FIG.5.1

Basins Developed for Hydro Power

The largest and most viable potential small hydro projects are located in the southern half of the region where concentrations of head at two or three locations suggest possible development sites. These include Salmonier River at Pinsent's Falls, two of the tributaries of the Salmonier River (Back River and Little Harbour River), as well as Chance Cove Brook and Spout River. Capital costs for these projects are likely to be high relative to annual benefits under present economic conditions. Since other small sites on the island have more favorable benefit/cost ratios, these sites are unlikely to be developed for some time.

The projects at some of these potential sites, in particular Salmonier River, may present conflicts with fisheries. Additional costs would be incurred for studies and/or ameliorative measures; it is possible that no mutually satisfactory project could be developed.

Numerous sites in the study area are suitable for micro hydro development, to serve perhaps a few homes. Since energy from the grid is widely available in the study area, and costs for developing micro hydro are high, it is not economical at present to develop these sites.

Combined hydro power and water supply developments are also possible. *However, none of the developments mentioned above is* particularly promising for joint development. Spout River could serve Aquaforte, but it is already supplied from Daniel's Pond fish plant supply. Little Harbour River could serve Forest Field/New Bridge, but the combined population of the two communities is only about 100, and is fairly spread out. Even with the hydro project in place, the cost of distribution is likely to be very high. As for Chance Cove Brook and Back River (Salmonier), there are no population centres in the immediate area. Again, distribution costs to the nearest community (e.g. St. Catherines/ Mount Carmel in the case of Back River) are likely to be high.

5.1.3 - Value of Water Used for Hydro Power

The value of water used for hydro power can be determined from the value of the energy generated. For the plants on the Avalon peninsula, the alternate source of energy is thermal power from the plant at Holyrood. Assuming a cost of 5¢/kWh for alternative energy, the value of the water from the plants averages $8 million per year, as shown in Table 5.2.

5.2 - Recreation and Tourism

The surface waters of the study area are key centres for recreational activities both for tourists and residents. Because a large proportion of the province's population lives in the study area, in particular in the St. John's census metropolitan area, there is considerable pressure on recreational lands.

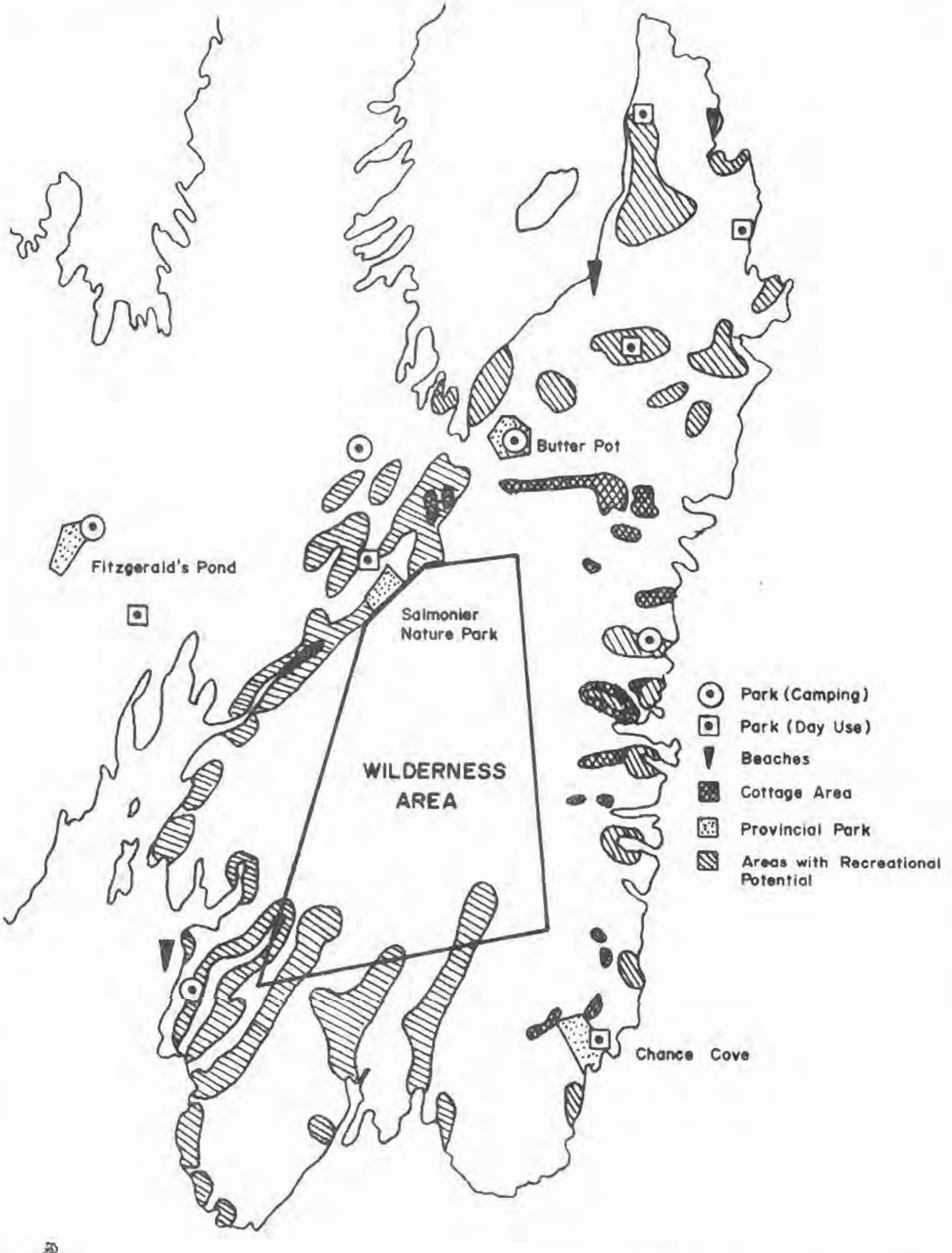
Figure 5.2 shows the location of major recreational areas, including provincial parks, areas identified as having recreational potential in the Canada Land Inventories, and designated summer cabin development areas. Summer cabins and year-round residences are located on many other brooks and ponds as well. Almost all these recreational areas use ponds and rivers either as the main source of attraction, or to enhance the aesthetic quality of the facilities. In additional to the provincial parks, a 1983 inventory(22) identified 88 other recreational facilities, chiefly municipal parks, a number of which focus on ponds and streams. The number and types of these facilities are shown in Figure 5.3.

TABLE 5.2

VALUE OF HYDRO ENERGY

Plant	Avg. Annual Energy Generation (GWh)	Value (1) (million $)	Water Used (Mm3)	Value (c/m3)
Petty Harbour	18.6	0.93	170	0.55
Pierre's Brook	25.2	1.26	150	0.84
Topsail	8.0	0.40	60	0.66
Mobile	41.6	2.08	190	1.09
Cape Broyle	34.8	1.74	310	0.56
Tors Cove	26.3	1.32	310	0.42
Seal Cove	10.5	0.53	90	0.58
TOTAL	165.0	8.25	1,280	4.71

(1) 5 c /kWh is based on oil at $ 30 /bbl and 600 kWh /bbl. No account is taken of operating and maintenance costs , or of costs associated with other factors such as increased emissions.



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Recreational Areas

FIG.5.2

ACRES

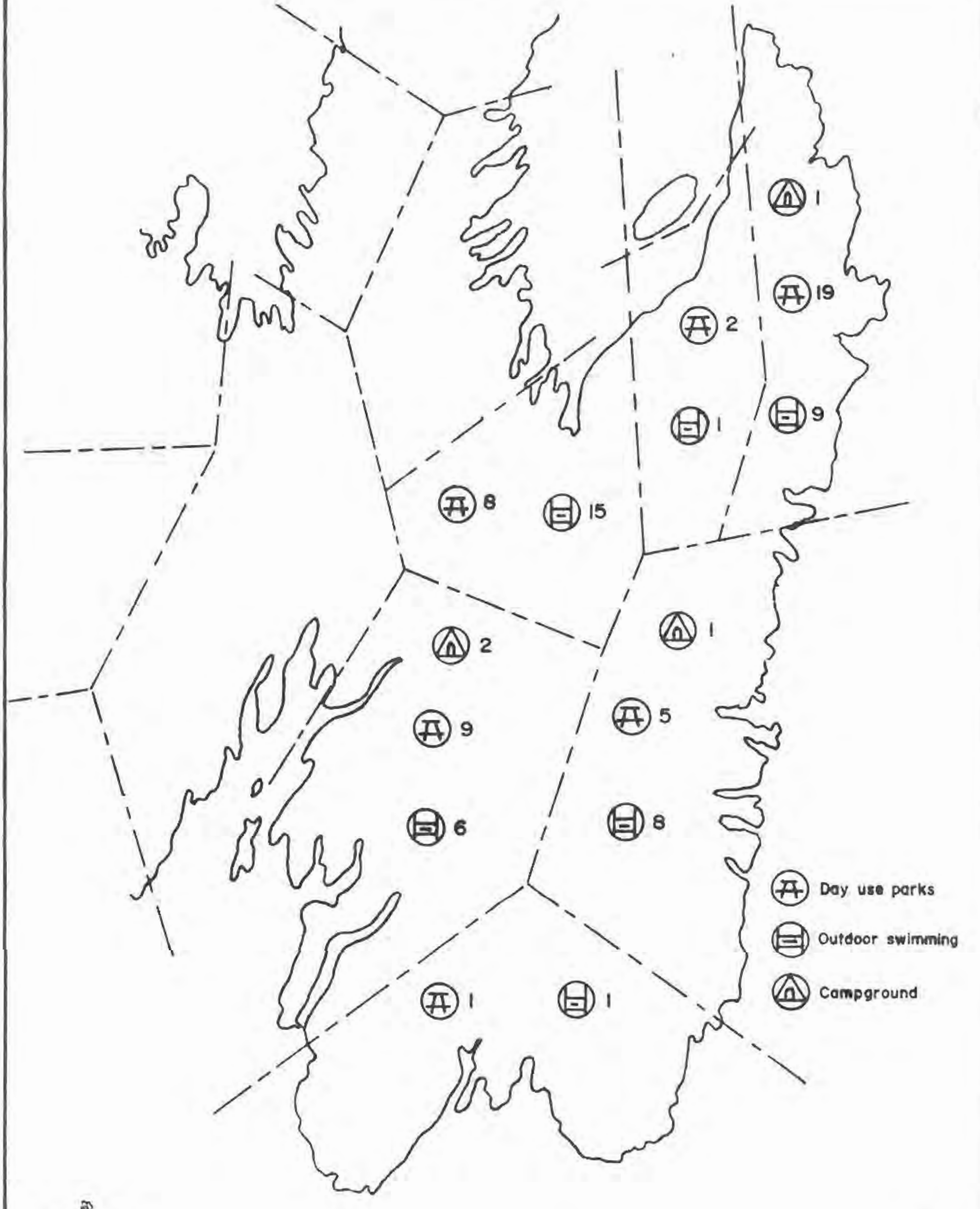

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FIG.5.3

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Municipal Recreational Facilities

ACRES

5.2.1 - Value of Water Used for Recreation

It is difficult to quantify the importance of the water resources to the tourism and recreation industry in the study area, but some relevant statistics are available from the Department of Tourism. These show that water based activities are important attractions for tourists and residents, and that tourism makes a substantial contribution to the economy.

Table 5.3 shows the results of a 1985 survey of non-resident auto visitors, indicating a high demand for water-based activities. Even greater numbers liked activities such as sightseeing and photography, which often have ponds and rivers as important focal points.

It is interesting to note that "participation" rates are lower than "liking" rates. The Department interprets this to mean that there is considerable latent demand on the part of non-resident visitors. Local residents also show a strong preference for water-based activities, as shown in Table 5.4. In general, residents have higher participation rates, presumably because they know where to go, and have suitable equipment.

The results presented in Tables 5.2 and 5.4 are for visitors to and residents of the whole island. A St. John's Regional Market Study carried out by the Department of Tourism in 1984 shows that St. John's residents also enjoy outdoor water-based activities. When asked to choose their preferred vacation (in Newfoundland), a summer cabin vacation was chosen by nearly 80 per cent. A summer resort vacation, featuring water-based activities, was the next most popular.

TABLE 5.3

RESULTS FROM SURVEY OF NON-RESIDENT AUTO VISITORS

Water-based Activities	Per cent Liking	Per cent Participating
Canoeing	44.5	9.8
Sailing/Boating	55.2	33.0
Swimming	72.0	41.1
Going to the Beach	74.4	63.9
Fishing	61.0	40.2
Other Activities		
Taking Day Tours	58.7	61.0
Sightseeing	90.8	95.4
Photography	85.8	92.6

TABLE 5.4

RESULTS FROM SURVEY OF RESIDENTS

Water-based Activities	Per cent Liking	Per cent Participating
Canoeing	75.2	42.0
Sailing/Boating	85.6	62.5
Swimming	93.0	82.0
Going to the Beach	94.4	85.6
Fishing	82.8	79.2
Other Activities		
Taking Day Tours	51.7	26.8
Sightseeing	91.6	88.4
Photography	88.6	84.0

Based on 1985 survey by Department of Development and Tourism. The Tourism Branch treats the difference between participation and liking rates as a measure of the potential demand for the activity.

The information from these surveys is confirmed by the experience of Provincial Parks. There are 250,000 visitors to the provincial parks in the study area annually, and most of these parks include water-based activities such as fishing, swimming and boating. Park officials report that if camp grounds are not located near water bodies, they are not used.

No breakdown of expenditures on these activities in the study area is available, but it may be noted that non-residents have spent of the order of $85 to 90 million per year on the island in the last few years. Of that amount, $25 to $30 million has been spent by auto visitors. It can probably be reasonably assumed that a sizeable portion of that amount has been spent near St. John's (i.e. in the study area). It may also be surmised from the surveys reported above that at least some of the economic benefits can be attributed to the attraction of the surface waters.

It is more difficult to assess the value of water to residents for recreation and everyday amenity. This value would seem to be high, given the preference of residents for water based activities and summer cabin vacations. Were these activities not available locally, residents would presumably choose to vacation elsewhere.

The benefits of everyday amenity derived from the rivers and ponds and associated pleasant open spaces in nearly all communities, most notably the City of St. John's, are difficult to measure. It can be assumed that they have an economic value in attracting and keeping new residents and perhaps businesses as well; the increased property values of adjacent properties would be one indication. In a region which cannot match the better climate and more extensive cultural opportunities available in other cities outside the province, good quality ponds and rivers in the urban centre constitute an important and unique resource.

For tourism and recreation, the benefits are associated with water quality as well as quantity. Maintaining good water quality, and equally important, the quality of the surroundings, is necessary to ensure the benefit.

5.3 - **Fisheries**

The clean, fresh, steadily flowing waters of the study area, together with good spawning and rearing areas, are well suited to salmon and trout. These are favorite sport fish, and their presence in the waters of the study area is important for at least two reasons. First, many residents and non-residents derive considerable pleasure from angling, or simply watching fish, and second, the presence of healthy fish is an indication of good water quality to the public at large.

Responsibility for fisheries rests with the Federal Department of Fisheries and Oceans (DFO). The policy objective of the Department is an overall net gain of habitat. The first goal is conservation, i.e., the maintenance of current productive capacity. Under this principle, unavoidable habitat losses are balanced by habitat replacement. Proposed changes to any river are evaluated on a case-by-case basis. In the construction of the Morris hydroelectric power, plant for example, spawning beds lost in one area were replaced by an equivalent spawning area adjacent to the tailrace channel.

The second goal is fish habitat restoration. An example of improved habitat is the Rennie's River system in St. John's. The City of St. John's, the Rennie's River Development Foundation, and DFO are co-operating to restore damaged fish habitat in the river. As part of this project, a new fishway was constructed at the outlet of Quidi Vidi Lake at a cost of about $80,000.

No rivers in the study area have been designated for enhancement by DFO, although counting fences have been established near Biscay Bay and Trepassey.

5.3.1 - Value of Water Used for Fisheries

The quantity, flow regime and quality of water and surrounding space are all important to the fishery. The value of the fishery in the study area arises from its economic contribution to tourism and recreation, and in the inherent value of preserving natural fish and aquatic life. There is no commercial fishery in the study area, and no commercial sports fishing camps. The public, through support of habitat management policies and of organizations dedicated to maintaining and improving fishing rivers, as well as by high use of any river or pond with fish, appears to assign a high value to the fresh water fishery.

6 - WITHDRAWAL USE: SUPPLY/DEMAND ANALYSIS BY COMMUNITY

6 - WITHDRAWAL USE: SUPPLY/DEMAND ANALYSIS BY COMMUNITY

Fresh water demands can be classified as instream requirements or withdrawal demands. Instream requirements were discussed in the previous section. This section, on withdrawal uses, analyses the present and projected supply/demand situation for each community in the study area. Following this section on withdrawal, Section 7 analyses overall water use, considering both withdrawal demands and instream requirements.

The major withdrawal use is municipal water supply to the St. John's region and other communities. Lesser withdrawal uses include

- Rural residential supply. This category includes very small communities and isolated homes, using either groundwater or surface supply systems on an individual or community basis.

- Industrial water supply. In the study area most industry is served by the St. John's regional system. The principal exception is fish plants outside the regional centre, which usually have their own fresh or salt water supply systems.

- Cooling water to the thermal generating station at Holyrood, drawn from a private source (Quarry Brook).

- Mine water supply. Use is very small; the only mine in the study area is the pyrophyllite mine at Manuels, which has its own groundwater supply.

- Agriculture. The federal Department of Agriculture reports that there are no irrigation schemes on the Avalon Peninsula. Livestock watering is usually from a private well or surface supply. Watering of lawns and home gardens usually uses the domestic supply source.

In this section, the industries and communities are grouped in the same geographical subregions as the drainage basins, i.e., north, south east and west. The present and projected water demands and sources of supply are described separately for each community within the subregions. Industrial demands are included with the community in which they are located.

The population growth and demand rates used in this study are discussed in Appendix C. Population growth rates used in this study range from 17 per cent per 5 year intercensal period for the fastest growing communities near St. John's (Torbay, Portugal Cove, Holyrood) to stable population (no growth) for small communities in the southern part of the region. Demand rates range from 0.78 m^3/d for St. John's to 0.41 m^3/d for most other communities.

6.1 - **North Region**

The communities in the north region (see Figure 6.1 for location of regions), in order of population, include

Name	Population (1986)
St. John's & communities served by the regional water supply system	143 713
Torbay	3 730
Portugal Cove	2 497
Holyrood	2 118
St. Phillip's	1 604
Pouch Cove	1 576
Outer Cove/Middle Cove/Logy Bay	1 300
Petty Harbour/Maddox Cove	974
Flatrock	884
St. Thomas	648
Bauline	423*
Hogan's Pond	139
Indian Pond near Holyrood	129*
TOTAL	159 735

*1981 Population

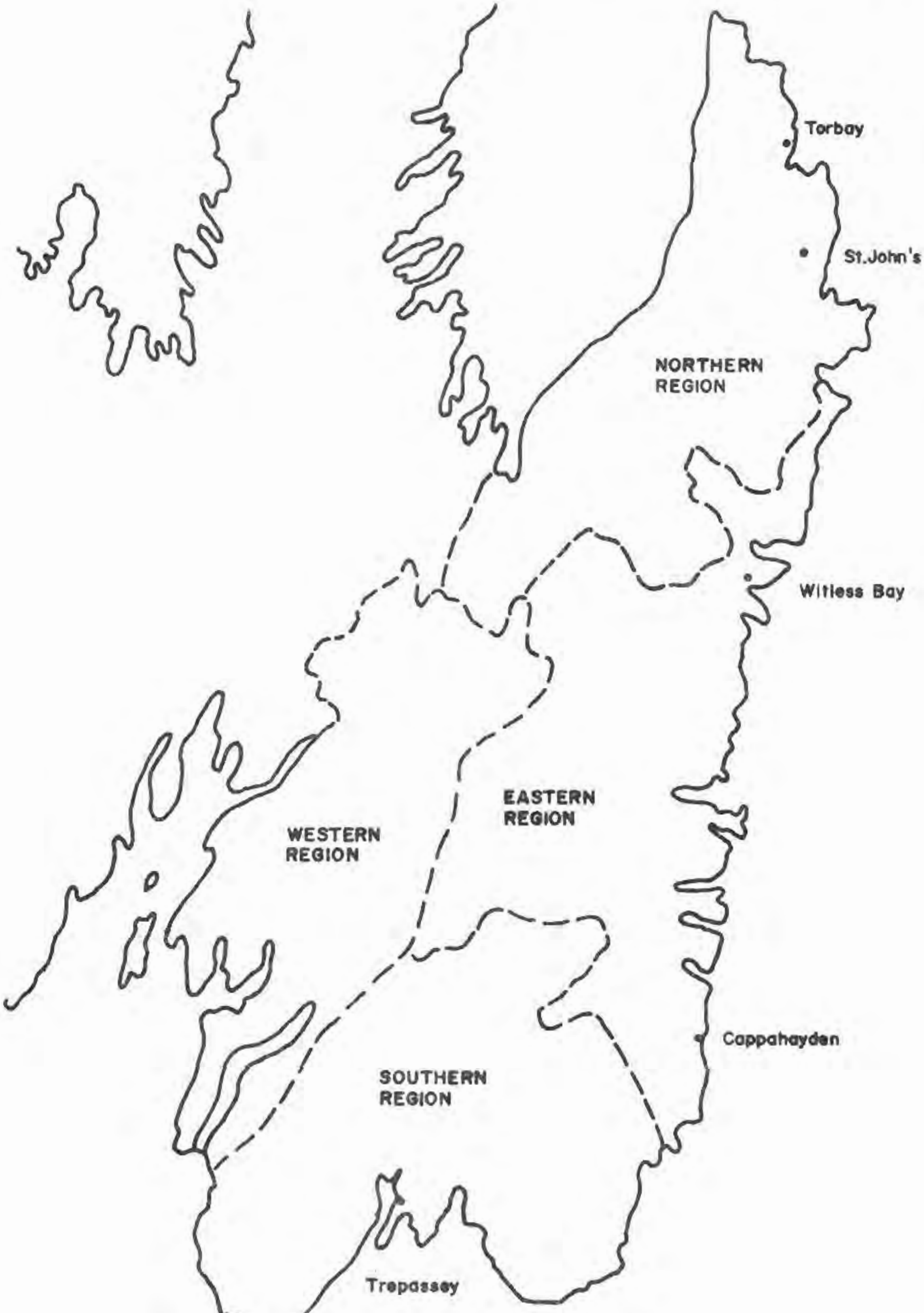

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FIG. 6.1

Location of Regions

The surface water supply systems for these communities are shown in Figure 6.2.

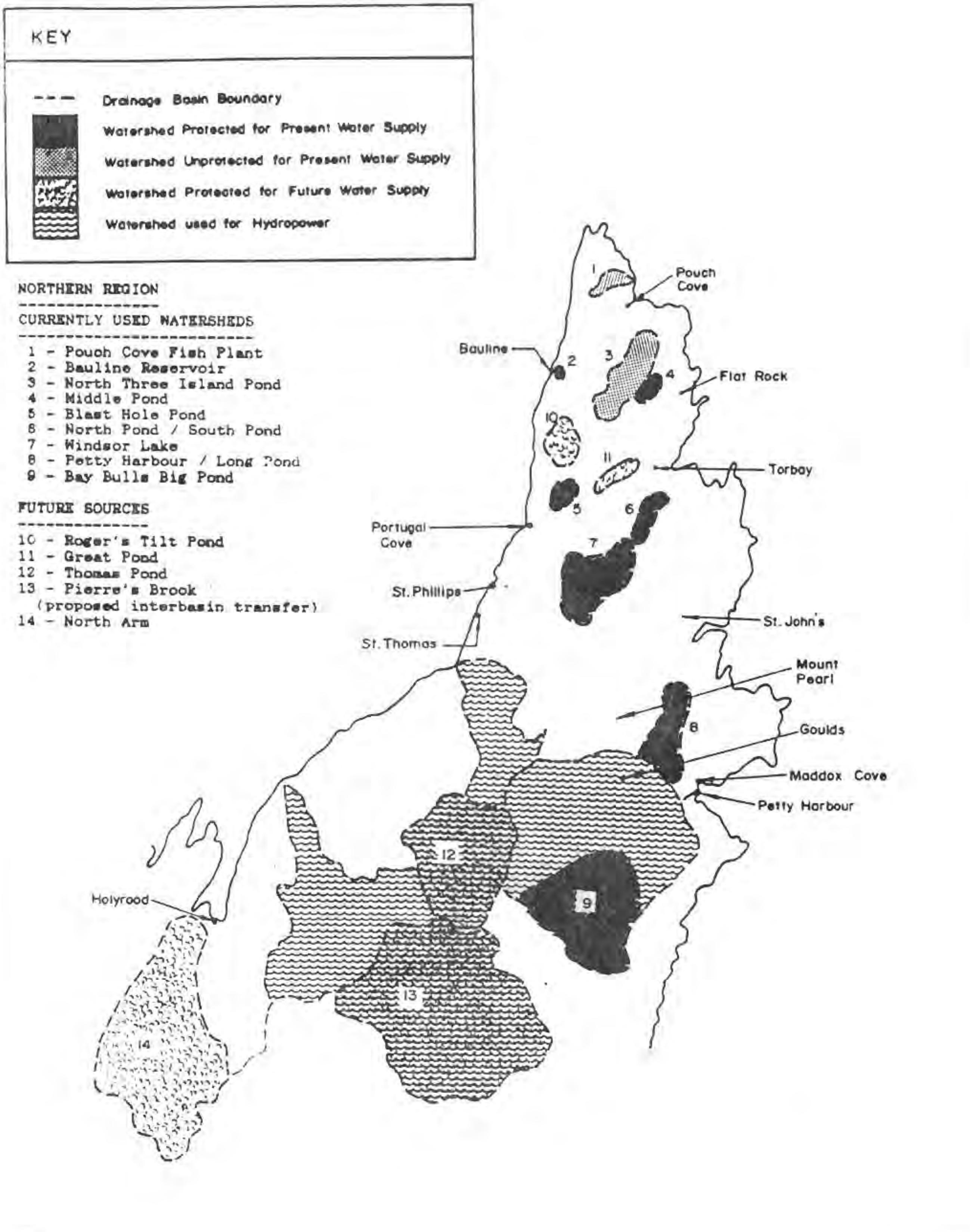
The water supply and demand in each of the communities is discussed in Sections 6.1.1 to 6.1.13, starting with the communities served by the regional system. A summary of the supply/demand analysis is provided in Section 6.5.

6.1.1 - Regional Water Supply System

The St. John's regional water supply system serves the City of St. John's and surrounding communities, including

Name	Population (1986)
- City of St. John's	92 216
- St. John's Metropolitan Area (Metro)	6 254
- Town of Mount Pearl	20 293
- Conception Bay South	15 531
- Goulds	4 688
- Paradise	3 346
- Wedgewood Park	1 385
Total	143 713

The total population served is less than this since not all residents of all communities are connected to the system. In particular, presently only about a third of Conception Bay South is connected, and not all the Metro area is served. The total population presently served is estimated in this study to be about 135 000.



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Regional Water Resources Study
Eastern Avalon Peninsula

FIG. 6.2

Northern Region Watersheds

ACRES

Present Demand

The demand on the regional water supply system is about 38.6 Mm^3/a, or about 105,600 m^3/d (1.22 m^3/s). On a per capita basis, this is about 780 litres per capita per day (l/c/d). The industrial and commercial portion of this, estimated approximately from water tax records, is about half of the total. Certain buildings in the public administration sector are subject to commercial rates, and are included in this figure. Schools, hospitals, and Memorial University, on the other hand, are excluded. The domestic or non-metered portion of the water use thus represents a per capita consumption of about 390 l/c/d.

Table 6.1 shows water consumption from the three regional system sources, Petty Harbour Long Pond, Windsor Lake, and Bay Bulls Big Pond. Figure 6.3 shows the average distribution of demand through the year. The peak weekly summer demand is generally about the same as the peak weekly winter demand, and is only perhaps 5-10 per cent higher than the average weekly demand. Seasonal demand peaks do not vary as much in Newfoundland as they do in other parts of Canada, because the summer lawn-watering and agricultural irrigation component is much smaller. Winter demands are sometimes higher than expected because unusually cold periods cause people to leave their taps running to prevent pipes from freezing.

Instantaneous peak demands are determined by consideration of typical values, past records, required fire flows and the like, and are required for the design of the distribution system. As such they are outside the scope of this study.

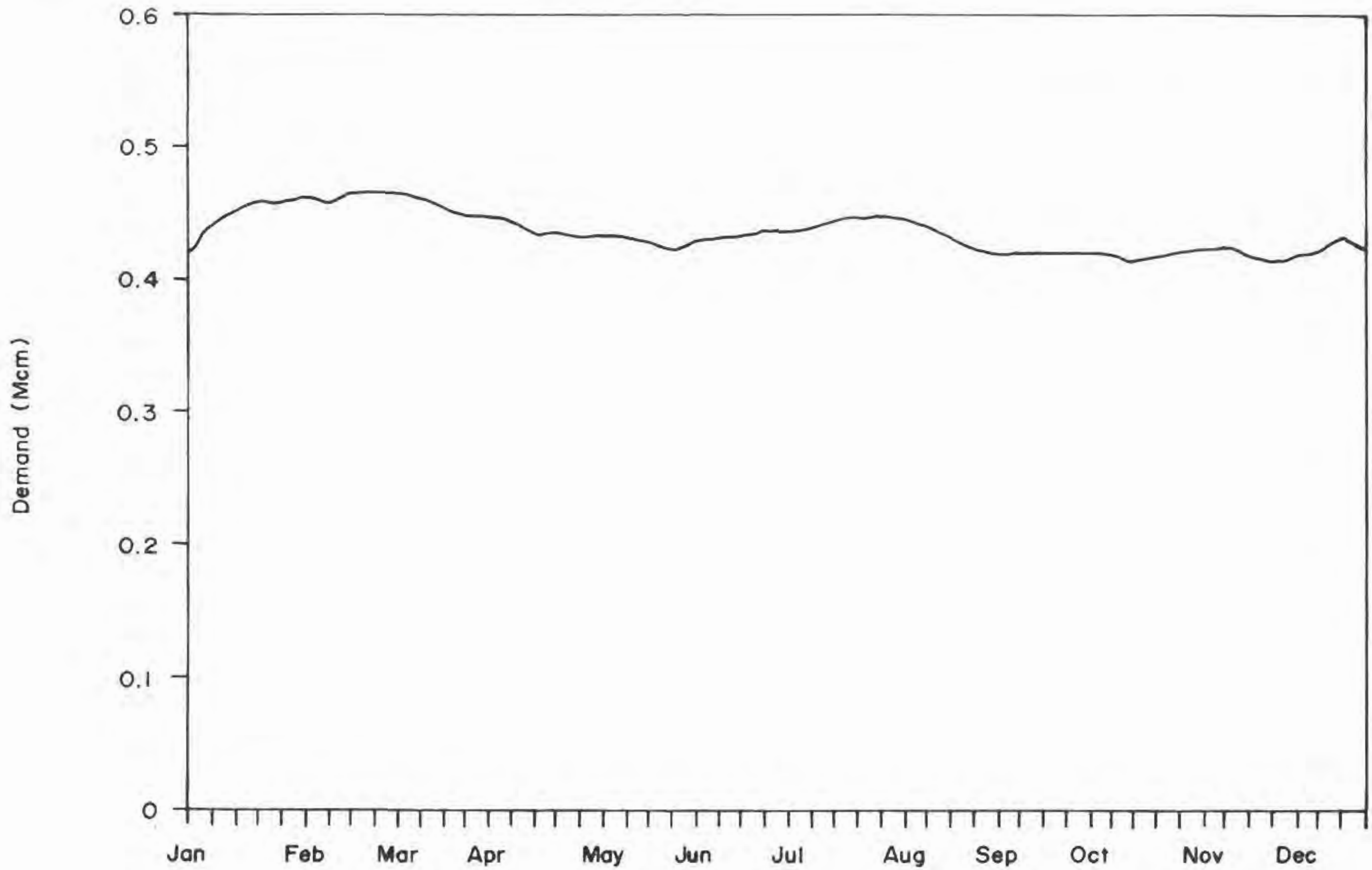
TABLE 6.1

ST. JOHN'S REGIONAL SYSTEM : ANNUAL WATER USE

Year	PH/WL (Mm3)	BBBP (Mm3)	TOTAL REGIONAL (Mm3)	TOTAL REGIONAL (m3/day)
1970	18.51		18.51	50,700
1971	18.96		18.96	51,900
1972	21.93		21.93	60,000
1973	24.04		24.04	65,900
1974	24.80		24.80	67,900
1975	25.56		25.56	70,000
1976	24.69		24.69	67,600
1977	23.80	1.6	25.39	69,600
1978	22.81	6.2	28.97	79,400
1979	23.82	7.6	31.40	86,000
1980	23.81	8.3	32.10	87,900
1981	24.10	9.0	33.08	90,630
1982	23.25	9.3	32.54	89,200
1983	23.23	9.6	32.79	89,800
1984	25.03	11.4	36.47	99,900
1985	22.07	13.4	36.07	98,800
1986	23.66	14.9	38.56	105,600

Note:

PH/WL - Petty Harbour/Long Pond plus Windsor Lake
BBBP - Bay Bulls Big Pond



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Eastern Avalon Peninsula

Average Weekly Water Consumption - Regional System

FIG.6.3

Water Supply Sources

The water supply for the regional water supply system comes from three sources

- Windsor Lake
- Petty Harbour/Long Pond
- Bay Bulls Big Pond.

The three watersheds are shown on the map in Figure 6.2.

George's Pond, on Signal Hill, was originally the City's source of water. It is now used for emergencies only. The reliable yield from these three sources is given Table 6.2.

The water supplied by the regional water supply system meets the Health and Welfare Canada standards for drinking water. The water from Petty Harbour Long Pond sometimes causes complaints about colour, fine suspended material, and odour. The treatment process (screening, chlorination and pH adjustment) does not remove colour, odour, or very fine particles.

Windsor Lake is reported to have been originally chosen because of the excellent quality of its water. The watershed is protected, and no new residential or recreational developments are permitted. Treatment presently consists of screening chlorination, and pH adjustment. As with Petty Harbour, this process does not remove colour, odour, or very fine particles.

The water from Bay Bulls before treatment is soft, acidic, and moderately coloured. The watershed is protected, but there is development along the highway, and the pond has traditionally had extensive recreation use. It is also located adjacent to an area of agriculture and dairy farming. The water from the pond is

TABLE 6.2

RELIABLE YIELD, REGIONAL SYSTEM WATER SOURCES

Source	Reliable Yield m^3/d(1)	Reliable Yield (m^3/d)(2)	Approximate 1986 Consumption m^3/d
Windsor Lake	43 200	45 400	65 000
Petty Harbour Long Pond	17 000	18 200	
Bay Bulls Big Pond	100 000	104 600	41 000
Total	160 200	168 200	106 000

Note:

1. From St. John's Urban Region Regional Plan 1980. An additional reserve of 4,500 m^3/d would be pumped from Broad Cove River for a total of 164,700 m^3/d.
2. St. John's Regional Water System Study.(19)

treated using an ozone process, and as a result is of excellent quality.

Projected Demand, St. John's Regional System

The population to be served by the regional water supply system was projected as a proportion of St. John's Census Metropolitan Area (CMA). By 2011 demand was assumed to be 156,700 m^3/d. Details of these projections are presented in Appendix C, and summarized in Table 6.3 below. Two cases are considered. The first is a reasonably optimistic base case of 5.5 per cent per 5 year intercensal period. The second is an extremely high case of 12.4 per cent per intercensal period (the highest growth rate ever achieved in an intercensal period).

Comparison with reliable yield shows that present sources will have sufficient water to supply the system for the next 25 years. If growth rates are extremely high, however, the system will reach its limit around the turn of the century.

Future Sources

Notwithstanding the fact that present sources should be adequate well into the next century, it is prudent to identify future sources and to ensure their protection.

Three future sources for the regional water supply system have been identified and designated as protected watersheds in the 1987 St. John's Urban Region Draft Regional Plan (#), Thomas Pond, Pierre's Brook, and North Arm River. Estimated yields are given in Table 6.4.

The locations of these three watersheds are shown on Figure 6.2. Each is briefly discussed below. Broad Cove River (Little Powers Pond) and Paddy's Pond are also discussed.

TABLE 6.3

POPULATION AND DEMAND FORECAST REGIONAL SYSTEM

Case	Year	Pop'n St. John's CMA	Pop'n Served	Estimated Demand (m^3/d)	Supply/ Demand Ratio
Present	1986	161 901	135 000	105 600	1.5
Base Case	2011	211 598	201 000*	156 700	1.0
Extremely High Case	2011	290 456	276 000*	215 200	0.7

Note: Reliable Yield = 160,200 m^3/d

*assuming 95 per cent of CMA served

TABLE 6.4

FUTURE REGIONAL WATER SUPPLY SOURCES

Area Watershed	Estimated Yield (m^3/d)
Thomas Pond	50,000*
Pierre's Brook	215,000
North Arm River	100,000*
Little Powers Pond	36,300

*Yield will depend on the scheme selected. Reference 53 estimates 109,000 m^3/d for North Arm River.

Thomas Pond

At present a principal candidate as next source is Thomas Pond. A Resource Development Scheme was prepared for the St. John's Metropolitan Area Board in 1983(8) for the Thomas Pond watershed, and although it has never been officially adopted, it is used for unofficial planning purposes.

Thomas Pond is more centrally located than the alternatives, North Arm River or Pierre's Brook. Present uses in the watershed include

- agriculture (Cochrane Pond Farmland Development Project)
- forestry
- quarrying (aggregate deposits)
- recreation
- power generation.

Future uses could include, besides water supply,

- pyrophyllite mining
- peat harvesting.

With careful management, most of the present uses could continue without posing threats to the watershed. The one clear economic conflict is with hydro power. This conflict occurs in several watersheds, including Bay Bulls Big Pond. It may be noted, however, that the volume of water from Thomas Pond designated for water supply is worth at least several hundred thousand dollars a year in energy generation. Since essentially the same consumers use both the energy and the water, it is important to consider the increased cost of electricity in assessing the economics of developing a water supply source. Very little water is spilled from these reservoirs, so water cost to supply water may not necessarily be replenished.

Water quality at Thomas Pond is not particularly good. In addition to high colour and turbidity, it has high concentrations of iron and manganese. Coliform counts are also high, probably due to the agricultural and possibly the recreational use. A treatment plant comparable to that at Bay Bulls Big Pond would likely be required. The reported reliable yield from Thomas Pond is 50,000 m^3/d or 81,800 m^3/d if storage is developed.

Pierre's Brook

The proposal for Pierre's Brook is to pump the water to Bay Bulls Big Pond, a distance of 16 km, where it would be treated in the Bay Bulls plant. Pumping costs, expansion of the treatment plant, and the value of lost energy would be the major costs associated with development at Pierre's Brook.

No reports of reliable yield are available. The reliable yield can be approximately estimated by considering the plant capacity and the present very small spill; the reservoirs are presently regulating about 15 to 20 per cent of the annual flow volume. With this storage ratio, the system should be able to yield 60 per cent of the annual flow volume (using methods developed in Section 2) for water supply, i.e. about 250,000 m^3/d. In the calculations of supply and demand a more conservative estimate of 215,000 m^3/d was used.

North Arm River

North Arm River, draining a large watershed south of Holyrood, is the third watershed protected as a future regional water supply source. No detailed studies have been done to date on this watershed; the 1:10 year 1 month low flow is about 30,000 m^3/d; this could presumably be considerably improved with the development of storage. An estimate of just over 100,000 m^3/d was provided in an earlier study(53) and 100,000 m^3/d is used in the supply/demand calculations in this report. Additional protection may be required to supply that yield.

Present watershed uses are forestry, recreational and some mineral working. There is no hydro power plant on the river.

The chief disadvantages of this watershed appear to be its low elevation and distance from the population centre. A more thorough evaluation of this watershed, and how it might be most efficiently used in connection with the other sources for regional water supply system, is required.

Broad Cove River (Little Powers Pond)

Little Powers Pond is already used by the city as a reserve supply. Before the development of Bay Bulls Big Pond, water was pumped from Little Powers Pond in very dry periods into Windsor Lake. Development proposals for the watershed involve building a high dam to increase the reliable yield to 36,300 m^3/d.

This watershed is already protected; some minor conflicts have arisen because of existing developments, but no major problems are envisaged. At the time of construction of Bay Bulls Big Pond, this scheme was found to be less economic than development of the Bay Bulls source; it should still be considered in future analysis.

Paddy's Pond

Paddy's Pond was also considered at the time that Bay Bulls was selected. It was rejected chiefly because of the conflicts with existing developments. These include

- hydro power
- seaplane base
- forest fire patrol
- recreation
- agriculture (community pasture).

It is also at a lower elevation than Thomas Pond, which drains into it. If used in conjunction with Thomas Pond, it would contribute approximately an additional 25 per cent to the Thomas Pond drainage area. It is not a protected watershed.

6.1.2 - Torbay

Torbay, located to the northeast of St. John's, is officially designated a town. Like many of the areas surrounding St. John's, it is becoming increasingly urbanized. The town boundaries cover a large area of low density development; in consequence, only about 30 per cent of the population is served by the water supply system. At a 1981 rate of 740 l/c/d, present demand is 740,000 l/d.

Torbay presently has its intake in North Pond. South Pond and Great Pond are future protected watersheds. The North Pond/South Pond watershed and the Great Pond watershed are shown in Figure 6.2. The reported value of the present system is $6.1 million.

The North Pond watershed alone cannot serve the entire population even at present. A reasonably inexpensive scheme has been proposed to augment the flow by diverting South Pond flow into North Pond. This would provide sufficient water for most of the present population, but with the projected rapid growth, an additional source may be necessary before the end of the planning period. Either Great Pond or a connection to the regional system would provide sufficient water. A recent report to the Town of Torbay recommends the latter on economic grounds. The projections for the regional system take account of this possible connection. Present and projected supply/demand estimates are as follows.

TORBAY

Year	Pop'n	Pop'n Served	Demand (m^3/d)	Source	Estimated Yield (m^3/d)	Supply /Demand Ratio
1986	3730	1000	740	North Pond	1560	2.1
2011	8705	8705	6440	South Pond	1160	
				Great Pond	5480	
				Total	8200	1.3

The demand rate of 740 l/c/d is based on reported consumption. It is a very high figure for a primarily residential area, and suggests high losses. It has been used to project demand, but it might be expected that if the losses are controlled, the consumption rate would decrease. Population projections have assumed a 17 per cent increase in each 5 year intercensal period, to 2011.

Like most surface water supply systems in the study area, North Pond provides good quality water. Treatment is with chlorine.

North Pond, South Pond and Great Pond watersheds are all protected. A small portion of the South Brook watershed overlaps the airport boundaries, and some degradation of water quality is possible from airport use, in particular increased nitrate levels from de-icing chemicals. The pond would have to be tested to determine whether any nitrates actually reach South Pond itself, since the biological uptake of nitrates between the airport and the runway is likely to be high. Chlorination and PH adjustment (lime feed) would be required at the Great Pond source.

6.1.3 - Portugal Cove

The Town of Portugal Cove obtains its water from Blast Hole Ponds and 2 neighboring ponds, Little Pond and Cross Pond. Little Pond has been dammed and a small diversion channel has been constructed to augment the water supply. Figure 6.2 shows the location of the watershed. The present value of the system is reported to be over $4 1/2 million. There are also 5 drilled community wells, the remainder of the homes have private groundwater supplies. The water supply serves both part of the community and the fish plant (Portugal Cove Ocean Products). Until recently the fish plant ran its own line up to Northeast Pond River, but it now obtains its fresh water from the municipal system.

Population is assumed to increase at 17 per cent per intercensal period to 2011. The feasibility study for the present water supply assumes that the population to be served will be limited to 1850. For this study, estimate of future demand conservatively assumes that all the population will be served by the municipal system. The demand rate used is 700 l/c/d, just over the 1981 average rate for all communities in the study area with populations greater than 1000, including St. John's. Yields were estimated using the curves developed in Section 2.

The fish plant uses both fresh and salt water. At full production they can use the equivalent over 1,000 m^3/day but the average annual use is much less. Upgrading to use 90 per cent salt water is planned. If their present assumed consumption of 260 m^3/day is reallocated to domestic use, approximately 350-400 additional residents could be served.

The table below shows that the surface supply is not adequate to serve all the community, and that groundwater is required to meet present demand.

Portugal Cove

Year	Population	Municipal Demand m^3/d	Est. Yield m^3/d	Total Demand (m^3/d)	Supply/ Demand Ratio
1986	2497	1750	2760	2010*	1.4
2011	6054	4240	2760	4240	0.7

*Taken from Pre-Design Report(10).

Options for meeting the future shortfall are

(1) Private groundwater supplies. The development in Portugal Cove, is taking place in low density residential areas, with individual site services. With proper control and monitoring, private groundwater supplies could continue to meet water supply needs outside the limits of the town's distribution system.

(2) Development of Northeast Pond River (presently unprotected). This would provide an additional 1500 m^3/d, approximately meeting the shortfall.

(3) Connection to regional system. Projections made in this study for the regional system take account of this possible connection. It is important to note that the demand rate and population projections are very high. If the demand

rate is assumed to be 410 l/c/d (the present measured rate at Holyrood), for example, there will be no shortfall.

6.1.4 - Holyrood

The Town of Holyrood is presently supplied by 3 wells. The water from one of these is not presently used, because of water quality problems. The addition of a filter, planned for the near future, will allow the third well to be used. The community system serves about half the population; the remainder have private wells. The value of the present system is reported to be nearly $3.7 million.

The present reliable yield is estimated to be 450 m^3/d. With the proposed upgrading, yield is expected to increase to over 1000 m^3/d. This is adequate to meet demand, but cannot supply the entire community, as the table below shows. A demand rate of 410 l/c/d and a population growth rate of 17 per cent per intercensal period have been used.

Holyrood

Year	Population	Demand (m^3/d)	Estimated Yield (m^3/d)	Supply/ Demand Ratio
1986	2118	900	450	0.5
2011	4644	1900	1000	0.5

The alternate proposed sources include North Arm River and Harbour Main Pond. North Arm River basin has been designated as a protected watershed for the regional water supply system; if this basin is developed, Holyrood could become part of the regional water supply system. The projections for the regional system take this possibility into account.

Holyrood Thermal Generating Plant

Holyrood is also the location of Newfoundland and Labrador Hydro's main thermal generating station. The plant obtains its cooling water from Quarry Brook, a small river to the northeast of the town's centre. The flows are much larger than the plant requirements; the maximum annual requirement, considering possible plant expansion, is 3000 m^3/d; the 1:10 year low flow in Quarry Brook is nearly 5000 m^3/d. No supply problems are anticipated.

6.1.5 - St. Phillip's

The Town of St. Phillip's is a low density residential area served primarily by private wells. There is a partial water distribution system to about 12 homes in the area close to the beach. The water from the present system receives ultraviolet treatment, and bacteriological quality is reported to be satisfactory.

Population is projected at 17 per cent. Demand is assumed to be 700 l/c/d, approximately the average for the larger communities near St. John's.

The total present and projected demand is shown below.

St. Phillip's

Year	Population	Demand (m^3/d)
1986	1604	1120
2011	3517	2460

Although St. Phillip's is growing rapidly, present plans call for continued low density development with groundwater supply until such time as servicing becomes economically feasible. It is unlikely that the whole town will be fully serviced by a surface system, because of the high elevations of a number of homes, and the hilly topography. A 1978 estimate to service the whole town was nearly $9 million. The most likely scenario is that servicing will be introduced in limited areas, probably from the Little Power's Pond/Windsor Lake portion of the regional water supply system.

6.1.6 - Pouch Cove

The Town of Pouch Cove receives its water from North Three Island Pond in the Shoe Cove Brook basin, as shown in Figure 6.2. The watershed is presently unprotected. Water quality from the surface system is reported to be satisfactory, with the exception of slightly elevated iron levels. As with most communities, a number of homes in low density areas are served by private wells. The present value of the surface supply system is reported to be about $7 million.

Estimated demand and yield are given below. Population was projected at 4 per cent per intercensal period. Demand was estimated using an average rate of 410 l/c/d for communities outside the St. John's area. Yield was estimated using the methods described in Section 2.

Pouch Cove

Year	Population	Demand (m^3/d)	Est. Yield (m^3/d)	Supply/ Demand Ratio
1986	1576	650	12100	15
2011	1925	790	9780	12

The water supply should be adequate well into the foreseeable future.

The fish plant in Pouch Cove has a separate water supply as shown in Figure 6.2. This supply is presently unprotected.

6.1.7 - Outer Cove/Middle Cove/Logy Bay

The Town of Outer Cove/Middle Cove/Logy Bay is located to the northeast of St. John's. Water supply is from private wells and is generally of good quality and abundant. Occasional problems may occur from local contamination of individual wells.

Housing density is low, and one of the objectives of the proposed development scheme for the area is to retain its predominant rural character. Since there is an insufficient density of development to make the provision of piped municipal services reasonable and acceptable, the continuation of the present system of on-site services is the preferred alternative in the proposed development scheme.

Nevertheless, the development scheme points out that the regional water supply system is providing a water supply main very close to the area. It recommends that consideration should be given to ensuring that all new development take place in such a manner as to permit municipal services to be economically provided should the need arise; in general terms this means new developments should be grouped at lower elevations.

The present and projected total demand is given below. Population is assumed to increase at 17 per cent in each intercensal period, and demand is estimated at the regional average for surface systems in large communities near St. John's of about 700 l/c/d. This is a very conservative demand estimate, for a rural community.

Outer Cove/Middle Cove/Logy Bay

Year	Population	Demand (m^3/d)
1986	1300	910
2006	2850	2000

As stated above, the demand will most likely be met from local groundwater sources, with connection to the regional water supply system an alternative. The projections for the regional system take account of this possible connection.

The Marine Sciences Research Laboratory is located in the Logy Bay area. It has its own small surface supply from the Sugarloaf Pond drainage basin.

6.1.8 - Petty Harbour/Maddox Cove

The Town of Petty Harbour/Maddox Cove has a 1986 population of 974 people.

The communities are presently served by a water supply originating in Beer Pond and First Pond. The watershed is protected as part of the Petty Harbour Long Pond water shed for the regional water supply system, shown in Figure 6.2. These two ponds do not flow into Petty Harbour Long Pond, although water has been pumped from Beer Pond into Long Pond in dry flow periods to augment the regional water supply system. Treatment consists of straining, pH adjustment, and chlorination. A new chlorination system was recently installed, and water samples tested for bacteria are satisfactory. The reported value of the system is $4.5 million.

The demand is estimated below, assuming that all the population will be serviced. The rates of population increase and demand are 17 per cent per intercensal period, and 700 l/c/d, as used in this study for large communities near St. John's. The fish plant obtains its water from the municipal system; the demand rate is high enough to include its use. Yield is estimated by the methods of Section 2.

Petty Harbour/Maddox Cove

Year	Population	Demand (m^3/d)	Est. Yield (m^3/d)	Supply/ Demand Ratio
1986	974	680	1870	2.8
2011	2136	1495	1980	1.3

The present supply should be adequate to meet demand until the end of the planning period. The town is advantageously placed to draw on the regional water supply system, using Petty Harbour Long Pond, should the need arise.

6.1.9 - Flatrock

Flatrock is an incorporated town with a 1986 population of 884 up about 9 per cent from the 1981 population of 808. Residents presently obtain their water from private wells. Water quality is generally good, but occasional local bacteriological and chemical problems are reported from individual wells.

A municipal services study completed March 1986, recommends development of a surface supply from Middle Pond (also called Medalsis Pond), shown in Figure 6.2. This watershed is protected. The water in Middle Pond is reported to be of excellent quality. Details of treatment processes have not yet been developed, but are expected to be simple, e.g. filtration, chlorination, PH adjustment.

Present and projected supply and demand are given below, assuming that all the population will be served. The growth rate used is 17 per cent per intercensal period, and the demand rate is 700 l/c/d. The municipal services report states that the total storage will be 1.27 Mm^3. Using the methods developed in Section 2, the reliable yield for this storage is estimated to be 3280 m^3/d.

Flatrock

Year	Population	Demand (m^3/d)	Est. Yield (m^3/d)	Supply/ Demand Ratio
1986	884	620	3280	5.3
2011	1939	1360	3280	2.4

The estimates above indicate that the proposed surface water supply should be able to supply the required demand for the next 25 years.

6.1.10 - St. Thomas

The Town of St. Thomas, located on Conception Bay, is presently served by private wells. The wells in the area are reported to have good production rates on an individual basis. Water quality is generally good; occasional local bacteriological and chemical problems are reported from individual wells.

Projected population and demand are given below, at the rates of 17 per cent per intercensal period, and 700 l/c/d as used in this study for communities near St. John's.

St. Thomas

Year	Population	Demand (m^3/d)
1986	648	450
2011	1420	990

The present system of providing on-site water supply could continue to meet future needs if the development continues to be low density residential, as presently envisaged. St. Thomas may also eventually be connected to the regional water supply system, since the adjacent communities of Conception Bay South and Paradise are being connected. The projections for the regional system take account of this possible connection.

6.1.11- Bauline

Bauline is an unincorporated community with a 1981 population of 423. About 40 homes are served by a small reservoir (about 730 m^3) on Bauline Brook, as shown in Figure 6.2. The remainder of the residents have private wells. The surface system is treated by chlorination. The bacteriological water quality is usually good, but iron levels exceed the recommended limits. The cost of the reservoir and tank is about $100 000 in present dollars.

The projected population and demand are given below. A growth rate of 4 per cent per intercensal period is used, the rate assumed in this study for communities in the St. John's CMA but remote from the urban core. A demand rate of 410 l/c/d is used, for small communities outside the St. John's area. Yield for both reservoirs was estimated using the methods developed in Section 2.

Bauline

Year	Population	Pop'n Served	Demand (m^3/d)	Source	Est. Yield (m^3/d)	Supply/ Demand Ratio
1981	423	150	60	Bauline Res.	130	2.1
2011	535	535	220	Bauline Res.	130	4.8
				Rogers Tilt Pd.	920	
				Total	1050	

The present system can continue to serve the central part of the community, and there is an adequate supply of water in Roger's Tilt Pond to supply the additional population along Bauline Line and Portugal Cove Road.

The development of a water supply system from Roger's Tilt Pond is likely to be expensive, because of the rocky terrain, and may not be necessary with continued low density development. The recent proposed Bauline development scheme recommends that adequate on-site services be provided, and that schemes alternate to conventional municipal services should be encouraged. These recommendations are in keeping with the general policy of maintaining the present agricultural and rural character of the area.

6.1.12 - Hogan's Pond

Hogan's Pond is a small incorporated town with a 1986 population of 139. It is located northwest of St. John's, near St. Phillip's. Residents presently obtain their water from groundwater. This area is very attractive and being in close proximity to St. John's is under development pressure. Projected demand is given below, using rates for communities near St. John's.

Hogan's Pond

Year	Population	Demand (m^3/d)
1986	139	90
2011	305	210

On-site water supplies should be able to continue to supply domestic needs if low density residential development continues as planned. The other alternative, very expensive at present for such a small community, is connection to the regional system take account of such a connection.

6.1.13 - Indian Pond Near Holyrood

Indian Pond near Holyrood is an unincorporated community with a 1981 population of 129. Projected demand is estimated below.

Indian Pond

Year	Population	Demand (m^3/d)
1981	129	130
2011	283	200

Since the regional water supply system is presently being extended into the adjacent community of Conception Bay South, and may eventually serve Holyrood, it is possible that sometime in the future it may also supply Indian Pond. Projections for the regional system take account of such a connection. However, with controlled development and careful location of on-site services, water supply needs can continue (See Figure 6.4) be met by groundwater.

6.2 - Eastern Region

All the communities from Bay Bulls to Cappahayden are located in the eastern region. These are listed below, in order of population.

Communities	Population (1986)
Bay Bulls	1114
Witless Bay	1022
Ferryland	762*
Cape Broyle	698*
Fermeuse/Kingman's Cove	546
Calvert	482*
Renews/Cappahayden	587
Tors Cove	332*
Aquaforte	201
Burnt Cove	173*
Mobile	171*
Port Kirwin	142
Brigus South	112*
Admiral's Cove	99*
Total	6441

*1981 Population. Little change expected in 1986.

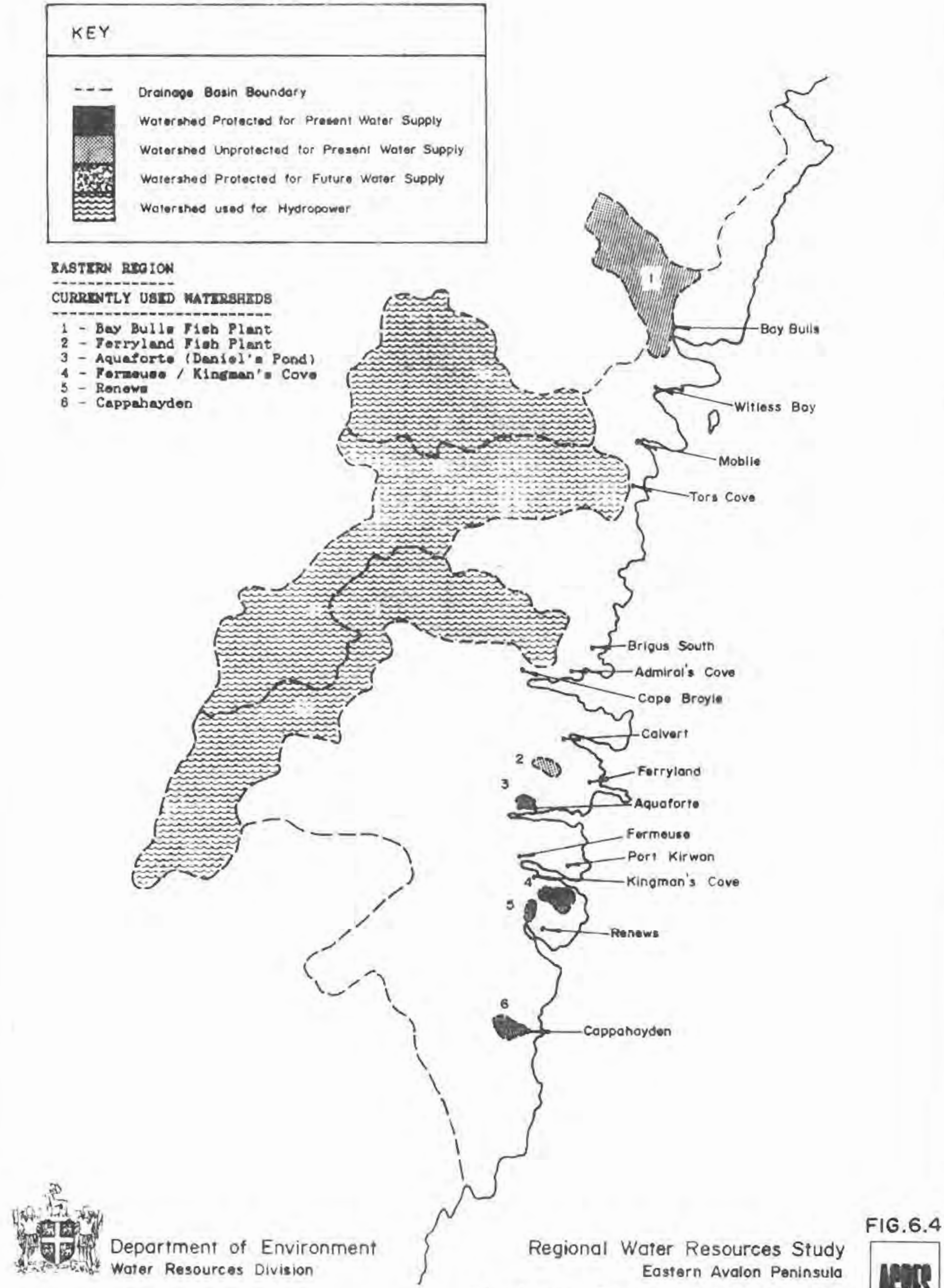

FIG.6.4

Regional Water Resources Study
Eastern Avalon Peninsula
Eastern Region Watersheds

The water supply/demand situation for each of these communities is given in the following sections. A summary of the supply/demand analysis is given in Section 6.5.

6.2.1 - Bay Bulls

The Town of Bay Bulls has a 1986 population of 1114. Water supply is from individual wells and 4 community wells. The reported value of the community system is $15,000.

Present and projected demands are estimated in the table below. A population growth rate of 4 percent per intercensal period and a demand rate of 410 l/c/d were used.

If the present pattern of low density residential development continues, groundwater should be able to continue to meet the demand. There are two alternatives for surface supply. One is Bay Bull's River and the other is Pierre's Brook at Gull Pond.

The fish plant obtains its water from Bay Bulls River as shown in Figure 6.4. Few homes are reported to be connected to this water supply system at present. No problems with supply or quality are reported; the water is chlorinated. No storage has been developed but the one month low flow having a return period of 1:10 years is estimated to be 14 000 m^3/d, more than adequate to meet both town and fish plant requirements.

A supply from Pierre's Brook could serve both Bay Bulls and Witless Bay. Reliable yield is of the order of 215,000 m^3/d. Conflicts may arise with hydropower and/or with the use of this supply for the St. John's regional system.

Bay Bulls

Years	Population	Demand (m^3/d)
1986	114	460
2011	1460	600

6.2.2 - Witless Bay

The Town of Witless Bay is served by groundwater from private wells and 5 drilled wells.

Bacteriological water samples are always satisfactory and careful location of wells and septic tanks and adequate safeguards against contamination of groundwater supplies (e.g. from leaking oil tanks or other hydrocarbon sources) should prevent water quality problems. The population is growing, but if low density development continues as expected, no problems with water quantity are anticipated. The table below shows present and projected demand.

Witless Bay

Years	Population	Demand (m^3/d)
1986	1022	420
2011	1340	550

The fish plant at Witless Bay taps directly into the Newfoundland Light and Power penstock from Pierre's Brook at Gull Pond. Annual use at the plant varies, but is unlikely to exceed about 1400 m^3/d. This plant does not have a salt water system. The town could access the same supply; the estimated reliable yield of 215,000 m^3/a is very high. As mentioned for Bay Bulls, conflicts might arise with hydro power and/or the use of this supply for the St. John's regional system.

6.2.3 - Ferryland

Ferryland is an incorporated community with a 1986 population of 762. At 410 l/c/d, demand is 310 m^3/d. In addition to private wells, 3 community wells provide groundwater, which is chlorinated before delivery to residents. The value of the existing system is reported to be $118,000.

The fish plant is supplied with surface water, as shown in Figure 6.4. This watershed is presently unprotected. The plant also uses salt water for processing.

With expected stable population growth, present sources should be adequate to meet future demand.

6.2.4 - Cape Broyle

Cape Broyle, an unincorporated community with a population of nearly 700, is supplied with water from community and private wells. The water from the community wells is chlorinated before it is distributed. Present value of the community system is reported to be $15,000.

Total demand is estimated to be about 290 m^3/d. With the expected stability in population, present sources should be adequate to meet future demand.

6.2.5 - Fermeuse/Kingman's Cove

Fermeuse and Kingman's Cove are adjacent communities with a combined 1986 population of 546. Fermeuse is an incorporated community; Kingman's Cove is unincorporated. Water supply is from both surface and groundwater sources. The supply serves both the fish plant and part of the community. The remaining houses are served by wells.

The surface supply location is shown in Figure 6.4. The outlets from Bear Cove Pond and Merrymeeting Ponds area dammed to provide a reliable yield of about 8700 m^3/d (using methods from Section 2). Disinfection with chlorine compounds is provided just past the intersection of the lines from the 2 ponds. Water samples tested for bacteria are consistently satisfactory. Reported value of the present system is $1.07 million.

The highest fish plant use recorded in recent years (1982) is a monthly average of just over 2700 m^3/d. Fish plant demand is estimated at an average of two-thirds of the maximum recent record for this study. The domestic use is only a small fraction of this; residential use of all sources is estimated to be about 220 m^3/d. Supply and demand are presented in the table below.

Fermeuse/Kingman's Cove

Pop'n	Domestic Demand (m^3/d)	Fish Plant Demand (m^3/d)	Total Demand (m^3/d)	Reliable Yield (m^3/d)	Supply/ Demand Ratio
546	220	1810	2030	8700	4.3

With the expected stable population, and no planned expansion, present sources should remain adequate.

6.2.6 - Calvert

Calvert is an unincorporated community with a 1981 population of 482. Residents presently obtain their water from private groundwater sources and a drilled community well. Present value of the community system is reported to be $57,000.

Total domestic demand is presently estimated at just under 200 m^3/d. Since population is expected to remain stable, present sources should continue to meet future demand.

The fish plant at Calvert uses salt water. Small amounts of fresh water are obtained from ground water as required for the purpose of consumption only.

6.2.7 - Renews/Cappahayden

Renews is incorporated as a community with Cappahayden. The total 1986 population of the two communities is 587; about 100 live in Cappahayden, and the remainder are in Renews. Renews obtains its water from private wells and springs, as well as 12 dug wells located throughout the community. Water samples tested for bacteria are generally satisfactory; occasional local contamination occurs. A surface supply in Duck Pond shown in Figure 6.4 provides untreated water to a few homes. The watershed is protected, but residents report that groundwater provides better quality water.

With population expected to remain stable, and continued low density development, the present system of independent sources should be adequate to continue to supply the demand. The reliable yield of Duck Pond is estimated to be about 2400 m^3/d; domestic demand in Renews is about 200 m^3/d, so it is more than adequate to meet demand if required.

The fish packing plant on the east side of the harbour uses salt water. The plant on the west side is not in operation.

The residents of Cappahayden obtain their water from 2 community wells, as well as from Broad Cove Pond, as shown in Figure 6.4. The Broad Cove Pond watershed is protected.

Supply and demand are shown in the following table, assuming all the population is served by the surface system. Reliable yield was estimated using the techniques developed in Section 2.

Cappahayden

Population	Demand (m^3/d)	Estimated Yield (m^3/d)	Supply/Demand Ratio
100	41	4140	101

With the expected stability in population, these sources should be adequate to meet future demand.

Present value of the Renews - Cappahayden systems is reported to be $161,000.

6.2.8 - Tors Cove

Tors Cove is an unincorporated community with a 1981 population of 332. Water is supplied by individual wells. The estimated demand is about 140 m^3/d. The fish plant at Tors Cove obtains its fresh water directly from the penstock from Tors Cove Pond. A very large quantity of water is available from the Tors Cove Pond reservoir if required. With stable population growth and no anticipated expansion of the fish plant, present sources should remain adequate to meet future demands.

6.2.9 - Aquaforte

Aquaforte is an incorporated community with a 1986 population of nearly 201. Residents obtain their water from groundwater or from the fish plant surface water supply from Daniel's Pond, shown in Figure 6.4. Total residential demand is estimated to be just over 80 000 l/d.

The fish plant operates about 8 months of the year. It has the capacity to use about 490 m^3/d from either salt or fresh water systems.

Supply and demand are summarized below, assuming the fish plant uses an average of two-thirds of its maximum capacity in fresh water. Reliable yield was estimated using the methods developed in Section 2.

Aquaforte

Pop'n	Demand (m^3/d)	Fish Plant Demand (m^3/d)	Total Demand (m^3/d)	Reliable Yield (m^3/d)	Supply/ Demand Ratio
201	80	330	410	1360	3.3

The population is expected to remain stable, and no expansion of the fish plant is anticipated. Present sources should remain adequate for future demands.

6.2.10 - Burnt Cove

Burnt Cove is an unincorporated community with a 1981 population of 173. Its water supply requirements are presently being met by groundwater. The present demand is estimated at 71 m^3/d. The population is expected to remain stable and present sources should, therefore, be adequate to meet future demand.

6.2.11 - Mobile

Mobile is an unincorporated community with a 1981 population of 171. Present water supply is from groundwater. With the expected stable population, and continued low density development, present sources should be adequate to meet future demand. The adjacent Mobile River basin has been developed for hydropower, and a large quantity of water is available if required.

6.2.12 - Port Kirwin

Port Kirwin is an incorporated community with a 1986 population of 142. It is served by 2 separate systems, one in Port Kirwin North and the other in the main community of Port Kirwin. The reported present value of the systems is $590,000.

Port Kirwin North is an area of about 18-24 homes located on the road to Fermeuse. It obtains its water from a shallow community well located in the centre of the community. The yield is reported to be of the order of 40-65 m^3/d. This system was recently upgraded to include a storage tank, new pumphouse, and chlorination system.

About 70 percent of the population, or about 100 people, live in the main community of Port Kirwin. They are served by a surface supply from a small brook. This system is presently being upgraded to include a concrete storage reservoir of about 130 m^3, a booster pumping station, and a chlorination system. A simple sand filter will likely also be included. Water quality is reported to be good, with the exception of colour.

Total demand is estimated to be about 58 m^3/d. Given the expected population stability, present upgraded sources should continue to meet the demand.

6.2.13 - Brigus South

Brigus South is a small unincorporated community with a 1981 population of 112. Water supply is from private supplies and one community drilled well. Water is not chlorinated, but samples tested for bacteria are usually satisfactory. Reported present value of the community system is $50,000.

Present demand is estimated at 46 m^3/d. Since population is expected to remain stable, present sources should remain adequate.

6.2.14 - Admiral's Cove

Admiral's Cove is an unincorporated community with a population of almost 100, located near Cape Broyle. Total residential demand is estimated to be 41 m^3/d. Population is expected to remain stable, and the present groundwater sources should remain adequate.

6.3 - Southern Region

The communities from Chance Cove to St. Shott's are located in the southern region. These are listed below, in order of population.

Community	Population (1986)
Trepassey	1460
Portugal Cove South	375
St. Shott's	260
Biscay Bay	99
Total	2194

Each community is described in the following sections. A summary is provided in Section 6.5.

6.3.1 - Trepassey

The source of water for the Town of Trepassey is Northeast Pond River, as shown in Figure 6.5. New chlorination equipment has been installed, and samples tested for bacteria are satisfactory. The pH of the water exceeds acceptable limits, however. The present value of the system is reported to be $3.1 million.

The estimated demand and supply are given below, assuming all the population is served. Demand was estimated using the figure of 892 l/c/d reported in the municipal water use data base. It is over twice as high as expected, and suggests either substantial losses in leaks. Since no storage has been developed, supply is taken as the 1 month low flow having a return period of 1 in 10 years, estimated as described in Section 2.

Trepassey

Pop'n	Demand (m^3/d)	Estimated Yield (m^3/d)	Supply Demand Ratio
1473	1310	9900	7.6

Population in the area is stable, and the supply should be more than adequate for the planning period.

Fish Plant

The fish plant at Trepassey has a separate fresh water supply system. The water is pumped from Broom Cove Pond into the Rocky Pond watershed to a concrete lined storage basin. The location of the fresh water supply is shown in Figure 6.5. The water is chlorinated and filtered before use.

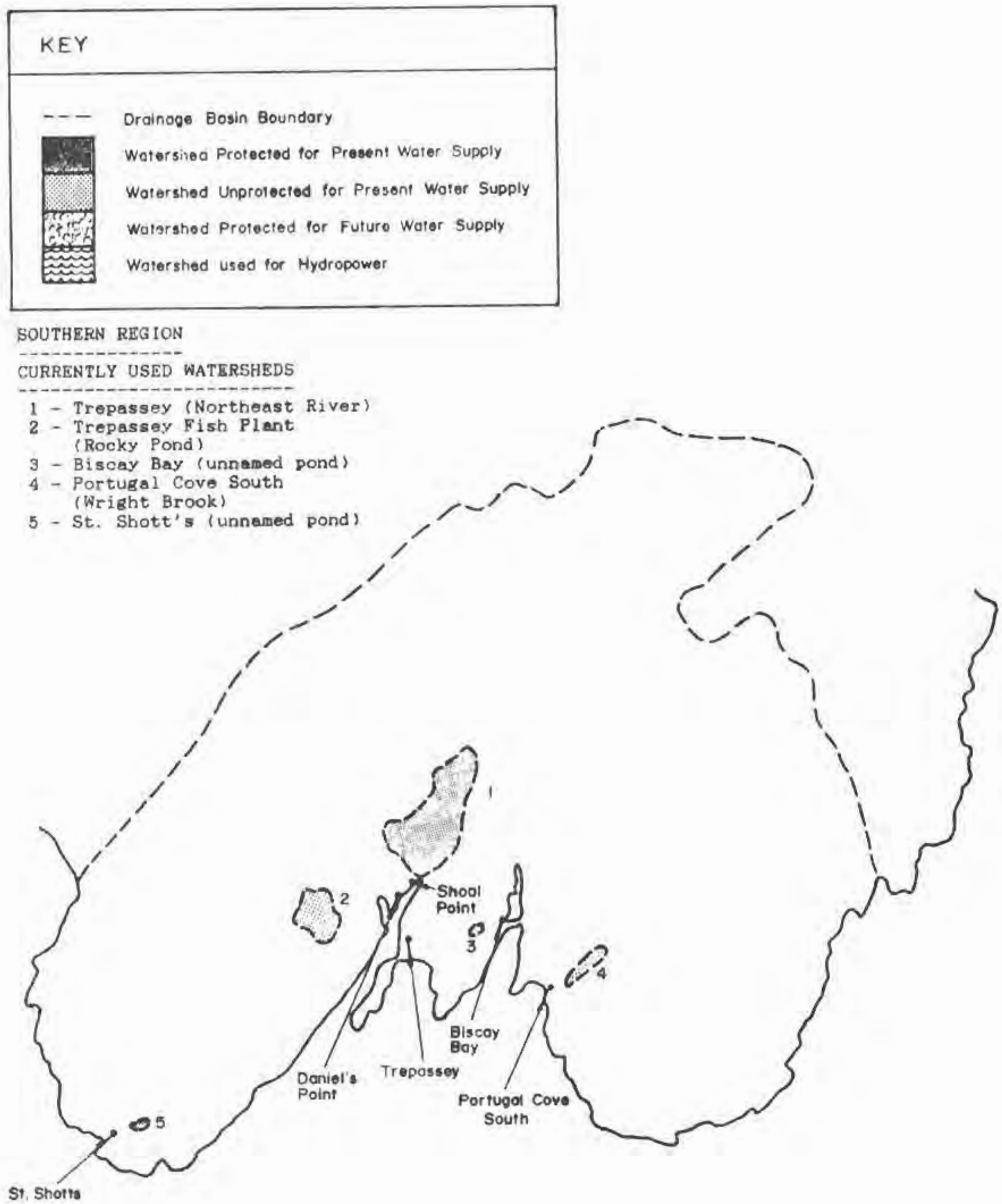

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FIG.6.5

Southern Region Watersheds

ACRES

The connection from Broom Cove Pond was originally designed to act as a siphon, but it is reported never to have worked properly, and pumping is required. The pond water also contains very fine suspended particles, which are not always entirely removed.

The fish plant at Trepassey has a relatively large processing capacity and consequent water demand (over 2 Mm^3 per year). The major source of water for the plant is the salt water system; it is capable of delivering 5 times the amount of the fresh water system. The fresh water supply is used only for minor uses such as drinking water.

6.3.2 - Portugal Cove South

Portugal Cove South is an incorporated community with a 1986 population of 375. It is served by a surface supply system from Wright's Brook, as shown in Figure 6.5. The watershed is presently unprotected. The system consists of a reinforced concrete dam forming a small reservoir; present value is reported to be $174,000.

Supply and demand are provided in the table below. Yield is estimated using the methods from Section 2.

Portugal Cove South

Population	Demand (m^3/d)	Estimated Yield (m^3/d)	Supply/ Demand Ratio
375	154	1260	8.2

With no population growth expected, this source should continue to meet future demand.

6.3.3 - St. Shott's

St. Shott's is an incorporated community with a 1986 population of 259. It is presently supplied with water from a stream about 2 km from the community. The intake is located at a small dam which controls the overflow from 3 ponds. The location is shown in Figure 6.5. Supply and demand are given in the following table.

St. Shott's

Population	Demand (m^3/d)	Estimated Yield (m^3/d)	Supply/ Demand Ratio
260	107	200	1.87

Since no appreciable storage has been developed, the 1 month low flow having a return period of 1 in 10 years is used to estimate the available supply.

With population expected to remain stable, present sources should be adequate.

6.3.4 - Biscay Bay

Biscay Bay is a small incorporated community with a population of just under 100. Residents obtain their water from a small surface supply located just west of the community, as shown in Figure 6.5. Total demand is estimated to be about 40 m^3/d. Population is expected to remain stable, and the present system should remain capable of meeting demand. The Department of Health reports that about half the samples tested for bacteria are unsatisfactory, however. Reported present value of the system is $25,000.

6.4 - **Western Region**

All the communities from Peter's River to Salmonier are located in the western region. These are listed below, in order of population.

Community	Population (1986)
St. Vincent's/St. Stephen's/Peter's River	727
Mt. Carmel/St. Catherine's/Mitchell's Brook	651
St. Mary's	712
Gaskiers/Point La Haye	517
Riverhead	407
Admiral's Beach	361
O'Donnell's	297*
St. Joseph's	213
Forest Field/New Bridge	98*
Mall Bay	71*
Total	4054

*1981 population

6.4.1 - **St. Vincent's/St. Stephen's/Peter's River**

St. Vincent's, St. Stephen's and Peter's River along the south coast of the study area have been incorporated as one community. The total population is 724.

St. Vincent's is the largest of these 3 communities. It is served by a number of public shallow wells, which are reported to go dry occasionally. The high school is served by an artisan well, and no problems are reported.

St. Stephen's has a surface water supply from a small brook with a concrete reservoir. Complaints have been received on water quality. Peter's River is served by a community well. Again no problems are reported.

With the population expected to remain stable, present sources are expected to be capable of continuing to meet demand, except at St. Vincent's.

6.4.2 - Mt. Carmel/St. Catherines/Mitchell's Brook

The three St. Mary's Bay communities of Mt. Carmel, St. Catherines and Mitchell's Brook are incorporated as one community with a population of 651. Present water supply is from private wells and springs. With population expected to remain at stable levels, and continued low density development, present sources should be adequate to meet future demand.

6.4.3 - St. Mary's

St. Mary's is an incorporated community with a population of 712. Residents presently obtain their water from a surface supply at Peddle's Pond, a groundwater-fed pond. The water is not filtered or chlorinated, and there are complaints of colour and fine particles. An artisan well supplies the school. The present value of the system is reported to be $455,000.

The fish plant water source is Barry's Pond. The town has already tapped into this line for a few houses. The eventual plan is to pump the water from Barry's Pond to a storage reservoir on Molloy's Hill, where it will be gravity fed to the remaining houses. Figure 6.6 shows the location of Peddle's Pond

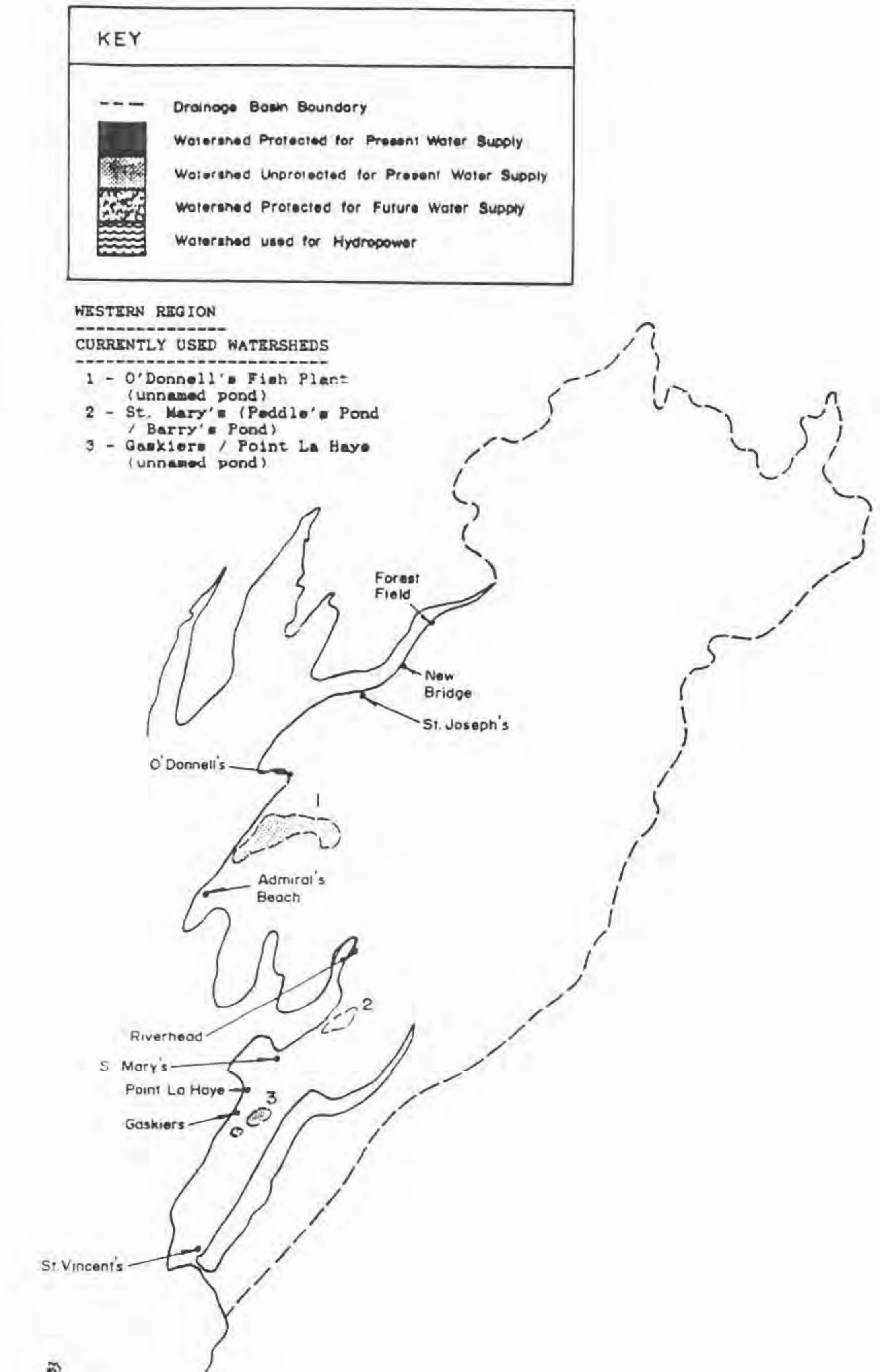

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FIG.6.6

ACRES

Western Region Watersheds

and Barry's Pond. Supply and demand are shown in the table below; yield is estimated using the methods of Section 2. Fish plant demand is taken as two-thirds capacity.

St. Mary's

Pop'n	Comm. Demand m^3/d	Fish Plant (m^3/d)	Estimated Yield Source	Supply (m^3/d)	Supp./ Demand Ratio
712 2.1	290	–	Peddle's Pond	620	
	–	2180	Barry's Pond	2000	0.9
TOTAL		2470		2620	1.1

This analysis suggests that although the supply/demand ratio is greater than one considering both sources, there may not be enough water in Barry's Pond alone to supply both the fish plant and all the community. Details of the proposed Barry's Pond scheme, and of fish plant use, are required to better assess the situation.

6.4.4 - Gaskiers/Point La Haye

Gaskiers/Point La Haye is an incorporated community with a 1986 population of 517. Residents presently obtain their water from 2 surface sources, as shown in Figure 6.6. The sources are protected, and are disinfected with chlorine compounds. The reported present value of the system is $303,000.

Present demand is estimated to be about 210 m^3/d. The estimated yield as determined from the methods in Section 2 is about 3300 m^3/d, as shown in the table below.

Gaskiers/Point LaHaye

Population	Demand (m^3/d)	Estimated Yield (m^3/d)	Supply/ Demand Ratio
517	210	3300	16

The present system provides ample water to meet demands.

6.4.5 - Riverhead

Riverhead, St. Mary's Bay, is an incorporated community with a population of 407. Its water supply requirements are met with groundwater from community and private sources. Present value of the community system is reported to be $270,000. With population expected to remain stable, present sources should be adequate to meet future demands.

6.4.6 - Admiral's Beach

Admiral's Beach is an incorporated community with a population of 361, located on St. Mary's Bay. Residents obtain their water from community and private wells. The present value of the community system is reported to be $617,000.

Community population is expected to remain stable, and groundwater supplies should be able to continue to meet the demand. Total demand for the population of 361 is about 150 m^3.

The fish plant has both fresh and salt water systems; the fresh water comes from Salmon Brook. A small dam and pumphouse are used with this system, and the water is chlorinated. A few homes draw their water from Salmon Brook as well. The maximum rate of consumption at the fish plant is about 200 m^3/d. The plant operates 6 months a year, and no expansion is planned. The water supply should therefore continue to meet the fresh water needs of the plant.

6.4.7 - O'Donnells

O'Donnells is an unincorporated community with a 1981 population of just under 300. Domestic water is provided from individual wells and from 2 community wells. The water from the community well is chlorinated. The present value of this system is reported to be $52,000.

With population expected to remain at stable levels, and no industrial expansion anticipated, present sources should continue to be able to meet future demand.

6.4.8 - St. Joseph's

St. Joseph's, St. Mary's Bay, is an incorporated community with a population of 213. Water supply is from community and private wells. Reliable yield from the community well is estimated to be about 65 m^3/d. About 17 homes are connected to the well; the maximum demand is the order of about 25 m^3/d. With population expected to remain stable, present sources should be adequate to meet future demand.

6.4.9 - Forest Field/New Bridge

Forest Field/New Bridge is an unincorporated community with a population of about 100. Residents presently obtain their water from groundwater. With the expected stable population present sources should remain adequate in the future.

6.4.10 - Mall Bay

Mall Bay is an unincorporated community with a population of about 70. Present water supply is from groundwater. With the expected stable population, present sources should be adequate to meet future demand.

6.5 - Value of Water Used for Water Supply

The value of water for water supplies can be calculated in various ways. For this study, it was first estimated by considering the price of water from the St. John's regional system. Water is sold to industries and large business at metered rates, and to homes at a flat rate. The overall blended price in 1986 was about $0.12/m^3, based on a revenue of $4.5 million and a consumption of 38.6 Mm^3. (The average metered rate is similar, less than a cent lower.)

Alternatively, the annual capital charges resulting from the cost of developing a source of water can be estimated. A new system similar to Bay Bulls would probably cost about $50 million. This includes the treatment plant but does not include distribution costs. Resulting capital charges would be of the order of perhaps $4 to $5 million per year. For a yield of 38 Mm^3/a, the cost of water is about $0.10 to $0.13/m^3.

The cost of providing water supplies to small communities varies widely, depending on the source and the extent of the distribution system. A reasonable approximation of the cost of a surface system to a small community might be $15,000 per household. In a community of 500 people (125 households), the capital cost would be about $2 million. Annual charges would be perhaps $170,000. With a consumption of 75,000 m^3/d, cost of water (excluding operation and maintenance) would be about $0.23/m^3.

6.6 - Summary of Fresh Water Demands for Water Supply

The total annual requirement for fresh water in the study area is about 53 Mm^3, as shown in the following table.

Municipal/Domestic	
Regional System	40 Mm
Other	2
Industrial	
Fish Plants*	5
Cooling Water (Generating Station)	1
Total	53 Mm^3

* Outside St. John's

Tables 6.5 to 6.8 summarize the supply/demand analysis by region. All regions have sufficient water in present and future proposed sources to meet demand. The St. John's regional system clearly dominates the supply; a number of adjacent communities with independent supplies at present look to the regional system to meet their future needs. A number of options are available for expanding the regional system; these require evaluation in the context of the demands from all the northern part of the study area.

Outside the northern area, populations are expected to remain stable, and present sources are likely to be able to continue to meet demand.

TABLE 6.5

NORTH REGION (PRESENT) : SUMMARY OF SUPPLY/DEMAND ANALYSIS

Surface supplies :

Name	1986 Pop'n	Demand (m3/d)	Source	Estimated Yield (m3/d)	S/D** Ratio
Regional System*	135,000	105,300 (1)	BBBP/PH/WL	160,200	1.5
Torbay	3,730	2,760 (2)	North Pond	1,370	0.5
Portugal Cove	2,497		Blast Hl Pd	2,760	0.8
community		1,748 (3)			
fish plant		1,636			
total		3,384			
Pouch Cove	1,576	646 (4)	Nth 3 Isl Pd	9,775	15.1
Ptty Hbr/Maddox Cv	974	682 (3)	First Pond	1,870	2.7
Flatrock	884	619 (3)	Middle Pond	3,280	5.3
Bauline (mixed)	150*	62 (4)	Bauline Res	130	2.1
OVERALL (SURFACE):	144,811	116,837		179,385	1.5

Groundwater+ :

Name	1986 Pop'n	Demand (4) (m3/day)	Name	1986 Pop'n	Demand (4) (m3/day)
Holyrood	2,118	868	Bauline	273	112
St. Phillip's	1,604	1,123 (3)	Hogan's Pond	139	97 (3)
OC/MC/LB	1,300	533	Ind Pd near Hly	129	90 (3)
St. Thomas	648	454 (3)	Remaining CMA++	10,438	4,280
OVERALL (GROUNDWATER) :				16,649	7,557

Regional Results :

YEAR	POP'N	DEMAND (m3/d)	ESTIMATED YIELD (m3/d)	S/D RATIO
1986	161,460	124,394	179,385	1.4

NOTES :

* Estimated population served.
** Assuming all population served. See discussion for individual communities.
\+ May include some surface supply.
++ Total CMA : 161901

Demand Rate (m3/c/d) :
(1) 0.78 (2) 0.74 (3) 0.70 (4) 0.41

TABLE 6.5 (cont'd)

NORTH REGION (FUTURE) : SUMMARY OF SUPPLY/DEMAND ANALYSIS

Surface Supplies :

Name	2011 Pop'n	Demand (m3/d)	Source	Estimated Yield (m3/d)	S/D Ratio
Regional System (1)	201,000	156,700	Present(total)	160,200	2.0
			Pierres Bk	215,000 (2)	
			Th. Pond	50,000	
			Nth Arm Rvr	100,000 (3)	
				310,200	
Torbay	8,705	6,442	North Pond	1,560	1.3
			South Pond	1,160	
			Great Pond	5,480	
				8,200	
Bauline	535	219	Bauline Res	140	4.8
			Rogers Tilt Pd	920	
				1,060	
Portugal Cove	6,054		Blast Hl Pd	2,470	0.7
community		4,238	Ntheast Pd(4)	1,500	
fish plant		1,636			
total		5,874		3,970	
Pouch Cove	1,925	789	Nth 3 Isl Pd	9,770	12.4
Ptty Hbr/Maddox Cv	2,136		First Pond	1,870	0.7
community		1,495			
fish plant		1,310			
total		2,805			
Flat Rock	1,939	1,357	Middle Pond	3,280	2.4
OVERALL (SURFACE) :	222,294	182,865		338,350	1.9

Notes :

(1) Base case (5.5% per intercensal period)
(2) Interbasin transfer proposed. Not included in calculation of supply/demand ratio.
(3) Reference 53 estimates 109,000 m3/day.
(4) Low flow from Q1:10

TABLE 6.6

EAST REGION : SUMMARY OF SUPPLY/DEMAND ANALYSIS

Surface Supplies :

Name	1986 Pop'n	Demand (1) (m3/d)	Source	Estimated Yield (m3/d)	S/D Ratio
Ferm./King Cv	546				
community		224	Bear Cv Pd	9860	4.8
fish plant		1810	Merrymtg Pd		
total		2034			
Renews	488	- (3)	Duck Pond	2410	-
Aquaforte	201		Daniels Pond	1360	3.3
community		80			
fish plant		330			
total		410			
Cappahayden	99	41	Broad Cv Pd	4140	101
Fish Plants					
Bay Bulls		1530			
Tors Cove		1330			
Cape Broyle		109			
OVERALL (SURFACE):	1334	7898		17770	2

Groundwater :

Name	1986 Pop'n	Demand (1) (m3/d)	Name	1986 Pop'n	Demand (m3/d)
Bay Bulls	1114	457	Tors Cove	332	136
	(2)1461	599	Burnt Cove	173	71
Witless Bay	1022	419	Mobile	171	70
	(2)1340	549	Port Kerwin	142	58
Ferryland	762	312	Brigus South	112	46
Cape Broyle	698	286	Admirals Cove	99	41
Calvert	482	198			
OVERALL (GROUNDWATER) :				5107	2094
				(2)5772	2366

Regional Results :

YEAR	POP'N	DEMAND (m3/d)	ESTIMATED YIELD (m3/d)	S/D RATIO
1986	6441	9992	17770	1.8
2011	7106	10264	17770	1.7

NOTES :
(1) Demand rate : 0.41 m3/c/d
(2) For year 2011
(3) Water supply serves only a few homes.
(4) Fish plant demand : Assumed to be two-thirds of maximum plant capacity.

TABLE 6.7

SOUTH REGION : SUMMARY OF SUPPLY/DEMAND ANALYSIS

Surface Supplies:

Name	1986 Pop'n	Demand** (m3/d)	Source	Estimated Yield (m3/d)	S/D Ratio
Trepassey					
community	1,460	604	Ntheast River	9,940	5.2
fish plant		1,310			
total		1,914			
Portugal Cv South	375	154	Wright's Brk	1,260	8.2
St. Shott's	260	107	Local stream	230	2.2
Biscay Bay	99	39	Small surface system	*	-
OVERALL (SURFACE):	2,194	2,214		11,430	5.2

Notes :

* Too small to measure from 1:50,000 scale mapping. Supply is probably just adequate for demand.

** Demand Rate : 0.41 m3/c/d

TABLE 6.8

WEST REGION : SUMMARY OF SUPPLY/DEMAND ANALYSIS

Surface Supplies :

Name	1986 Pop'n	Demand (1) (m3/d)	Source	Estimated Yield (m3/d)	S/D Ratio
Admiral's Beach*	361		Unnamed	2800	10
community		148			
fish plant		131			
total		279			
St. Mary's	712				1.1
community		292	Peddle's Pd	674	
fish plant		2,182	Barry's Pd	2070	
total		2,474		2744	
Gaskiers/Pt LaHaye	517	212	2 Ponds	3290	16
OVERALL (SURFACE):	1590	2965		11578	3.9

Groundwater Supplies :

Name	1986 Pop'n	Demand (m3/d)	Name	1986 Pop'n	Demand (m3/d)
StVin/StSteph/PtRv	727	298	St. Joseph's	213	87
MtCar/StCath/MitBk	651	267	For Fd/New Br	98	40
Riverhead	407	167	Mall Bay	71	29
O'Donnell's	297	122			
OVERALL (GROUNDWATER) :				1737	1010

Regional Results :

YEAR	POP'N	DEMAND (m3/d)	ESTIMATED YIELD (m3/d)	S/D RATIO
1986	3327	3975	11578	2.9

NOTES :

* Surface water supply/demand calculation assumes all population and fish plant served by surface water.

** Demand Rate : 0.41 m3/c/d

7 - WATER RESOURCE ASSESSMENT

7 - WATER RESOURCE ASSESSMENT

In the previous sections, the amount of water available was evaluated, the non-consumptive uses were identified and the water supply/demand situation for the communities and industries in each region were analyzed. That supply/demand analysis (in Section 6) considered only the water readily available to users from existing or proposed water supply schemes. The amount of natural water available in the study area is actually much larger than that available from municipal or industrial sources, and demands arise from a number of uses. In this section, the overall water use situation is evaluated, and a ranking is assigned to each region.

The ranking is based on the ratio of naturally available supply to demand, and on the number of competing uses in the basin. The lower the ratio of supply to demand, and the more competing uses, the higher the ranking. In addition, each sub-area is classified in applicable categories, according to its water use potential.

Section 7.1 below outlines the approach and criteria used in this Section, and Sections 7.2 to 7.7 discuss each region in turn. Section 7.8 then summarizes the ranking and classifications.

7.1 - Approach

The approach taken was to

- group the basins into sub-areas
- calculate the overall supply/demand ratio
- tabulate the uses for each subbasin
- assign the basin to applicable water use categories
- rank sub-areas.

7.1.1 - Sub-areas

A preliminary examination of the detailed supply/demand situation for each community and of the water availability led to the grouping of the basins as shown in Table 7.1. These correspond to the four geographic divisions (north, south, east and west) of Section 2 with two additional divisions. The first separates the north region into the area served by the St. John's regional system, and the less developed area to the north. The second additional division was in the east region, where the more developed Bay Bulls/Witless Bay/Tors Cove area was separated from the less developed southeastern part.

The locations of the sub-areas are shown in Figure 7.1.

7.1.2 - Supply/Demand Ratio

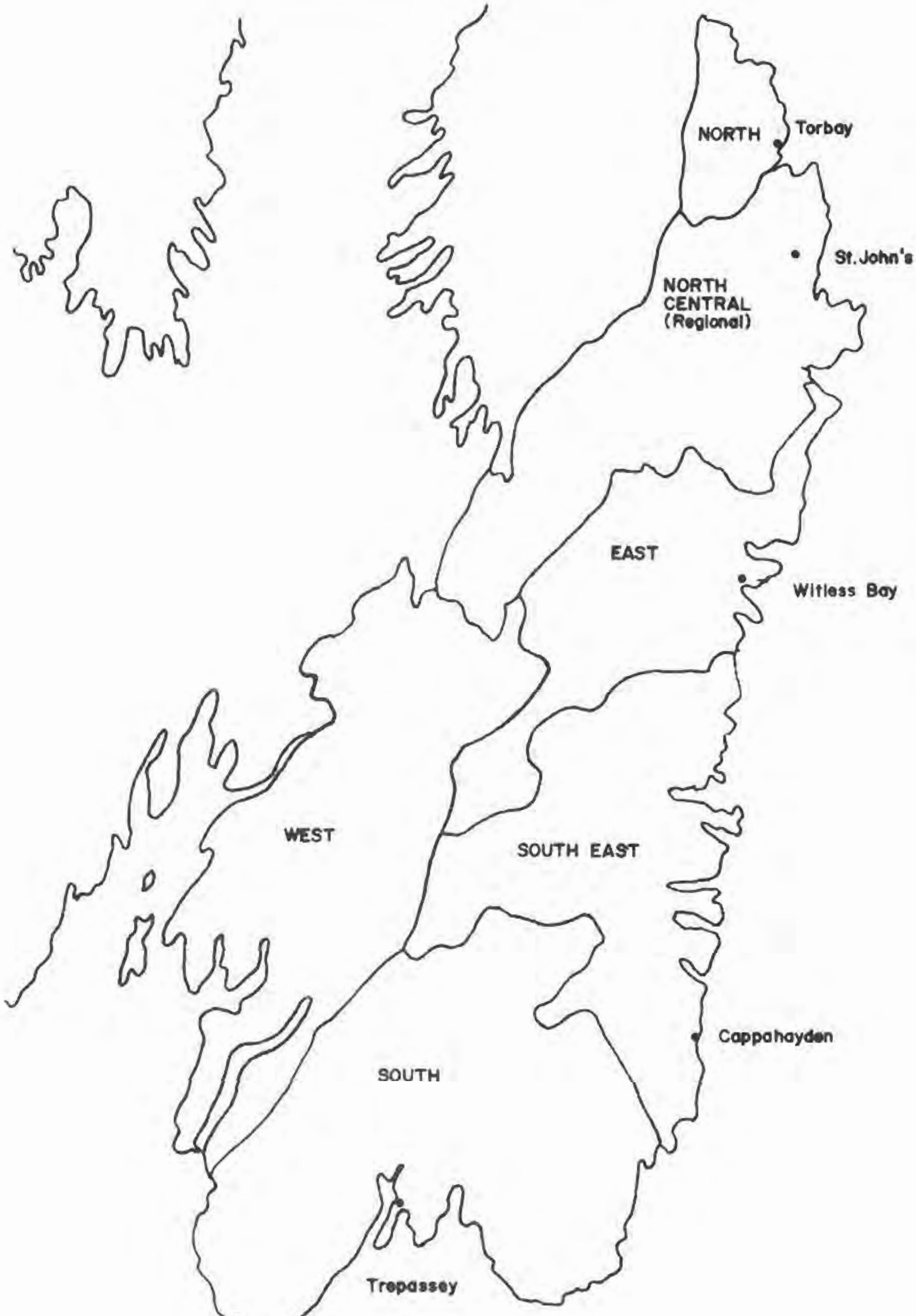
To determine the supply/demand ratio, estimates were required for both demand and supply. The total demand was taken to be the sum of the individual community and industrial demands for the sub-area. As in Section 6, fish plant demand was assumed to be two-thirds fresh water pump capacity, unless other information was available. The supply criterion was defined more broadly than in Section 6, where it was taken to be the supply from existing or proposed water supply developments. For this analysis, it was the sum over a portion of the major basins in the sub-area of the one month low flows having a return period of one in 10 years.

For the north sub-area, because much of the lower parts of the basins are developed, only a third of the basin area is assumed to be available. For the north central area (St. John's), no presently unprotected basins are assumed to be available because of the high level of development throughout the basin. Instead, the reliable yields of the present sources are used as the

TABLE 7.1

SUB-AREAS

Sub-area		Location
1.	North	The northern tip of the study region, roughly forming a triangle from Cape St. Francis to Flat Rock to Portugal Cove.
2.	North-Central	The area presently or potentially served by the St. John's regional water supply system, forming a broad band from Holyrood in the west to Petty Harbour and Torbay in the east.
3.	East	Bay Bulls to Tors Cove
4.	Southeast	La Manche to Cappahayden
5.	South	Cape Race to St. Shott's
6.	Southwest	Holyrood Pond to Salmonier River



Department of Environment
Water Resources Division

Regional Water Resources Study
Eastern Avalon Peninsula
Location of Subareas

FIG.7.1

available supply. In the east, southeast, south and west, two-thirds of the basins are assumed to be available.

The drainage areas identified as coastal were not assumed to be available. These represent about 20-25 per cent of the total area of each region, except in the north (including north-central), where they represent about 10 per cent. These coastal areas usually consist of small ponds and brooks, a number of which presently supply the small communities along the coast. On the small scale, therefore, they are occasionally important, but in general the coastal areas do not offer much potential for development for water supply.

These criteria are somewhat arbitrary, but they provide a means of assessing the overall natural availability of water in each sub-area, and of comparing availability among sub-areas.

7.1.3 - Basin Uses

The information for basin uses was taken from Section 5 (Instream Uses), as well as from land use mapping, planning documents (in particular, the St. John's urban region regional draft plan, and agricultural plans), and various government departments and agencies having responsibility for development, fisheries, parks, tourism, forestry, and land management.

7.1.4 - Water Use Categories

In addition to having a ranking assigned, each region was also classified in one or more descriptive categories according to its water use potential. These categories are listed in Table 7.2.

The assignment of categories is discussed for each sub-area. A summary table is provided in Section 7.8.

TABLE 7.2: WATER USE CATEGORIES

Category I	Sufficient quantity of water to meet present and projected future demands.
Category II	Abundant water; development can be encouraged.
Category III	Insufficient quantity; present or potential shortages.
Category IV	Present or potential conflicts as a result of multiple use.
Category V	Developments affecting water quality or quantity.

7.2 - North Sub-area Flat Rock to Cape St. Francis

The north sub-area consists of 9 major basins and 8 coastal areas, listed in Table 7.3. The main basins originate in the relatively undeveloped ridge forming the spine of the peninsula to Cape St. Francis. The average annual flow from all these major basins is about 4 m^3/s. Using the water supply criteria outlined in Section 7.1 (one-third of drainage areas, 1:10 year 1 month low flow), the flow available for water supply from all major natural sources is about 14,700 m^3/d. The total projected

TABLE 7.3

NORTH SUBAREA : OVERALL SUPPLY AND DEMAND

SUPPLY INFORMATION :

REF. NO.	Drainage Basin	Mean Ann. Flow (m3/s)	Q1:10 1 month (m3/s)
N 1	Northeast Pond	0.13	0.02
N 2	Pouch Cove Brook	0.48	0.06
N 3	Brook at Small Point	0.08	0.01
N 4	Shoe Cove Brook	0.44	0.06
N 5	Bauline Brook	0.29	0.04
N 6	Half Moon Pond	0.21	0.03
N 7	Piccos Brook	1.11	0.14
N 8	Island Pond Brook	0.61	0.08
N 13	Main Northeast Pond River	0.60	0.08
	TOTAL (m3/s)	3.95	0.51
	TOTAL VOLUME (m3/d)	341,280	44,025
	TOTAL AVAILABLE (1/3 Low Flow)		14,675
Coastal Areas			
NC 1	Cape St. Francis West	0.15	0.02
NC 2	Cape St. Francis East	0.12	0.02
NC 3	Pouch Cove Coastal	0.09	0.01
NC 4	Blackhead N Coastal	0.07	0.01
NC 5	Red Head	0.10	0.01
NC 6	Cove Pond Brook	0.04	0.00
NC 9	Torbay Coastal	0.14	0.02
NC 10	Freshwater Pond	0.42	0.05
	TOTAL (m3/s)	1.12	0.15
	TOTAL VOLUME (m3/d)	97,200	12,539

DEMAND INFORMATION :

Name	Estimated Population 2011	Demand (m3/d)
Torbay	8,705	6,442
Portugal Cove (community)	6,054	4,238
(fish plant)		1,093
Flatrock	1,939	1,357
Pouch Cove	1,925	789
Bauline	535	219
TOTAL POPULATION	19,158	
TOTAL DEMAND (m3/d)		14,138

SUPPLY/DEMAND RATIO 14,675 /14,138 = 1.04

demand is about 14,200 m^3/d, giving an overall supply/demand ratio of 1.04:1 as summarized below.

Total Volume Available for Water Supply (m^3/d)	Total Projected Demand (m^3/d)	Supply/ Demand Ratio
14,700	14,200	1.04

This ratio indicates that with the given assumptions, there is a high demand for water in the sub-area, and not much natural surplus. As Section 6 showed in detail, most communities have developed storage at one or two sites, to improve the reliability over the natural conditions.

Other Uses

As Table 7.4 shows, most of the basins in the sub-area support multiple uses. The area is subject to development pressure from the expansion of the regional centre, while at the same time the rivers and ponds are favoured recreational locations. Much of the area is also suitable for agriculture. As Table 7.4 shows, *Picco's Brook, Bauline Brook, and Shoe Cove Brook* have the greater number of potentially conflicting uses; they all also include protected watersheds.

Water Use Categories

The analysis for each community in Section 6 indicates that the water supplies are sufficient to meet projected demand, so the sub-area is assigned to Category I. Because of the multiple uses

TABLE 7.4

NORTH SUBAREA : BASIN USES

REF. NO.	Drainage Basin	Sc/Tou/ Rec (D)	Sc/Tou/ Rec (P)	Comment	Cott (D)	For (D)	Rur (D)	PWS (D)	PWS (P)	Agri (D)	Agri (P)	Min	Arch Site	Urb (D)	Ind	Wat Supp	Hyd
N 1	Northeast Pond	X	X			X	X									F	
N 2	Pouch Cove Brook	X	X			X	X							X			
N 3	Brook at Small Point									X	X						
N 4	Shoe Cove Brook	X		Cabins		X	X	X	X	X						M	
N 5	Bauline Brook	X					X	X	X					X		M	
N 6	Half Moon Pond					X	X			X	X			X			
N 7	Piccos Brook	X		Cabins		X	X	X	X	X	X			X			
N 8	Island Pond Brook						X			X	X	X		X			
N 13	Main Nrthest.Pond Riv.	X				X	X	X	X	X	X			X		M	
NC 1	Cape St. Francis West	X	X	Park		X											
NC 2	Cape St. Francis East	X				X	X							X			
NC 3	Pouch Cove Coastal	X	X											X			
NC 4	Blackhead N Coastal					X				X	X	X		X			
NC 5	Red Head						X			X				X			
NC 6	Cove Pond Coastal					X											
NC 8	Torbay Coastal	X									X			X			
NC 9	Freshwater Pond								X								

KEY

Sc./Tou./Rec. - Scenic/Tourism/Recreation
Arch. Site - Archeological Site
Wat. Supp. - Water Supply
Agri. - Agriculture
Cott. - Cottage area
PWS - Protected Water Shed
Min. - Mineral
Urb. - Urban
Ind. - Major Industry
For. - Forestry
Rur. - Rural
Hyd. - Hydro
P. - Present
D. - Designated
F. - Fishplant
M. - Municipal

of the drainage basins, however, the sub-area is also assigned to Category IV. The potential conflicts include

- urban growth leading to degradation of water quality for recreation

- desire to locate residences adjacent to ponds or water-courses, leading to decreased public access

- runoff from agricultural uses leading to water quality degradation.

7.3 - North Central Sub-area: St. John's Region

This sub-area is the part served by the St. John's regional water supply system. It also includes some adjacent communities, such as Petty Harbour/Maddox Cove, St. Phillip's, St. Thomas, Hogan's Pond and Holyrood. These are not presently part of the regional water supply system, but they may be connected in the future.

Twenty nine drainage basins were identified, as well as three coastal basins. Many of the basins are small, particularly those draining into Conception Bay. The largest are Petty Harbour, *developed for hydropower, and Daniels/North Arm River near* Holyrood.

The comparison of supply and demand using present and future sources is given below. Because of the highly developed nature of the sub-area, there is little natural water available for water supply, other than presently protected sources. Reliable yields from developed sources are therefore used to estimate supply, as described in Section 7.1. Demand is for the base population projection case. As shown in Section 6, the supply/-

demand ratio is less than 1 for the upper limit case, with no new source of supply.

The existing water supply sources are just adequate to meet projected demand. As Table 7.5 shows, the natural basins in the area have sufficient quantity to meet the projected demand; two-thirds of the sum of the low flows is just over 200,000 m^3/d. In general, however, the multipurpose uses of all the surface waters in the St. John's area would make it difficult to rehabilitate and/or protect them for water supply.

Water Supply Source	Estimated Yield (m^3/d)		Projected Demand (m^3/d)	Supply/ Demand Ratio
Present	160,000	Base: High:	160,000 215,200	1.0 0.7
Future				
Thomas Pond	50,000	Base:	160,000	2.2
North Arm River	100,000	High:	215,200	1.6
Little Power's Pond	36,000			
(Pierre's Brook)	215,000(1)			

(1)Interbasin transfer proposed. Not included in calculation of supply/demand ratio.

Basin Uses

Table 7.6 lists the basin uses in the sub-area. Most basins have multiple uses, including hydropower, water supply, and recreation and tourism. Land uses in the basins likely to affect water quality include urban and industrial development, agriculture, quarrying, and forestry.

TABLE 7.5

NORTH CENTRAL SUBAREA : OVERALL SUPPLY AND DEMAND

SUPPLY INFORMATION (Natural Basins) :

REF. NO.	Drainage Basin	Mean Ann. Flow (m3/s)	Q1:10 1 month (m3/s)
N 9	North Pond Brook	0.23	0.03
N 10	Jones Pond Brook	0.03	0.00
N 11	Kennedys / Soldiers Brook	0.21	0.03
N 12	Outer Cove Brook	0.40	0.05
N 14	Virginia River	0.44	0.06
N 15	Windsor Lake	0.66	0.08
N 16	Rennie's River	1.01	0.13
N 17	Beachy Cove Brook	0.25	0.03
N 18	Goat Cove Brook	0.09	0.01
N 19	Horse Cove Brook	0.17	0.02
N 20	Broad Cove River	0.81	0.10
N 21	Waterford River	2.22	0.29
N 22	Petty Harbour Coastal	0.29	0.04
N 23	Fowlers Brook	0.08	0.01
N 24	Manuels River	0.63	0.08
N 25	Topsail River	1.29	0.17
N 26	Conway Brook	0.46	0.06
N 27	Steadywater Brook	0.22	0.03
N 28	Foxtrap River	0.14	0.02
N 29	Kelligrews River	0.52	0.07
N 30	Lower Gullies River	0.74	0.09
N 31	Upper Gullies River	0.13	0.02
N 32	Billy Brook	0.12	0.02
N 33	Quarry Brook	0.51	0.07
N 34	Seal Cove River	2.97	0.38
N 35	Mahers River	1.94	0.25
N 36	Daniels / North Arm River	4.43	0.57
N 37	Petty Harbour Long Pond	0.26	0.03
N 38	Petty Harbour	5.78	0.74
	TOTAL (m3/s)	27.0	3.5
	TOTAL VOLUME (m3/d)	2,333,584	301,032

Coastal Areas

NC 7	Bauline Coastal	0.04	0.00
NC 8	Flatrock Coastal	0.13	0.02
NC 11	Torbay Coastal	0.03	0.00
NC 12	Logy Bay Coastal	0.33	0.04
NC 13	Sugarloaf Coastal	0.09	0.01
NC 14	St. John's Coastal	0.23	0.03
NC 15	Freshwater Coastal	0.55	0.07
NC 16	Cape Spear Coastal	0.70	0.09
NC 17	St. Phillips Coastal	0.06	0.01
	TOTAL (m3/s)	2.1	0.3
	TOTAL VOLUME (m3/d)	185,637	23,947

TABLE 7.5 (cont'd)

SUPPLY INFORMATION (Basins Developed for Water Supply) :

Present Sources	Supply (m3/d)
Bay Bulls Big Pond	100,000
Windsor Lake	43,200
Petty Harbour/Long Pond	17,000
TOTAL AVAILABLE	160,200

Future Sources	Supply (m3/d)
Pierre's Brook*	215,000
North Arm River	100,000
Thomas Pond	50,000
Little Power's Pond	36,000
TOTAL AVAILABLE	186,000
FUTURE + PRESENT	346,200

* Interbasin transfer proposed. Not included in calculation of supply/demand ratio.

DEMAND INFORMATION :

Name		Estimated Population 2011	Demand (m3/d)
St. John's Regional**		201,000	156,700
Petty Hrbr/Madd Cv	(community)	2,136	1,495
	(fish plant)		1,310
TOTAL POPULATION		203,136	
TOTAL DEMAND (m3/d)			159,505

** Base case for population/ demand projections (5.5% per intercensal period).

SUPPLY / DEMAND RATIO	
Base case , Present sources	1.0
Base case , Present + Future sources	2.2

TABLE 7.6

NORTH CENTRAL SUBAREA : BASIN USES

REF. NO.	Drainage Basin	So/Tou/ Rec (D)	So/Tou/ Rec (P)	Comment	Cott (D)	For (D)	Rur (D)	PWS (D)	PWS (P)	Agri (D)	Agri (P)	Min	Arch Site	Urb (D)	Ind	Wat Supp	Hyd
N 9	North Pond Brook	X						X	X	X	X	X		X		M	
N 10	Jones Pond Brook																
N 11	Kennedys / Soldiers Bk.	X		Scenic			X			X	X				X		
N 12	Outer Cove Brook	X					X			X	X			X	X		
N 14	Virginia River	X		Park		X	X					X		X	X		
N 15	Windsor Lake							X	X		X					M	
N 16	Rennie's River	X		Park			X				X		X	X			
N 17	Beachy Cove Brook	X					X			X	X			X			
N 18	Goat Cove Brook						X			X	X			X			
N 19	Horse Cove Brook	X					X				X			X			
N 20	Broad Cove River						X	X	X		X	X		X			
N 21	Waterford River						X	X	X	X	X	X		X	X	I	
N 22	Petty Hbr Coastal																X
N 23	Fowlers Brook						X			X	X			X			
N 24	Manuels River					X	X			X	X			X			
N 25	Topsail River		X			X	X	X			X			X			X
N 26	Conway Brook					X	X				X			X			
N 27	Steadywater Brook					X	X			X	X			X			
N 28	Foxtrap River					X	X			X	X	X		X			
N 29	Kelligrews River					X	X			X	X	X		X			
N 30	Lower Gullies River					X	X			X	X	X		X			
N 31	Upper Gullies River						X			X	X	X		X			
N 32	Billy Brook						X				X	X		X			
N 33	Quarry Brook	X	X	Park		X	X					X		X		I	
N 34	Seal Cove River	X	X	Park		X	X				X	X		X			X
N 35	Mahers River																
N 36	Daniels/North Arm Riv.					X	X				X	X		X		M	
N 37	Petty Harbour Long Pd.							X	X							M	
N 38	Petty Harbour	X		Park		X	X	X		X	X			X		M	
NC 7	Flatrock Coastal	X				X				X	X			X			
NC11	Logy Bay Coastal	X					X			X	X			X	X		
NC12	Sugarloaf Coastal					X	X										

KEY

So./Tou./Rec. - Scenic/Tourism/Recreation
Arch. Site - Archeological Site
Wat. Supp. - Water Supply
Agri. - Agriculture
Cott. - Cottage area
PWS - Protected Water Shed
Rur. - Rural
Hyd. - Hydro

Min. - Mineral
For. - Forestry
Urb. - Urban
Ind. - Major Industry
P. - Present
D. - Designated
I. - Industrial
M. - Municipal

The water quantity conflict having the most direct economic consequences is between hydropower and water supply. The two conflicts within the sub-area are Petty Harbour (Bay Bulls Big Pond) and Thomas Pond. A third conflict would result from the proposed inter-basin transfer from Pierre's Brook to Bay Bulls Big Pond.

The annual value of the water designated for water supply from each of these sources, using the value of water calculated in Section 5, is as follows.

Source	Power Plant	Yield (m^3/d)	Value (¢/m^3/d)	Annual Value
Bay Bulls Big Pond	Petty Harbour	100,000	0.55	$200,000
Thomas Pond	Topsail	50,000	0.66	$120,000
Gull Pond	Pierre's Brook	215,000	0.84	$660,000

Because of the low spill, there is little possibility of improving the utilization from the basin. Petty Harbour does spill a small amount, but a detailed operational study would be required to determine how much of this spill could be saved in a joint use project.

Other present and potential conflicts with water supply are water-quality related, including water uses for recreation, and land uses which might affect water quality, particularly agriculture. With strong watershed controls and strong monitoring and enforcement of regulations, some multiple uses of this type can be accommodated.

Other present and potential water quality conflicts in this sub-area involve the use of natural streams to convey industrial, agricultural or stormwater runoff. These uses create present and potential conflicts with recreation, fisheries and public amenity uses, as shown in Table 7.7 for the key basins of concern.

TABLE 7.7
NORTH CENTRAL SUB-AREA: WATER QUALITY CONFLICTS

	Type of Discharge	Basins	Conflict
1.	Industrial (e.g. Donovan's Ind. Park, O'Leary's and Airport industrial areas)	Waterford River Rennie's River Soldier's Brook Outer Cove Brook	Recreation/ Fisheries Public Amenity
2.	Agricultural (e.g. Gould's/Kilbride, St. Phillip's/ Portugal Cove)	Waterford River Northeast Pond Riv. Broad Cove River	Recreation/ Fisheries Public Amenity
3.	Stormwater Runoff	All rivers in developed areas; especially Waterford River Virginia River Rennie's River	Recreation/ Fisheries Public Amenity

Water Use Categories

Because the present regional water supply system can meet the projected demand, the north central sub-area is assigned to Category I, i.e., supply is sufficient to meet present and projected demands.

The north-central sub-area is also assigned to Category IV because of the numerous present and potential conflicts, and to Category V because degradation in water quality has occurred as a result of urban development.

7.4 - **East Sub-area Bay Bulls to Tors Cove**

The east sub-area includes the communities of Bay Bulls, Witless Bay, and Tors Cove. The area is dominated by two large basins, Pierre's Brook and Mobile River. They have been developed for hydropower, and Pierre's Brook has also been designated as a protected water shed for the St. John's regional water supply system. The fish plant in Witless Bay uses water from Pierre's Brook hydro power supply. The third major basin, Bay Bulls River, is also a protected watershed. It supplies the fish plant in Bay Bulls.

In calculating the overall supply/demand ratio, the assumptions were that

- no water is available from Pierre's Brook (all reserved for St. John's regional water supply system)

- half the annual average flow is available from Mobile, (this estimate takes account of storage available, using techniques developed in Section 2)

- two-thirds of Bay Bulls River drainage basin is available

- none of Tors Cove is available (all to hydropower).

The resulting ratios are summarized below. Table 7.8 presents details on natural flows and community demands.

Total Volume Available for Water Supply (m^3/d)	Total Projected Demand (m^3/d)	Supply/ Demand Ratio
265,000	5,150	51

Table 7.8

EAST SUBAREA : OVERALL SUPPLY AND DEMAND

SUPPLY INFORMATION :

REF. NO.	Drainage Basin	Mean Ann. Flow (m3/s)	Q1:10 1 month (m3/s)
E 1	Bay Bulls River	1.54	0.20
E 2	Pierre's Brook (Gull Pond)	5.01	0.65
E 3	Mobile (Mobile First Pond)	5.93	0.76
E 4	Tors Cove	9.89	1.28
	TOTAL (m3/s)	22.4	2.9
	TOTAL VOLUME (m3/d)	1,932,245	249,260
	* TOTAL AVAILABLE (m3/d)		264,820

* 50% Mobile MAF + 2/3 *Q1:10 Bay Bulls Rvr

Coastal Areas

EC 1	Motion Head Coastal	1.20	0.15
EC 2	Bull Head Coastal	0.65	0.08
EC 3	Witless Bay Coastal	0.60	0.08
EC 4	Witless Bay Brook Coastal	0.85	0.11
EC 5	Tors Cove Coastal	0.40	0.05
	TOTAL (m3/s)	3.7	0.5
	TOTAL VOLUME (m3/d)	319,828	41,258

DEMAND INFORMATION :

Name		Estimated Population 2011	Demand (m3/d)
Bay Bulls	(community)	1,461	599
	(fish plant)		1,530
Witless Bay	(community)	1,340	549
	(fish plant)		930
Tors Cove	(community)	332	136
	(fish plant)		1,330
Mobile		171	70
TOTAL POPULATION		3,304	
TOTAL DEMAND (m3/d)			5,144

SUPPLY/DEMAND RATIO 264,820 / 5,144 = 51

It is clear that there is abundant water to meet the demand, whether it is allocated as described above or in some other way. It would seem reasonable, for example, to use some of the water from Pierre's Brook rather than Mobile River for Bay Bulls and/or Witless Bay, since it is more centrally located.

Basin Uses

The other uses for each basin are given in Table 7.9. The main present conflicting use is between hydropower and water supply at Pierre's Brook. If other watersheds were developed for water supply, there would be potential conflicts not only with hydro power, but also with recreation. The area is popular for summer cabins, and some cottage areas have been designated in the region.

Water Use Categories

Because present water supplies are not only sufficient to meet projected demand but also show a surplus, the sub-area is assigned to Categories I and II. The sub-area is also assigned to Category IV because of potential conflicts with hydropower and recreation if future sources were developed for water supply.

7.5 - Southeast Sub-area Southeast La Manche to Cappahayden

The Southeast Region contains 10 major basins and a number of smaller coastal areas. The communities in the southeast sub-area include Brigus South, Admiral's Cove, Cape Broyle, Calvert, Ferryland, Aquaforte, Fermeuse, Port Kirwan, Kingman's Cove, Renews and Cappahayden. The available supply, the total projected demand and the supply/demand ratio are given below. A breakdown by basin and community appears in Table 7.10.

TABLE 7.9

EAST SUBAREA : BASIN USES

REF. NO.	Drainage Basin	Sc/ Tou/ Rec	Comment	Cott (D)	For (D)	Rur (D)	PWS (D)	Agri (D)	Agri (P)	Min	Arch Site	Urb (D)	Ind	Wat Supp	Hyd
E 1	Bay Bulls River					X	X	X	X	X		X		F	
E 2	Pierre's Brook (Mob. Big Pd.)						X								X
E 3	Mobile				X	X									X
E 4	Tors Cove	X	Canoe/Wild												X
EC 1	Motion Head Coastal				X	X									
EC 2	Bull Head Coastal				X	X					X	X			
EC 3	Witless Bay Coastal				X	X				X	X	X			

KEY

Sc./Tou./Rec. - Scenic/Tourism/Recreation
Arch. Site - Archeological Site
Wat. Supp. - Water Supply
Agri. - Agriculture
Cott. - Cottage area
PWS - Protected Water Shed
Min. - Mineral
Urb. - Urban
Ind. - Major Industry
For. - Forestry
Hyd. - Hydro
Rur. - Rural
D. - Designated
P. - Present
F. - Fishplant

TABLE 7.10

SOUTHEAST SUBAREA : OVERALL SUPPLY AND DEMAND

SUPPLY INFORMATION :

REF. NO.	Drainage Basin	Mean Ann. Flow (m3/s)	Q1:10 1 month (m3/s)
E 5	Horse Chops	9.70	1.25
E 6	Cape Broyle River	2.13	0.28
E 7	Spout River	4.77	0.62
E 8	Aquaforte River	2.89	0.37
E 9	Little River	0.15	0.02
E 10	Chance Pond River	0.17	0.02
E 11	Bear Cove Pond	0.12	0.01
E 12	Renews River	3.56	0.46
E 13	Old Women's Brook	0.65	0.08
E 14	Cappahayden	2.26	0.29
	TOTAL (m3/s)	26.4	3.4
	TOTAL VOLUME (m3/d)	2,280,814	294,225
	TOTAL AVAILABLE (2/3*tot. vol.)		196,150

Coastal Areas

REF. NO.	Drainage Basin	Mean Ann. Flow (m3/s)	Q1:10 1 month (m3/s)
EC 6	La Manche Coastal	3.33	0.43
EC 7	Ferryland Coastal	1.51	0.19
EC 8	Fermeuse Coastal	1.24	0.16
EC 9	Renews Coastal	0.39	0.05
EC 10	Cappayhayden Coastal	1.28	0.16
EC 11	Chance Cove Coastal	1.12	0.14
	TOTAL (m3/s)	8.9	1.1
	TOTAL VOLUME (m3/d)	764,700	98,646

DEMAND INFORMATION :

Name	Estimated Population 2011	Demand (m3/d)
Ferryland	762	312
Cape Broyle (community)	698	286
(fish plant)		109
Fermeuse/King Cv (community)	546	224
(fish plant)		1,810
Renews	487	200
Calvert	482	198
Aquaforte (community)	201	82
(fish plant)		327
Port Kirwin	142	67
Brigus South	112	46
Admiral's Cove	99	41
Cappahayden	100	41
TOTAL POPULATION	3,629	
TOTAL DEMAND (m3/d)		3,742

SUPPLY/DEMAND RATIO 196,150 / 3,742 = 52

Total Volume Available for Water Supply (m^3/d)	Total Projected Demand (m^3/d)	Supply/ Demand Ratio
196,000	3,800	52

Basin Uses

Table 7.11 presents a summary of basins uses, and shows that there is little development pressure on the basins. One basin, Cape Broyle River, has already been developed for hydropower. Conflicts are not anticipated because there is no indication that the water might be required for another use. The level of agricultural activity in the area is low; Spout River basin contains a regional pasture in the lower reaches. The upstream reaches of several of the basins border on the wilderness area, but again no conflicts are anticipated. Most of the tourist interest is in the coastal basins, in particular La Manche and Cappahayden. Horse Chops River has been identified as having recreational potential, but again, no conflicts are expected.

Water Use Categories

As the supply/demand ratio shows, there is an abundance of water, and the area is consequently assigned to Category II. The communities are generally located on the coastal fringe, away from the large sources. There is sufficient water to meet projected demands, and the sub-area is assigned to Category I. No major new developments are planned; any such development using large quantities of fresh water would have to tap a source further inland in the area.

TABLE 7.11

SOUTHEAST SUBAREA : BASIN USES

REF. NO.	Drainage Basin	Sc/ Tou/ Rec	Comment	Cott (D)	For (D)	Rur (D)	PWS (P)	Agri (P)	Min	Arch Site	Urb (D)	Ind	Wat Supp	Hyd
E 5	Horse Chops	X	Cott.	X										X
E 6	Cape Broyle River	X	Wild.											
E 7	Spout River	X	Wild.				X	X					M	
E 8	Aquaforte River													
E 9	Little River													
E 10	Chance Pond River													
E 11	Bear Cove Pond						X						M	
E 12	Renews River	X	Wild.											
E 13	Old Women's Brook													
E 14	Cappahayden						X							
EC 6	La Manche Coastal	X	Park	X										
EC 7	Ferryland Coastal									X				
EC 8	Fermeuse Coastal							X		X				
EC 9	Renews Coastal						X						M	
EC10	Cappayhayden Coastal						X	X					M	
EC11	Chance Cove Coastal	X	Park					X						

KEY

Sc./Tou./Rec. - Scenic/Tourism/recreation
Arch. Site - Archeological Site
Wat. Supp. - Water Supply
Agri. - Agriculture
Cott. - Cottage Area
PWS - Protected Water Shed
Rur. - Rural
Urb. - Urban
Ind. - Major Industry
For. - Forestry
Min. - Mineral
Hyd. - Hydro
M. - Municipal
D. - Designated
P. - Present

7.6 - South Sub-area Cape Race to St. Shott's

The south sub-area includes the communities of Portugal Cove South, Biscay Bay, Trepassey, Shoal Point, Daniel's Point, and St. Shott's. Among its 14 identified basins are several large ones, including Biscay Bay River, Northwest Brook, and Peter's River. Like the southeast sub-area, the south sub-area has abundant water, as shown in Table 7.12. Most of the population is located in the Trepassey area, and is supplied from Northeast Pond River. The remaining communities are on the coastal fringe, and demands are low.

The total availability, the total demand, and the supply/demand ratio are given below. Availability is based on the assumptions described in Section 7.1, i.e. two-thirds drainage area, 1:10 year 1 month low flow.

Total Volume Available for Water Supply (m^3/d)	Total Projected Demand (m^3/d)	Supply/ Demand Ratio
325,000	2,200	147

Basin Uses

Table 7.13 shows the water uses for each basin in this sub-area. With little development pressure, no water use conflicts are anticipated. The agricultural development area is near the coast, and contamination from agricultural runoff is unlikely. A regional pasture is located in St. Shott's basin; if the area were developed for water supply, some controls would be necessary.

TABLE 7.12

SOUTH SUBAREA : OVERALL SUPPLY AND DEMAND

SUPPLY INFORMATION :

REF. NO.	Drainage Basin	Mean Ann. Flow (m3/s)	Q1:10 1 month (m3/s)
S 1	Peter's River	6.27	0.81
S 2	Northwest Brook	8.59	1.11
S 3	St. Shott's River	3.60	0.46
S 4	Tartan Lake River	0.16	0.02
S 5	Northeast Brook	0.89	0.12
S 6	Back Brook	1.14	0.15
S 7	Portugal Cove Brook	1.74	0.22
S 8	Chance Cove Brook	4.07	0.53
S 9	Clam Cove	1.35	0.17
S 10	Wrights River	0.23	0.03
S 11	Bristy Cove River	1.46	0.19
S 12	Long River	0.56	0.07
S 13	Freshwater River	0.54	0.07
S 14	Biscay Bay River	13.19	1.70
	TOTAL (m3/s)	43.8	5.6
	TOTAL VOLUME (m3/d)	3,784,116	488,151
	TOTAL AVAILABLE (2/3 tot. vol.)		325,434

Coastal Areas

SC 1	Cape Race Coastal	1.64	0.21
SC 2	Mutton Bay Coastal	1.40	0.18
SC 3	Trepassey Coastal	2.51	0.32
SC 4	Shoal Point Coastal	0.19	0.02
SC 5	Daniel's Point Coastal	1.58	0.20
SC 6	St. Shott's Coastal	1.86	0.24
SC 7	Gull Island Coastal	5.02	0.65
	TOTAL (m3/s)	14.2	1.8
	TOTAL VOLUME (m3/d)	1,227,220	158,311

DEMAND INFORMATION :

Name	Estimated Population 2011	Demand (m3/d)
Trep/Danls Pt/Shl Pt (comm.)	1,473	604
(fish pl.)		1,310
Portugal Cove South	375	154
St. Shott's	260	107
Biscay Bay	99	39
TOTAL POPULATION	2,207	
		2,214

SUPPLY/DEMAND RATIO 325,434 / 2,214 = 147

TABLE 7.13

SOUTH SUBAREA : BASIN USES

REF. NO.	Drainage Basin	Sc/ Tou/ Rec	Comment	Cott (D)	For (D)	Rur (D)	PWS (P)	Agri (P)	Min	Arch Site	Urb (D)	Ind	Wat Supp	Hyd
S 1	Peter's River (lower)													
S 1	Peter's River (upper)	X	Wild.											
S 2	Northwest Brook													
S 3	St. Shott's River							X				X		
S 4	Tartan Lake River													
S 5	Northeast Brook						X						M	
S 6	Back Brook													
S 7	Portugal Cove Brook							X						
S 8	Chance Cove Brook	X	Park					X						
S 9	Clam Cove							X						
S 10	Wrights River							X						
S 11	Bristy Cove River							X						
S 12	Long River							X						
S 13	Freshwater River							X						
S 14	Biscay Bay River	X	Wild.											
SC 1	Cape Race Coastal	X						X						
SC 2	Mutton Bay Coastal							X						
SC 3	Trepassey Coastal							X						
SC 4	Shoal Point Coastal													
SC 5	Daniel's Point Coastal							X						
SC 6	St. Shott's Coastal							X						
SC 7	Gull Island Coastal											X		

KEY

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Wat. Supp. - Water Supply
Agri. - Agriculture
Cott. - Cottage area
PWS - Protected Water Shed
Min. - Mineral

Ind. - Major Industry
For. - Forestry
Hyd. - Hydro
Rur. - Rural
P. - Present
D. - Designated
M. - Municipal

Northwest Brook and Biscay Bay River have both been identified as having recreational potential, and the whole area is popular for fishing by residents. Fisheries counting fences are located near Biscay Bay and Trepassey.

Water Use Categories

Because supply is sufficient to meet projected demand, the sub-area is assigned to Category I. The supply in the major inland basins is abundant, and development could be encouraged. The sub-area is thus assigned to Category II as well.

7.7 - Southwest Sub-area Holyrood Pond to Salmonier

The communities in this sub-area are St. Vincent's, Gaskiers, Point La Haye, St. Mary's, Riverhead, Admiral's Beach, O'Donnell's, St. Joseph's, New Bridge and Forest Field. Three large basins dominate the area; these are Little Harbour River, Salmonier River, and Crossing Place River. The Salmonier River basin extends past the study boundary, but the whole of the basin is included in the water use assessment in this section.

As Table 7.14 shows, the west sub-area is another region of abundant supply. The total availability, total demand, and supply/demand ratio are given below. The assumption for supply was that two thirds of all the drainage basins were available, except Salmonier River basin because of extensive recreational use. The low flow criterion was the 1:10 year 1 month low flow.

Total Volume Available for Water Supply (m^3/d)	Total Projected Demand (m^3/d)	Supply/ Demand Ratio
160,700	3,700	42

TABLE 7.14

WEST SUBAREA : OVERALL SUPPLY AND DEMAND

SUPPLY INFORMATION :

REF. NO.	Drainage Basin	Mean Ann. Flow (m3/s)	Q1:10 1 month (m3/s)
W 1	Salmonier River	8.90	1.15
W 2	Little Harbour River	9.98	1.29
W 3	Crossing Place River	7.38	0.95
W 4	Holyrood Pond	1.55	0.20
W 5	Path End	0.56	0.07
W 6	Riverhead River	0.80	0.10
W 7	Mall Bay Brook	0.90	0.12
W 8	St. Josephs Pond	0.44	0.06
	TOTAL (m3/s)	30.5	3.9
	TOTAL VOLUME (m3/d)	2,636,381	340,093
	TOTAL AVAILABLE (2/3 Low Flow)		226,729
	TOTAL (excluding Salmonier River)		158,400

Coastal Areas

WC 1	St. Stephen Coastal	1.99	0.26
WC 2	Upper Holyrood Pond Coastal	0.39	0.05
WC 3	St. Mary's Coastal	1.61	0.21
WC 4	Riverhead Coastal	1.06	0.14
WC 5	Mall Bay Coastal	0.80	0.10
WC 6	Shoal Bay R. Coastal	0.58	0.07
WC 7	Salmon Brook Coastal	1.83	0.24
WC 8	St. Joseph's Coastal	0.48	0.06
	TOTAL (m3/s)	8.7	1.1
	TOTAL VOLUME (m3/d)	755,583	97,470

DEMAND INFORMATION :

Name	Estimated Population 2011	Demand (m3/d)
St.Vinc./St.Steph./Peter's Rvr.	727	326
St. Mary's (community)	712	292
(fish plant)		2,182
Gaskiers/Point La Haye	517	212
Riverhead	407	177
Admiral's Beach (community)	361	148
(fish plant)		131
O'Donnell's	297	122
St. Joseph's	213	107
Forest Field/New Bridge	98	40
TOTAL POPULATION	3,332	
TOTAL DEMAND (m3/d)		3,737

SUPPLY/DEMAND RATIO: TOTAL 226,729 / 3,737 = 61
EXCL SALMN R 158,400 / 3,737 = 42

Basin Uses

Table 7.15 shows that the prime land uses related to water quality and quantity are recreation and agriculture. Most of the agricultural uses are in the coastal areas; there is a large regional pasture in the St. Mary's coastal area. No conflicts are expected.

Water Use Categories

As in the southeast sub-area, most of the communities are located along the coastal fringe, and cannot take advantage of the large inland sources. Their present supplies (groundwater or small surface systems) are nevertheless sufficient to meet projected demand, so the area has been assigned to Category I. Because of the general abundance of water, the area is also assigned to Category II. Major new developments using large quantities of fresh water would have to tap inland sources, however, and conflicts with recreation and fisheries could occur.

The sub-area has also been assigned to Category IV because of the possibility of conflicts in the Salmonier River Basin. These could include potential conflicts between different types of recreational use, between recreational developments and fisheries/wildlife, or between fisheries and potential hydropower.

7.8 - Ranking of Sub-areas

Tables 7.16 and 7.17 summarize the results of the preceding sections. Table 7.16 ranks the 6 sub-areas in order of decreasing pressure on water resources and Table 7.17 places each sub-area into the appropriate category.

TABLE 7.15

WEST SUBAREA : BASIN USES

REF. NO.	Drainage Basin	Sc/Tou/ Rec	Comment	Cott (D)	For (D)	Rur (D)	PWS (P)	Agri (P)	Min	Arch Site	Urb (D)	Ind	Wat Supp	Hyd
W 1	Salmonier River	X	Can/Pk/Wild	X	X							X		
W 2	Little Harbour River	X	Wild.					X						
W 3	Crossing Place River	X	Wild.											
W 4	Holyrood Pond	X												
W 5	Path End							X						
W 6	Riverhead River							X						
W 7	Mall Bay Brook							X						
W 8	St. Josephs Pond													
WC 1	St. Stephen Coastal	X	Wild.					X						
WC 2	Upper Holyrood Pd Coastal													
WC 3	St. Mary's Coastal	X	Park				X	X					M	
WC 4	Riverhead Coastal							X						
WC 5	Mall Bay Coastal													
WC 6	Shoal Bay R. Coastal													
WC 7	Salmon Brook Coastal													
WC 8	St. Joseph's Coastal													

KEY

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Arch. Site - Archeological Site
Wat. Supp. - Water Supply
Agri. - Agriculture
Cott. - Cottage Area
For. - Forestry
Rur. - Rural
PWS - Protected Water Shed
Min. - Mineral
Urb. - Urban
Ind. - Major Industry
Hyd. - Hydro
M. - Municipal
D. - Designated
P. - Present

TABLE 7.16

RANKING OF SUB-AREAS

Rank	Sub-area	Supply/ Demand Ratio	Description
1	North-Central	1.00	St. John's Region
2	North	1.04	Flat Rock to Cape St. Francis
3	East	42	Bay Bulls to Tors Cove
4	West	51	Salmonier Line to Holyrood Pond
5	Southeast	52	La Manche to Cappahayden
6	South	147	Cape Race to St. Shott's

TABLE 7.17

ASSIGNMENT OF SUB-AREAS INTO CATEGORIES

		Category				
		I	II	III	IV	V
Area		Sufficient	Abundant	Shortage	Conflicts	Degradation
1.	North	x			x	
2.	North-Central	x			x	x
3.	East	x	x		x	x
4.	Southeast	x	x			
5.	South	x	x			
6.	West	x	x			

The north-central sub-area (St. John's region) is the area of most concern. It has the lowest supply/demand ratio and the most development pressure on its watersheds, and consequently requires the most protection, for both water supply, recreation, fisheries and public amenity. The north area follows very closely in ranking, again because of a relatively low supply/demand ratio and because of the multiple demands on its water resources.

The third-ranking area is the east, followed closely by the west and the southeast. These three sub-areas are all roughly equivalent in supply/demand ratio. The fish plant requirements dominate the demands, so better knowledge of these requirements and of salt water conversion plans would allow a better assessment of overall water needs.

In the east sub-area, several large water supplies have already been developed for hydropower. Any substantial withdrawal use taking advantage of these large sources, such as municipal or industrial water supplies, is likely to conflict with the hydropower developments. This sub-area may also experience conflicts between recreation, agriculture, and water supply uses in protected watersheds.

Although the west and southeast areas are close in supply/demand ratio, the west sub-area has additional water use pressures from recreation (summer cabins) and fisheries.

In the southeast, water is abundant inland. Development of inland sources is likely only for large water users because of high distribution costs; no such developments are presently planned. Conflicts could arise between recreation fisheries, or hydropower and water supply uses if such development did occur.

The remaining sub-area is the south which clearly has an abundance of water, and few pressures.

8 - CONCLUSIONS AND RECOMMENDATIONS

8 - CONCLUSIONS AND RECOMMENDATIONS

The principal conclusion of this study is that the natural waters of the study area are an abundant resource, which should be managed to maximize benefits to the Province. In a region lacking many other natural resources, both the abundant quantity and the relatively good quality of the surface waters offer substantial economic and other benefits including

- plentiful sources for water supply schemes, with little treatment required, as well as inexpensive groundwater nearly anywhere in the area for rural homes and agriculture;

- hydro energy production, averaging about 165 million kWh/a, and valued at over $8 million per year;

- recreational opportunities close to major population centres, providing activities for tourists and encouraging residents to vacation at home or in local summer cabins, rather than out of the province;

- streams capable of supporting populations of favorite sports fish, even in urban areas if properly maintained. These fisheries streams not only provide angling opportunities, but also provide residents with an assurance of the quality of the water and surrounding space. In remote areas, they provide an opportunity to conserve natural fish and wild-life.

The principal recommendation of this study is that water uses, and land uses affecting water quantity and quality, must be carefully managed to maximize the benefits of the resource to the Province. Although the overall quantity of water is renewable, its quality is not, nor can the same water be withdrawn from the same water body for more than one user.

The specific conclusions and recommendations arising from each part of the study are presented below.

8.1 - Surface Water Availability

Conclusion

- The average annual runoff in the study area is high, at nearly 1300 mm, and is quite evenly distributed through the year. Runoff tends to be slightly higher in the southern part of the region, where it also shows slightly less seasonal variation. Estimates of mean annual runoff and low flows would be improved with additional data and analyses.

Recommendations

- A regional low flow analysis for the Island of Newfoundland should be undertaken. The analysis should provide regional equations to be used to estimate low flows at ungauged sites.

- Several precipitation gauges should be located near the centroids of basins with streamflow gauges, to allow the determination of evapotranspiration by comparing the streamflow and precipitation data for the same basin.

- The reliability of the automatic rain gauge at Cape Race should be assessed. The Cape Race record is the only long-term record in the southern part of the study area, and data from that station is important for comparison with more recently established stations.

8.2 - **Water Quality**

Conclusion

- Water quality is generally good; levels of colour, turbidity, iron, manganese are sometimes higher than desirable, but these are primarily aesthetic considerations. The natural water tends to be corrosive because of its softness and low pH. The most important water quality concerns identified in this study include

  - degradation of water quality due to anthropogenic activities, particularly in developed areas

  - high sensitivity to acid rain

  - possible coastal and estuarine pollution resulting from discharge of most wastes directly to the sea.

Recommendations

- The water quality data base should be improved by continued and expanded monitoring. In particular, monitoring of parameters likely to be affected by anthropogenic activities should be expanded to detect trends. Parameters related to acid rain and non-point pollution from agricultural and brush control chemicals should be included.

- The effect of land uses on water resources should be a fundamental consideration in any land use planning, not only in protected watersheds. The water resource management authority should be a key figure in interdepartmental land use planning.

- Surface waters in developed areas should be rehabilitated at least to a level suitable for swimming and recreation to improve the benefit from tourism, recreation, and public amenity. Problems identified in other studies, such as storm sewer/sanitary sewer cross connections, should be corrected. Further degration should be prevented though a high level of monitoring, enforcement of existing regulations, and the introduction of others if necessary.

- A public education program should be instituted to increase the public's recognition of the value of its water resources, and of its role in maintaining water quality.

8.3 - Water supply

Conclusion

Quantity

The present and proposed future water supply sources are adequate to meet projected municipal and industrial demand, to the year 2011. Estimates of supply and demand would be improved with an improved data base on municipal and industrial water use.

The sub-area with the lowest ratio of supply to demand is the region served by the St. John's regional system, closely followed by the area to the north (Torbay to Pouch Cove). The remaining areas have abundant water inland, but since communities are small, and located on the coastal fringe, it is not economic to develop these sources. Consequently most of these communities rely on small local surface systems, or groundwater.

Quality

Most of the water supply systems in the study area provide chlorination treatment only. The St. John's regional system provides screening and pH adjustment from its Windsor Lake and Petty Harbour/Long Pond sources in addition to chlorination. The plant at Bay Bulls Big Pond provides full treatment.

Recommendations

Quantity:

- A regional water supply study should be undertaken to identify future sources of water for all the communities in the northern part of the study area, i.e. from Holyrood to Bay Bulls/Witless Bay to Pouch Cove. The study should be broad in scope, taking into account costs and benefits of all alternate water uses.

- The inventory and assessment of water supply systems outside the St. John's regional system presented in this report should be updated with field data, in particular available storage. The general condition of the system and approximate value can also be assessed in the field program.

- The Province should maintain its own municipal and industrial water use inventory. The information in this data base should be obtained from metering (or otherwise reliably obtained, e.g. from measurements of reservoir drawdown and inflow).

Quality

- Water quality of municipal water supplies should be sampled regularly at both ends of the line, i.e. in both the raw water and at the tap. One concern is that the softness and low pH of typical natural waters could cause metals such as copper and lead from pipes and plumbing to come into solution. Another is that treatment of the coloured water ubiquitous in the study area with chlorine may lead to the formation of chlorinated organic compounds, such as trihalomethane. Tests appropriate to these parameters should be done.

- Watersheds presently used for water supply but not protected should be evaluated to determine whether protection is required. Communities and fish plants served by unprotected watersheds include

Communities	Fish Plants
Biscay Bay	Tors Cove
Aquaforte	Pouch Cove
Portugal Cove South	Ferryland
Pouch Cove	Trepassey

8.4 - Instream Uses

Conclusion

- The principal instream uses in the study area are hydro power, tourism and recreation, and fisheries/wildlife conservation. These all bring economic and/or other benefits to the study area.

Recommendations

- The costs or benefits to an instream use should always enter into the evaluation of any proposed development for land or water use.

- Development trends in small-scale hydro power projects and legislation elsewhere should be noted. Because of the abundant water and hilly topography of the study area, there are numerous sites suitable for small hydro projects. At present, they are not economically viable because power from the grid is relatively cheap, but that situation may change.

- A study should be undertaken to estimate the value of water quantity and quality for recreation, tourism, and fisheries and wildlife uses. Such a study would be helpful in making water management decisions. This study should be broad in scope, including for example the value to a municipality of a natural stream in attracting residents, or the saving (if any) in providing swimming areas in natural rivers and ponds over construction of outdoor pools in parks.

LIST OF REFERENCES

1. ________ Freshwater Bay Offshore Base, Environmental Impact Statement, February 1986.

2. ________ "Water Supply and Sanitary Sewerage Systems, St. Mary's, St. Mary's Bay, Newfoundland", for Department of Municipal Affairs, undated.

3. Acres International Limited, "Hydrologic Design Methodologies for Small-Scale Hydro at Ungauged Sites - Phase II", for Environment Canada, Inland Waters Directorate, Atlantic Region, 1985.

4. Acres International Limited, "Water Supply Constraints to Energy Development", for Environment Canada, Inland Waters Directorate, executed for Energy, Mines and Resources Canada, 1986.

5. Arambarri, E. and R.L. Haldrich, "Waterford River Ecological Survey 1983" Salmon Association of Newfoundland, January 1984.

6. Canadian-British Engineering Consultants, "Report on Water Supply System", for the City of St. John's, 1966.

7. CBCL, "St. John's Regional Water System Extension, Kenmount Hill", for Department of Municipal Affairs, 1984.

8. CBCL, "Thomas Pond Resource Development Scheme, Phase I: Data Collection and Water Supply Review", for St. John's Metropolitan Area Board", 1980.

9. Community Resource Services Ltd., "Hibernia: Demographic Impacts," Report to Mobil Oil Canada Ltd., October 1984.

10. DeLCan, "Portugal Cove: Pre-Design Report", Department of Municipal Affairs, 1979.

11. DeLeuw Cather, "Town of Conception Bay South Water Transmission Main, Pre-Design Report" for Department of Municipal Affairs, 1977.

12. D.W. Knight Association Limited, Torbay Municipal Plan, 1985-95, for Department of Municipal Affairs, September 1985.

13. Environment Canada and Government of Newfoundland and Labrador, "Water Quality Data, Newfoundland, 1965-1980", 1982.

14. Environment Canada, Environmental Protection Service, Atlantic Region, "Environmental Quality in the Atlantic Region 1985", 1985.

15. Environment Canada, Inland Waters Directorate, Water Planning and Management Branch, Atlantic Region, "Analysis of Low Streamflows in Northeastern New Brunswick". 1978.

16. Environment Canada, Inland Waters Directorate, Water Planning and Management Branch, Atlantic Region, "Analysis of Low Streamflows on Cape Breton Island, Nova Scotia", 1978.

17. Environment Canada, Inland Waters Directorate, Water Planning and Management Branch, Municipal Water Use Database.

18. Environment Canada, Inland Waters Directorate, Water Resources Branch, Water Survey of Canada. "Surface Water Data, Atlantic Provinces", to 1986.

19. Fenco, "St. John's Regional Water System Study" for DREE and Department of Municipal Affairs, 1974.

20. Fisheries and Environment Canada, Inland Waters Directorate, Water Quality Branch, "Surface Water Quality in Canada - An Overview", Ottawa, 1977.

21. Government of Canada, Department of Fisheries and Oceans "Policy for the Management of Fish Habitat" Ottawa, Ontario 1986.

22. Government of Newfoundland and Labrador, Department of Culture Recreation and Youth," Provincial Masters Plan for Recreational Facility Development: Stage I Inventory Assessment Report", October 1983.

23. Government of Newfoundland and Labrador, Department of Development and Tourism "St. John's Regional Market Study-1984".

24. Government of Newfoundland and Labrador, Department of Environment, Water Resources Division, and Environment Canada, Inland Waters Directorate, "Urban Hydrology Study of the Waterford River Basin: Surface Water Quality Study" Technical Report No. UHS-WRB 1-4, July 1985.

25. Government of Newfoundland and Labrador, Department of Environment, Water Resources Division, Groundwater Branch. "Hydrogeology of the Avalon Peninsula Area", 1984.

26. Government of Newfoundland and Labrador, Department of the Environment, "Water Quality Study of Mundy Pond, Kenny's Pond, Long Pond, Kents Pond, Quidi Vidi, 1984.

27. Government of Newfoundland, Department of Forest Resources and Lands, Land Management Division, "Land Use Atlas " (current).

28. Government of Newfoundland, Department of Forest Resources and Lands, Land Management Division, "Water Supplies", February 1986.

29. Government of Ontario, Ministry of the Environment, "Water Management - Goals, Policies, Objectives and Implementation Procedures" November 1978, Revised May 1984.

30. Harris and Associates, "Flatrock: Municipal Services Study" for Department of Municipal Affairs, 1986.

31. Institute of Hydrology, "Low Flow Studies". Wallingford, Oxon, 1980.

32. LGL Ltd. "Urban Development: Guidelines for Protection of Fish Habitat in Insular Newfoundland "Government of Canada, Fisheries and Oceans, St. John's, March, 1983.

33. McNeely, R.M., V.P. Neimanis and L. Dwyer "Water Quality Sourcebook: A Guide to Water Quality Parameters", Environment Canada, Inland Waters Directorate, Water Quality Branch, Ottawa, 1979.

34. Newfoundland Design Associates, "St. John's Northeast Expansion Area, Interim Servicing Study" for Department of Municipal Affairs and City of St. John's", 1986.

35. Newfoundland Design Associates, "Town of Torbay Water Supply Alternatives" for Town of Torbay, 1987.

36. Nolan Davis, "Admiral's Beach: Proposed Water Supply Treatment Plant", for Department of Municipal Affairs, 1980.

37. Nolan White, "Riverhead: Coot's Hill Reservoir Assessment", for Department of Municipal Affairs, 1976.

38. Nolan White and Associates Limited, "Report on Domestic Water Supply Design, St. Joseph's, St. Mary's Bay", for Department of Municipal Affairs, 1974.

39. Pearse, P. H., F. Bertrand, and J. W. MacLaren, "Currents of Change: Final Report, Inquiry on Federal Water Policy", for Government of Canada, 1985.

40. Polaris Engineering, "Community of Port Kirwin: Report of Water System Improvements", for Department of Municipal Affairs, 1983.

41. Phillips, David, W. "Monthly Water Balance Tabulations for Climatological Stations in Canada" Environment Canada, Atmospheric Environment, DS#4-76, Revised.

42. Procter and Redfern, "Pouch Cove: Progress Report on Water Supply and Sewerage", for Department of Municipal Affairs, 1976.

43. Project Management and Design (1974) Limited, "Portugal Cove South: Feasibility Study for Improvements to Community Water System", for Department of Municipal Affairs, 1980.

44. Project Management and Design (1974) Limited "Report on Preliminary Investigation of Fresh Water Quality, Fishplant Fresh Water Supply, Trepassey, Newfoundland", for Department of Municipal Affairs, 1977.

45. R. J. Noah and Associates Limited, "Proposed Water Supply System, Trepassey, Newfoundland, Preliminary Report" for Atlantic Development Board,1965.

46. R. J. Noah and Associates Limited, "Salt Water Supply System, Trepassey, Newfoundland: Preliminary Report", for Clean Air, Water and Soil Authority, 1971.

47. R. J. Noah and Associates Limited, "Water Resources Study, Trepassey, Newfoundland, Preliminary Report", for Atlantic Development Board, 1966.

48. Scruton, D.A. "A Compilation of Water Quality, Government of Canada, Department of Fisheries and Oceans, Fisheries Research Branch, Data for Newfoundland and Labrador for the Years 1972-80" Report No. 441, February 1984.

49. Scruton, D.A., "Overview of Fisheries and Oceans LRTAP Activities in Newfoundland 1980-85, with an Outlook to Future Research and Monitoring". Presented to Atlantic Region LRTAP Working Group, Moncton, N.B. December 1985.

50. Scruton, D.A. "A Survey of Headwater Lakes in Insular Newfoundland with Special Reference to Acid Precipitation", Report No. 1195, August 1983.

51. Scruton, D.A. "Spatial and Temporal Variation in the Water Chemistry of Atlantic Salmon Rivers in Insular Newfoundland, Government of Canada Fisheries and Oceans, Fisheries Research Branch, Report No. 1451, July 1986.

52. Scruton, D.A. "The Potential for Acidification of Newfoundland and Labrador Fresh Waters and Implications for Resident Fish". Brief delivered to the Parliamentary Sub-Committee on Acid Rain, St. John's, April, 1984.

53. Shawinigan Engineering Company Limited and Janes F. Maclaren Limited, "Water Resources Study of the Province of Newfoundland and Labrador", for Atlantic Development Board, 1968.

54. St. Phillip's Municipal Plan, 1984, Department of Municipal Affairs.

55. Statistics Canada "1986 Tourism and Recreation, A Statistical Digest" Ottawa, October 1986.

56. Task Force on Water Quality Guidelines, Canadian Council fo Resource and Environment Ministers "Canadian Water Quality Guidelines" March 1987.

57. Tate, D. M., "Canadian Water Use Trends 1981 - 2011", Canadian Water Resources Journal, Vol. 11, No. 3, 1986, PP1-10.

58. Tate, D. M. and David N. Scharf, "Water Use in Canadian Industry 1981" for Environment Canada, Inland Waters Directorate, Water Planning and Management Branch, 1985.

59. Terpstra Municipal Engineering Associates Limited, "St. Vincent's - St. Stephen's - Peter's River: Preliminary Design, Water and Sewer System", 1975.

60. W. Pierce, "An Inventory of Agricultural Pesticide Usage in Newfoundland, 1982". Environment Canada Environmental Protection Service.

WATER RESOURCES STUDY OF
EASTERN AVALON PENINSULA

APPENDICES

APPENDIX A

HYDROLOGY

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A - HYDROLOGY

1 - ESTIMATION OF LONG TERM MEAN ANNUAL RUNOFF

Long-term mean annual runoff was estimated from gauge records maintained by Water Survey of Canada (WSC), and calculated at climatological stations from Atmospheric Environment Service (AES) data. The procedures are described in Section 1 of this Appendix.

For Streamflow Data

(1) Convert mean annual flows from WSC data to runoff depths in millimeters.

(2) Compare the annual runoff depths for stations with longer records. Select the one which best represents the area to use as the basis for estimating long-term runoff for all gauge records (Section 1.1.2).

(3) Using the selected long-term record, estimate long-term mean annual runoff for all records.

(4) Plot mean annual runoff at centroid of each basin.

For Precipitation Data

(1) Obtain long-term (1951-1980) total precipitation for all stations from AES data.

(2) For stations established since 1980, estimate long-term total precipitation, using selected long-term record(s) (as step 3 above for WSC gauges).

(3) Estimate the actual amount of precipitation available as runoff for each station.

(4) Plot the estimated runoff at the location of the AES station.

1.1 - Streamflow Data

A list of the WSC gauges in the study area and their lengths of record is given in Table A1.1.

Rocky River is not in the study area, but because it is immediately adjacent to it, and has a longer record than any of the gauges in the area, it was included in the analysis.

Their locations are shown on the map in Figure 2.3 of the main report.

1.1.1 - Selection of Records to Use for Normalization

Because the drainage areas and lengths of record vary, the mean annual flows from the gauging stations could not be compared directly. To permit such comparison, the flows were normalized by proration with a long term record. This method was chosen because it provides an estimate of a longer-term mean, and ensures that records from all basins cover the same range of wet and dry years. In the specific case of the records from the gauges in the study area, it is also conservative, i.e., the estimates of long-term runoff are lower than the means from the shorter periods of record.

In order to select the station to use as the basis for estimating the long-term mean annual runoff, the average annual flows for the six gauges with the longest records were plotted and

TABLE A1.1

LIST OF WSC GAUGES

Gauge	Name	Drainage Area (km^2)	No. of Complete Years	Start	End
M001	Petty Harbour River at Second Pond	134	23	Oct./62	Present
M002	Pierres Brook at Gull Pond	117	23	Oct./62	Present
M003	Mobile River at Mobile First Pond	112	23	Oct./62	Present
M004	Horse Chops River near Cape Broyle	88.1	0	Jul./51	Mar./52
M006	Northeast Pond River at Northeast Pond River	3.9	32	Apr./53	Present
M007	Broad Cove Brook near St. Phillips	-	13	Sep./67	Jul./82
M008	Waterford River at Kilbride	52.7	12	Jan./74	Present
M009	Seal Cove Brook near Cappahayden	53.6	6	Mar./79	Present
M010	Waterford River at Mt. Pearl	16.6	4	Apr./81	Present
M011	Waterford River near Donovans Indus. Park	11.4	4	Jun./81	Dec./84
M016	South River near Holyrood	17.3	3	Jan./83	Present
M017	Leary Brook at St. John's	15.3	3	Jan./83	Present
M018	Virginia River at Pleasantville	13.3	2	Jan./84	Present
M019	Virginia River at Cartwright Place	5.55	<1	Mar./84	Present
M020	Leary Brook at Prince Philip Drive	17.8	<1	Mar./86	Present
N001	Northwest Brook at Northwest Pond	53.3	20*	Jun./66	Present
N002	St. Shott's River near Trepassey	10.8	1	Jan./85	Present
K001	Rocky River near Colinet	285	36	Oct./48	Present

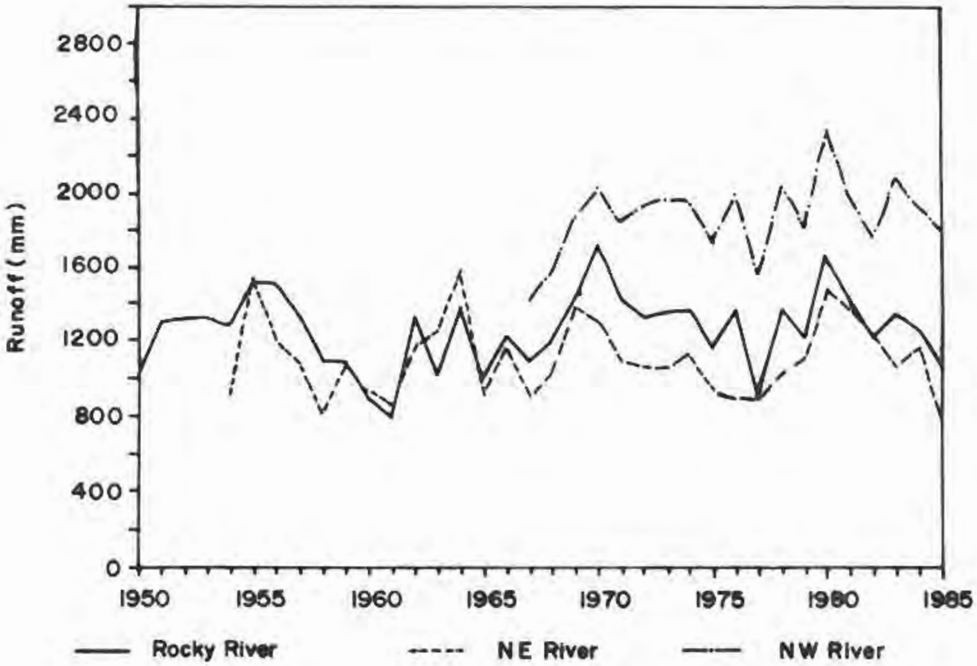
*February - June/81 missing

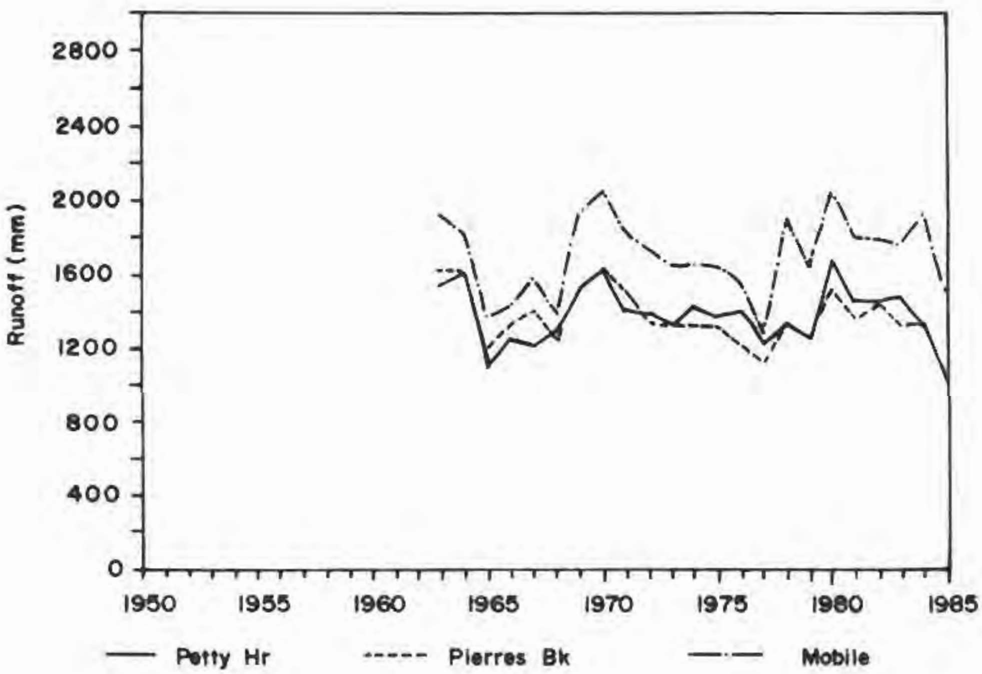
compared. The stations with the longest records are Rocky River (02ZK001) and Northeast Pond River (02ZM006). Four others, Petty Harbour, Pierre's Brook, Mobile, and Northwest Brook also have 19 or more years of record. Petty Harbour, Pierre's Brook and Mobile records are from basins regulated for hydro power and would therefore be excluded from any seasonal or low flow analysis. However, for the purpose of comparing annual runoff, the effect of the regulation was assumed to be negligible, and they were included.

The annual runoffs for the six rivers for the period of record is shown in Figure A1.1. For convenience, the average annual runoff is shown separately for the natural streams and for the streams regulated for hydro power. When all six records are compared, the annual pattern is about the same, whether the record is from a natural or a regulated basin. A simple regression analysis of annual runoff depths showed that Rocky River best represented the group as a whole. Since Rocky River also has the longest period of record, it was used to estimate the long-term mean annual runoff for all gauges. The procedure is described in the following section.

1.1.2 - Estimation of Long-Term Mean Annual Runoff

The long-term mean annual runoffs for all the gauges with shorter records were estimated by proration with Rocky River. The average runoff was calculated for the Rocky River gauge and the shorter-term gauge for the period of overlapping record. The ratio between the means for the overlapping period was then used to estimate the long-term mean of the shorter record.





Department of Environment
Water Resources Division

Regional Water Resources Study
Eastern Avalon Peninsula

Mean Annual Runoff Selected Basins

FIG. AI.1

ACRES

The Northeast Pond River record is the second longest in the study area. For comparison, it was also used to predict the long-term mean runoff at the other gauges. The results were very similar, averaging about 5 per cent higher than the estimates using Rocky River.

For two basins the long-term runoffs were estimated using Northwest Brook rather than Rocky River. These were St. Shott's River and Seal Cove Brook at Cappahayden. St. Shott's River was treated separately because it had only one year of record, 1985. 1985 was a generally dry year in the rest of the study area, but it seems to have been less dry along the south coast. At Northwest Brook, for example, the 1985 flow was very close to the mean annual flow. Since Northwest Brook and St. Shott's River flows appear to be well correlated (based on 12 months data), the Northwest Brook long-term mean annual runoff (1795 mm) was used to estimate the long-term mean annual runoff at St. Shott's. Seal Cove Brook at Cappahayden also gave more consistent results when Northwest Brook was used, for similar reasons.

Table A1.2 shows the annual runoffs for all the gauges in the study area, and the estimated long-term mean annual runoff.

1.2 - Meteorological Data

Precipitation records are available from 20 AES stations in the region. These stations, together with their elevations and years of record, are listed in Table A1.3. Their locations are shown in Figure 2.4 of the main report.

Precipitation data were used in this study to provide additional information on the distribution of runoff in the study area. In order to use the precipitation data, the runoff component of total precipitation had to be estimated. The estimation procedure is described below.

TABLE A1.2

ESTIMATED LONG TERM MEAN ANNUAL RUNOFF, GAUGED BASINS

	Rocky River	NE River NE Pond	Petty Harbour	Pierres Brook	Mobile	NW Brook NW Pond	Broad Cove	Waterfd Kilbride	Seal Cove	Waterfd M. Pearl	South R Holyrood	Leary Brook	Waterfd Donnvans	Virgina Pleasent	St Shotts
Drainage Area (km²)	285	3.9	134	117	112	53.3	23	52.7	53.6	16.6	17.3	15.3	11.4	13.3	15.5
Station No.	02ZK001	02ZM006	02ZM001	02ZM002	02ZM003	02ZN001	02ZM007	02ZM008	02ZM009	02ZM010	02ZM016	02ZM017	02ZM011	02ZM018	02ZN002
1950	1003														
1951	1284														
1952	1307														
1953	1307														
1954	1273	906													
1955	1495	1521													
1956	1495	1181													
1957	1318	1060													
1958	1085	801													
1959	1085	1060													
1960	885	922													
1961	777	850													
1962	1318	1149													
1963	1005	1230	1531	1610	1907										
1964	1373	1554	1597	1621	1814										
1965	988	930	1079	1187	1352										
1966	1218	1149	1241	1322	1434										
1967	1068	898	1194	1397	1572	1397									
1968	1185	1028	1290	1238	1389	1557	936								
1969	1417	1359	1531	1551	1910	1853	1550								
1970	1705	1287	1618	1643	2031	2013	1537								
1971	1406	1084	1399	1508	1829	1829	1118								
1972	1307	1044	1378	1332	1733	1924	915								
1973	1340	1044	1314	1311	1654	1960	826								
1974	1362	1117	1429	1316	1657	1936	995	1335							
1975	1140	930	1368	1311	1648	1723	916	1060							
1976	1351	898	1408	1208	1555	1989	871	1144							
1977	908	882	1213	1117	1273	1539	646	1006							
1978	1362	1019	1331	1330	1891	2037	941	1144							
1979	1207	1092	1246	1254	1640	1800	937	1449							
1980	1650	1456	1677	1529	2037	2327	1468	1617	2202						
1981	1428	1367	1451	1359	1798			1497	1796						
1982	1207	1197	1462			1752		1389	1884	1388			1489		
1983	1329	1052	1474	1319	1755	2066		1216	1913	1365	1439	1268	1390		
1984	1251	1141	1323	1335	1927	1924		1329	1743	1578	1589	1355	1442	1568	
1985	1052	752	987	1022	1462	1788		964	1754	1165	1162	1058		930	1869
Mean Annual Runoff for period of record of gauge	1247	1093	1371	1355	1694	1856	1051	1262	1882	1374	1397	1227	1440	1249	1869
Estimated Long Term Mean Annual Runoff:															
Rocky River	1247	1090	1344	1354	1693	1834	982	1239	1751#	1416	1439	1264	1423	1353	1917#

Estimated using Northwest Brook

TABLE A1.3

LIST OF METEOROLOGICAL STATIONS

Station Name	Elevation	Start	End
Cappahayden	50	May 1981	Ongoing
Cape Broyle	20	Oct 1955	Ongoing
Cape Race (Aut)	87	Oct 1920	Ongoing
Colinet	90	Aug 1938	Ongoing
Colinet Peat Bog (CDA)	180	Sep 1957	Ongoing
Holyrood	35	Aug 1951	Mar 1970
Holyrood Gen Stn	20	Nov 1970	Ongoing
Holyrood Ultramar	23	Dec 1961	Sep 1982
Logy Bay	90	Dec 1969	Ongoing
Petty Harbour	20	Oct 1955	Ongoing
Pierres Brook	50	Oct 1955	Apr 1978
St Marys	51	Nov 1982	Ongoing
St John's	150	Jan 1871	Jul 1975
St John's A	460	Jan 1942	Ongoing
St John's West (CDA)	375	Nov 1950	Ongoing
St Shotts	150	Aug 1971	Ongoing
Salmonier	475	Oct 1967	Ongoing
Seal Cove	50	Jul 1961	Ongoing
Trepassey	50	Nov 1982	Ongoing
Tors Cove	20	Oct 1955	Ongoing

The total precipitation recorded by AES is the sum of the rainfall and water equivalent of snowfall. Of this only a portion is available as runoff; the remainder is lost. During short-term events, losses may be of various types, e.g., storage, groundwater transport and evaporation and transpiration. Over the long-term, the losses are principally evaporation and transpiration. For the purposes of this study, an estimate of the total evapotranspiration losses was required so that the total annual precipitation values from the AES records could be converted to runoff and plotted.

AES has produced monthly water balance tabulations for a number of climatological stations in Canada. Its calculations use the Thornthwaite method. This method is based on an extensive set of experiments to establish the correlation between temperature and evapotranspiration. It was specifically developed for an area with close-set vegetation and adequate water supply in the latitudes of the United States, but gives reasonably good results when applied elsewhere. The original calculation procedure has been modified by AES to improve the snow storage and snowmelt runoff component. The standard method was found to underestimate winter surplus and overestimate spring runoff at Canadian stations. Procedures are described in detail in Reference 41.

Since the AES analysis was based on the 30 year means from 1941-1970, a check was made to ensure that no major change had occurred. Table A1.4 compares the means for the 30 year period 1941-1970 used for the analysis and the more recent summary period 1951-1980. The mean annual total precipitation amounts are very similar for the two periods of record. The other key factor used in the water balance calculations is temperature, and a check on mean annual temperature also showed little difference between the two periods, as shown in Table A1.5.

TABLE A1.4

PROPORTION OF TOTAL PRECIPITATION AVAILABLE AS RUNOFF AT SELECTED STATIONS

Station Name	Mean Annual Total Precip 1951-80 (mm)	Mean Annual Total Precip 1941-70 (mm)	No. of Yrs used in AES Analysis	Evap/ Trans 1941-70 (mm)	Runoff 1941-70 mm	%
Cape Race	1379	1374	25-29	447	927	67.5
Colinet	1432	1451	30	521	924	60.0
St. John's	1420	1386	10-14	526	860	62.0
St. John's A	1513	1511	25-29	511	1000	66.2
St. John's W	1595	1602	20-24	512	1090	68.0
Seal Cove	1273	1263	20-24	505	758	60.0

TABLE A1.5

MEAN DAILY TEMPERATURE (°C)

	1931-70	1941-80
St. John's W	5.1	5.0
Seal Cove	6.2	6.1
St. John's	5.5	5.5
St. John's N	4.9	4.8
Cape Race	4.3	4.3
Colinet	5.2	5.1

The average proportion of total precipitation available as runoff was taken from Table A1.4. St. John's was excluded from the calculation of the average because of the shorter period of record. Seal Cove was also excluded, because the precipitation records there are inconsistent.

The data required to assess this percentage are limited. There is some indication from data from the Waterford River basin that the percentage used may overestimate losses. The Waterford basin is the only one with a precipitation station in the basin (St. John's West station). In that basin, the long-term measured runoff is about 15 per cent higher than that predicted by the Thornthwaite analysis. The proportion of precipitation available as runoff would be 78 per cent, not 68 per cent. The underestimation of total runoff can be explained at least in part because the upstream reaches of the Waterford River and its tributaries originate at a higher altitude and slightly southwest of the climate station.

The results of this study are not very sensitive to this difference because most of the precipitation gauges are located along the coast. The principal effect will be to slightly underestimate runoff along the coastline and in the drier corridor on the western boundary of the study area.

1.2.1 - Normalization to Constant Period of Record

For most stations the long-term mean annual total precipitation was taken from the 1951-80 AES summary volume. This period corresponds very closely to the long-term period used to calculate the long-term runoff from the streamflow gauges. As Table A1.3 shows, a few of the stations were not established until after 1951, but given the approximate nature of the precipitation-to-runoff calculations, and the fact that the precipitation stations are generally not located in key areas for assessing water availability, the slight difference may be neglected.

Three newly established climate stations, however, are located along the southern shore of the study area, at Cappahayden, Trepassey, and St. Mary's. This is a region for which few data are available, and these new stations can help to improve the estimate of runoff in this area. Consequently, the annual total precipitations for these stations for the years available were compared with the three long-term records for the same years from St. John's Airport, St. John's West and Colinet. Cape Race could not be used because of problems with the automatic gauge. The long-term mean annual precipitations were then estimated by proration using the long-term means from the four long-term stations. The average of these was used for plotting.

These results are shown in Table A1.6, and confirm that the south coast of the study area is a region of high precipitation, even at low elevations. It is unfortunate that the long-term record from Cape Race could not be used, since as Table A1.6 shows, there are some differences in the temporal variation between the long-term stations and the records from the southern coastal areas. In 1984, for example, the precipitation amounts were very similar to the 1983 values for the long-term stations, but decreased slightly for the southern gauges. By contrast, in 1985, values were much lower than average for the long-term gauges, but fairly high for the southern gauges. This result is similar to the findings from the WSC data.

1.3 - Distribution of Mean Annual Runoff in Study Area

As a result of the analysis of the streamflow gauge records and the meteorological data described in Sections 1.1 and 1.2 above, the variation in mean annual runoff over the study area could be assessed. The mean annual runoff was plotted at every point at

TABLE A1.6

ESTIMATED MEAN ANNUAL LONG TERM TOTAL PRECIPITATION AT SELECTED STATIONS

	St Johns Airport	St Johns West	Colinet	St. Marys	Cappahayden	Trepassey
Years of Record	39	30	42	3	4	3
1951-80 Average	1514	1595	1432			
1981	1773	1768	1484			
1982	1713	1718	1372		1474	
1983	1681	1668	1460	1713	1573	2027
1984	1712	1609	1436	1415	1241	1856
1985	1231	1335	1108	1537	1672	1944
	1529	1599	1423	1555	1490	1942
Long term mean total precip. based on						
St. Johns A	---	---	---	1543	1438	1927
St. Johns W	---	---	---	1618	1505	2020
Colinet	---	---	---	1658	1578	2070
Average				1606	1507	2006

which it could be estimated, and isolines were drawn to indicate regions of equal runoff. Figures 2.1 and 2.2 in the main report show the points plotted and the isolines. The runoff depths estimated from streamflow records were plotted at the centroids of the gauged basins. The runoff amounts estimated from meteorological records were plotted at the locations of the climate stations.

In producing the map, greater consideration was given to the streamflow data than to the precipitation data, since it measures runoff directly. The precipitation data were used where no streamflow records existed, and also as a guide to interpolating between streamflow points. Topography was also considered in shaping the isolines.

The elevations, latitudes and longitudes of each centroid or station were tabulated and plotted to see whether these are any trends. Tables A1.7 and A1.8 list the variables for the streamgauge data and climatologic data respectively.

Figures A1.2 to A1.4 show mean annual runoff as a function of elevation, latitude, and longitude. For the streamflow records alone, there is a slight increasing trend with elevation, and decreasing trend with latitude, although there is considerable scatter in all plots.

The two data sets must be treated separately, because they are not drawn from the same population. The generally lower values of the AES points suggest that runoff may be slightly underestimated, as discussed in Section A1.4. The lower values from the precipitation gauges may to some extent, however, be a result of the lower elevation of most of the AES stations. As Figure A1.2 shows, only one of the WSC gauges is at a lower elevation, and only three of the AES gauges are at higher elevations.

TABLE A1.7

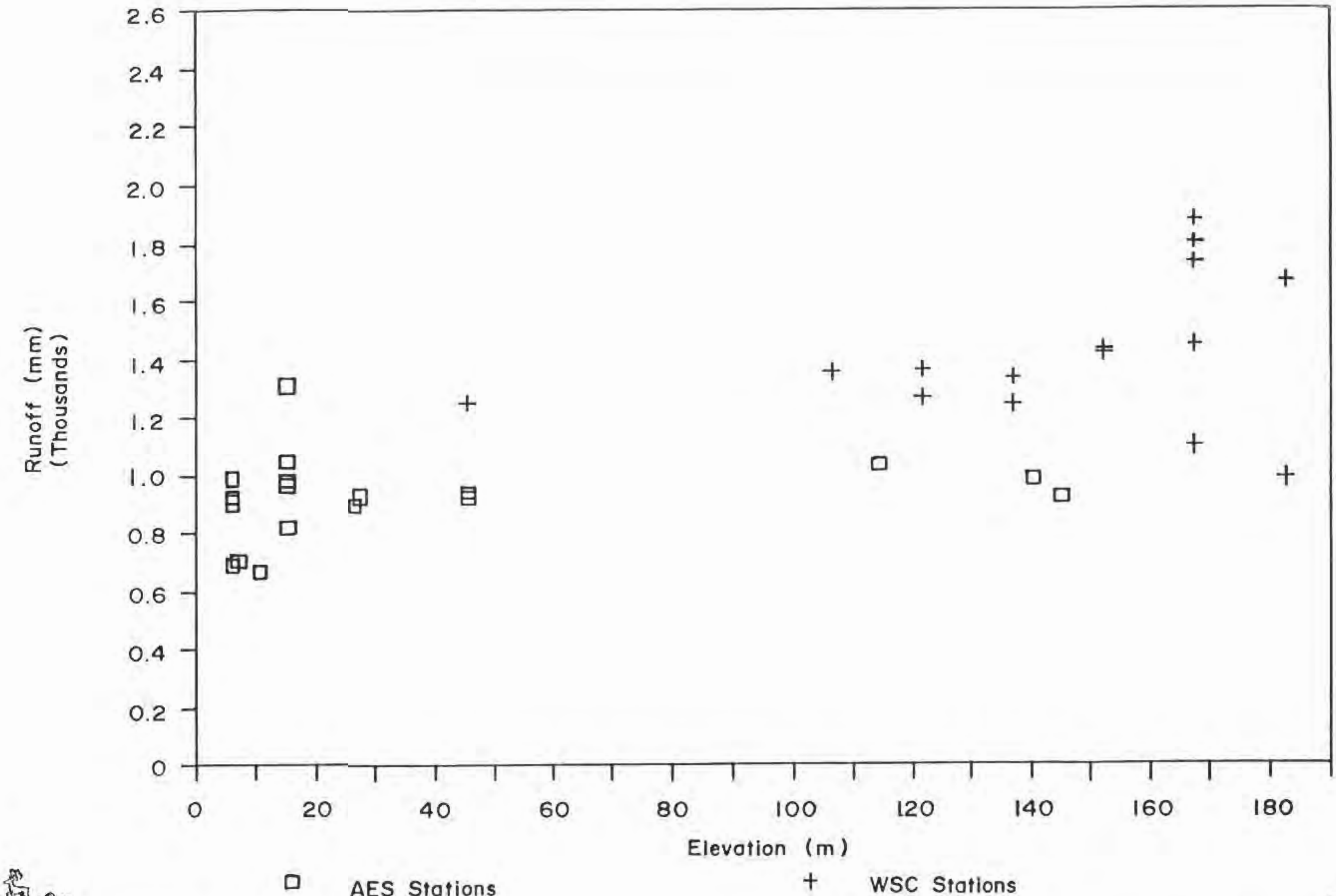
MEAN ANNUAL RUNOFF, ELEVATION, AND LOCATION OF CENTROID OF GAUGED BASINS

Station Name	Mean Annual Runoff	Elev. (m)	Lat.	Long.
Northeast River	1090	168	47.92	53.32
Broad Cove	982	183	47.55	52.87
Waterford at Kilbride	1239	137	47.52	52.80
Waterford at Mount Pearl	1416	152	47.53	52.85
Waterford at Donovans	1423	152	47.52	52.87
Virginia River at Pleasantville	1353	122	47.60	52.73
Learys Brook	1264	122	47.57	52.80
Holyrood	1439	168	47.33	53.13
Petty Harbour	1344	107	47.45	52.82
Pierres Brook	1354	137	47.33	52.93
Mobile	1693	183	47.30	53.05
Colinet	1247	46	47.32	53.58
Cappahayden	1751	168	46.87	53.05
Northwest Brook	1834	168	47.65	52.82
St Shotts	1917	168	46.75	53.52

TABLE A1.8

PRECIPITATION, ESTIMATED MEAN ANNUAL RUNOFF, ELEVATION, AND LOCATION OF PRECIPITATION STATIONS

Station Name	Total Precip.	Estimated Mean Annual Runoff	Elev. (m)	Lat.	Long.
Capahayden	1507	980	15	46.87	52.95
Cape Broyle	1522	989	6	47.10	52.93
Cape Race (Aut)	1379	896	27	46.65	53.07
Colinet	1432	931	27	47.22	53.55
Holyrood	1029	669	11	47.38	53.13
Holyrood Gen Stn	1075	699	6	47.45	53.10
Holyrood Ultramar	1084	705	7	47.38	53.13
Petty Harbour	1420	923	6	47.47	52.72
Pierres Brook	1484	965	15	47.28	52.82
Salmonier	1425	926	145	47.27	53.28
Seal Cove	1273	827	15	47.45	53.07
St John's	1421	924	46	47.58	52.67
St John's A	1514	984	140	47.62	52.75
St John's West (CDA)	1595	1037	114	47.52	52.78
St Marys	1606	1044	16	46.92	53.57
St Shotts	1453	944	46	46.63	53.58
Tors Cove	1390	904	6	47.22	52.85
Trepassey	2006	1304	15	46.77	53.37



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Eastern Avalon Peninsula

Mean Annual Runoff as a Function of Elevation

FIG. AI.2

ACRES

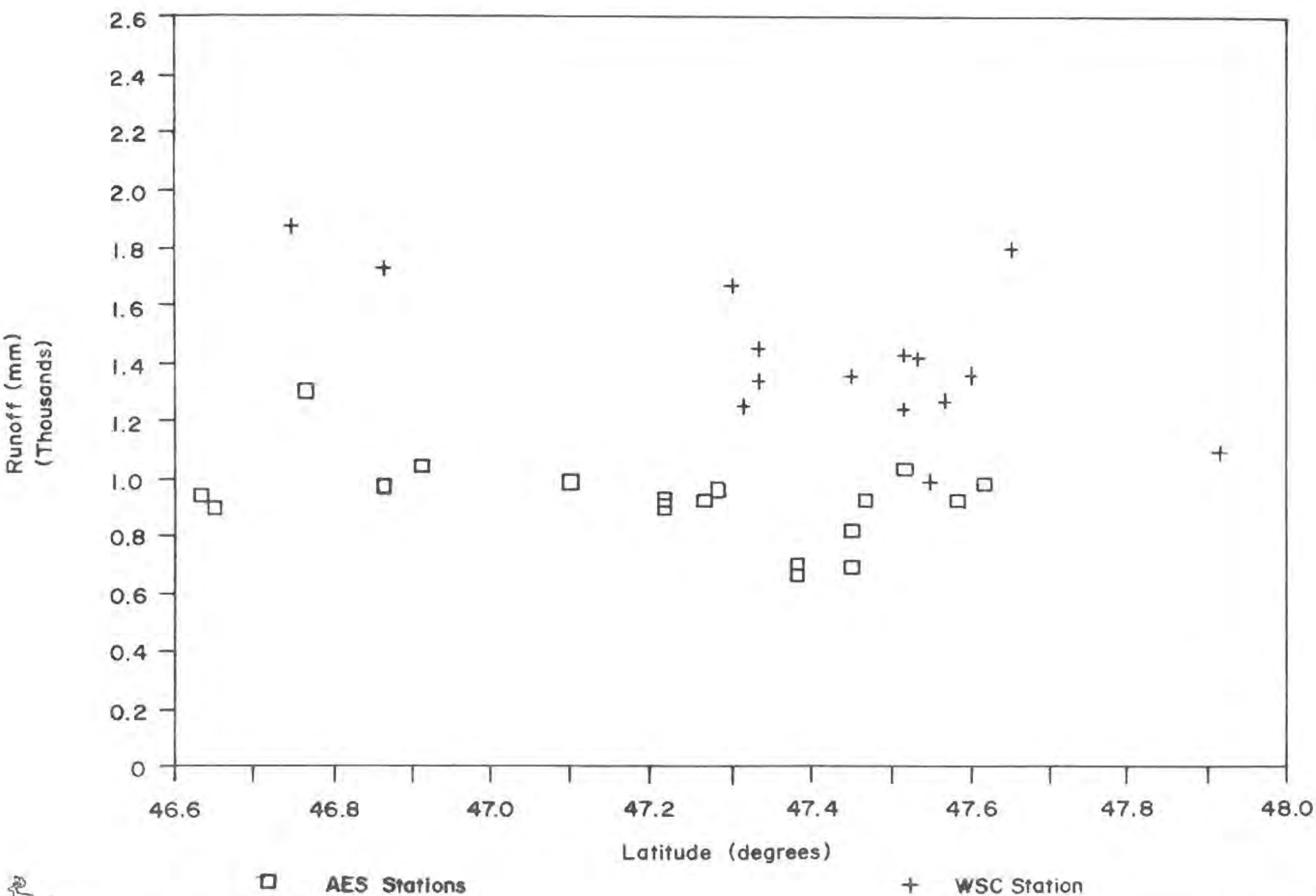

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FIG. AI.3

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Eastern Avalon Peninsula

Mean Annual Runoff as a Function of Latitude

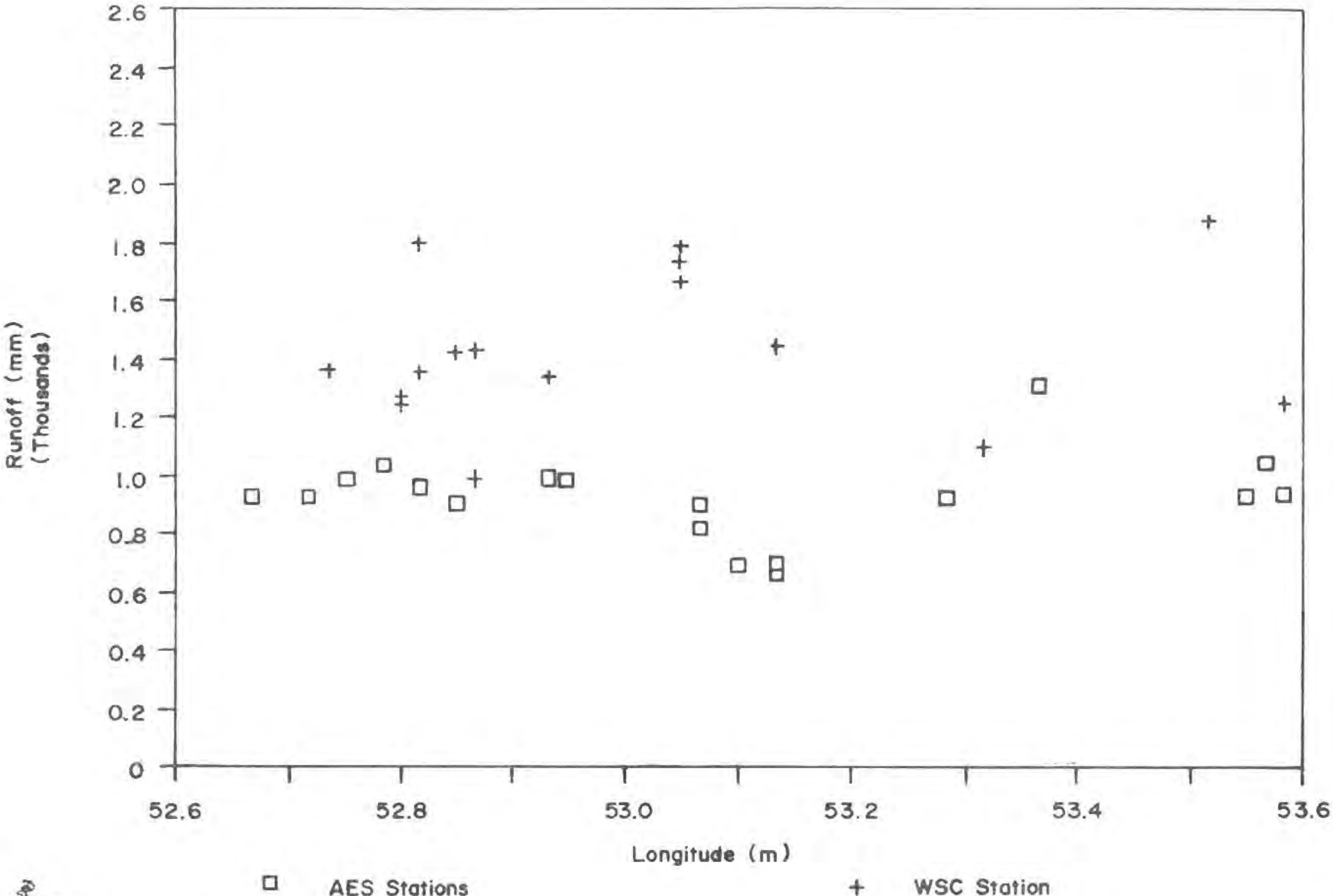

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FIG. AI.4

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Eastern Avalon Peninsula

Mean Annual Runoff as a Function of Longitude

2 - FLOW DURATION ANALYSIS

Daily flow duration curves were prepared from all gauge records. The daily flow duration curves for the 4 principal gauges used in the analysis are shown in Figure A2.1 to A2.4.

The daily curves show the expected relationship of variability to drainage area. The smallest basin, Northeast River, has a peakier curve, with more days with both high and low flows. Northwest River and Waterford River at Kilbride, with the same basin size, have similar flow duration curves, but the curve for Northwest River is slightly flattened in keeping with its southern location. Rocky River, a much larger basin at 285 km^2, shows a flatter curve, with fewer peaks and fewer low flows.

The curves for the three basins developed for hydro power, Petty Harbour, Mobile River and Pierre's Brook, are shown in Figures A2.5 to A2.7. The curves are easily recognizable by their unnatural shape. For optimal hydro power production, peak flows are stored, and released in drier periods, resulting in a flatter shape. More zero flows are recorded, because if flows are very low, it is preferable to store them until there is sufficient water to generate electricity efficiently.

The remaining curves in Figures A2.8 to A2.12 show the similarity of the other natural basins, although record lengths are too short to use for the low flow analysis.

Flow duration curves based on monthly values were also prepared, for the 4 gauges selected for detailed analysis; they are very similar to the daily curves, but as expected show higher flows at low exceedance values, and conversely lower flows at high exceedance values.

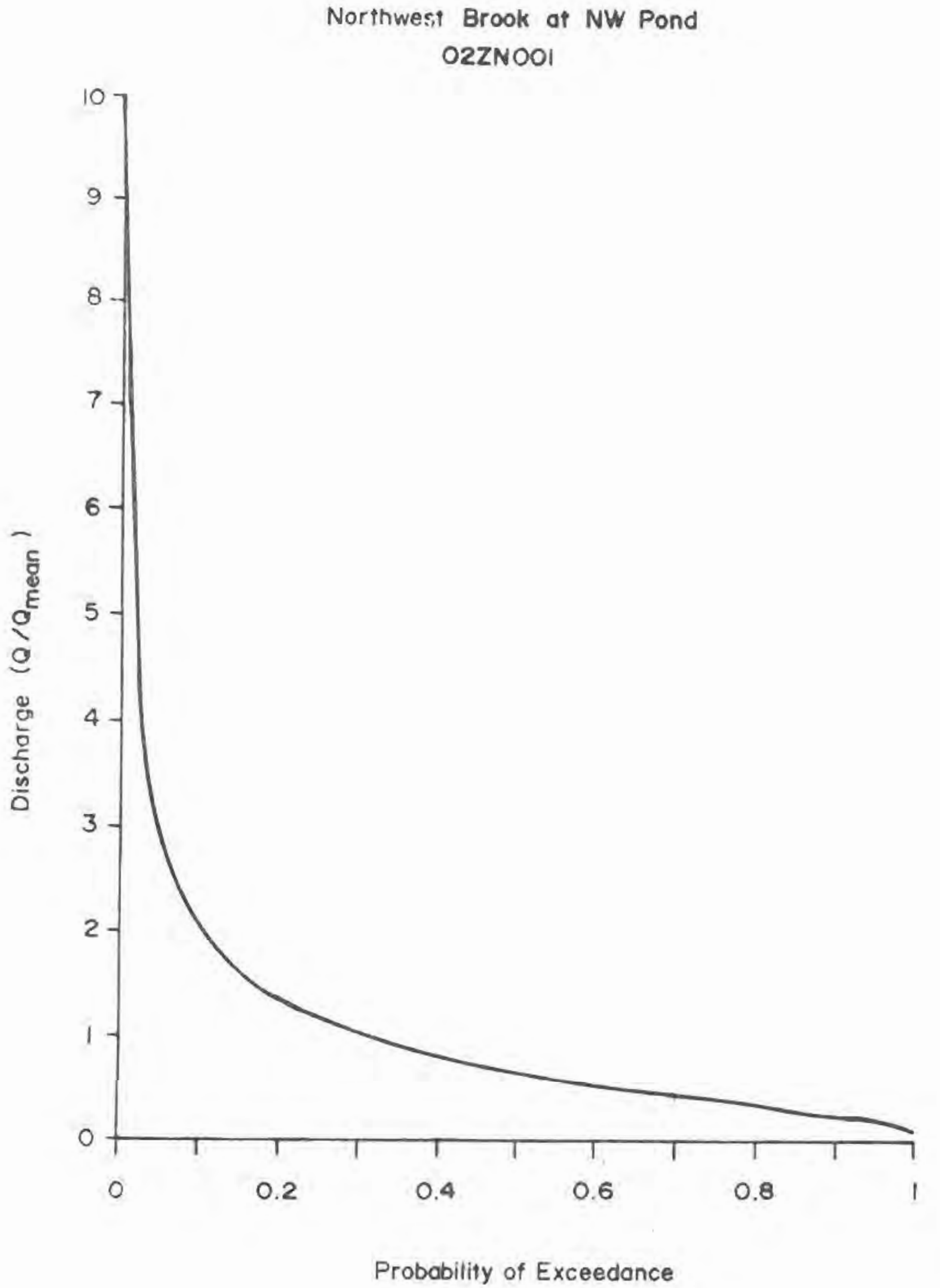

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FIG. A2.1

Regional Water Resources Study
Eastern Avalon Peninsula
Flow Duration Curve

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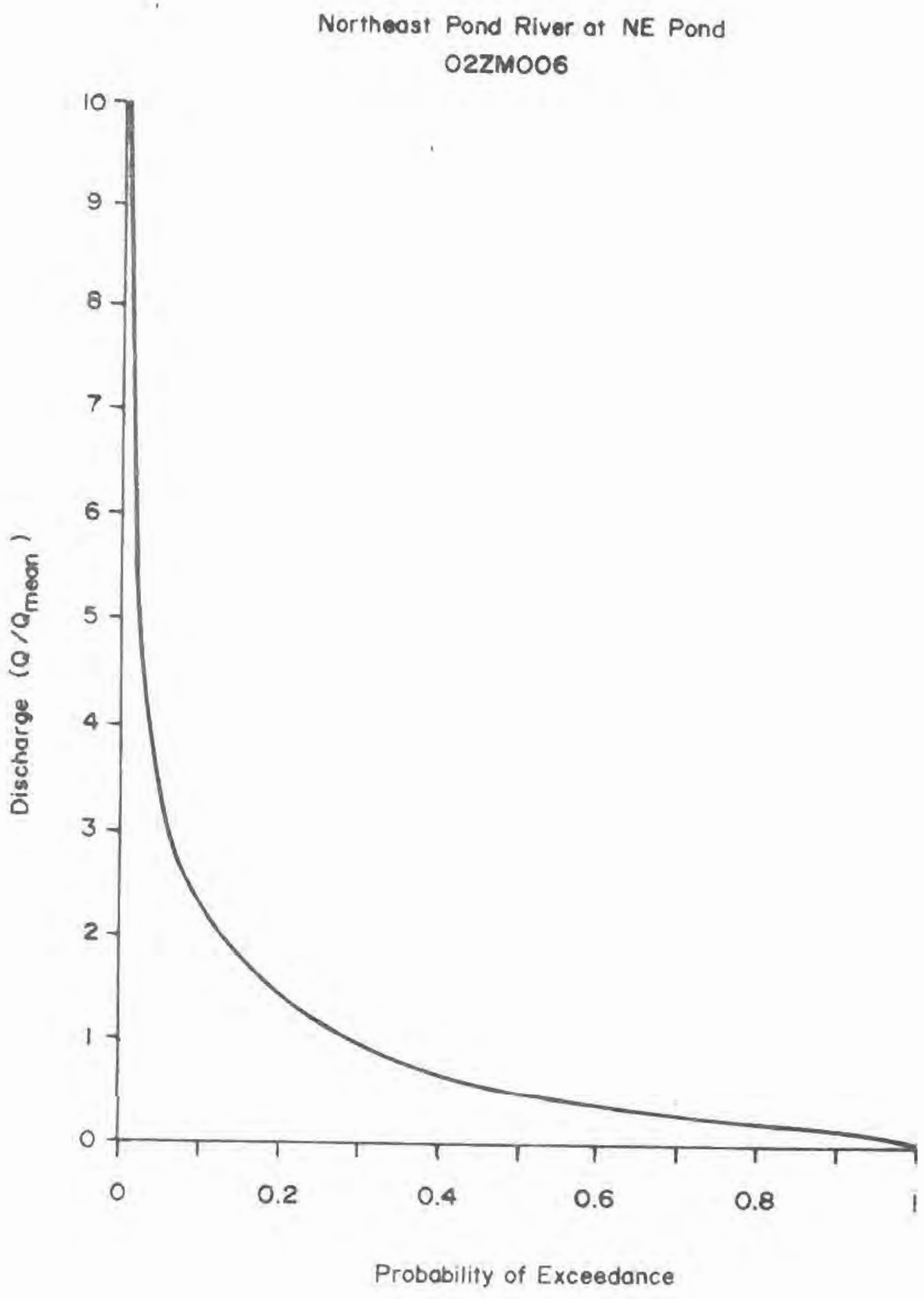

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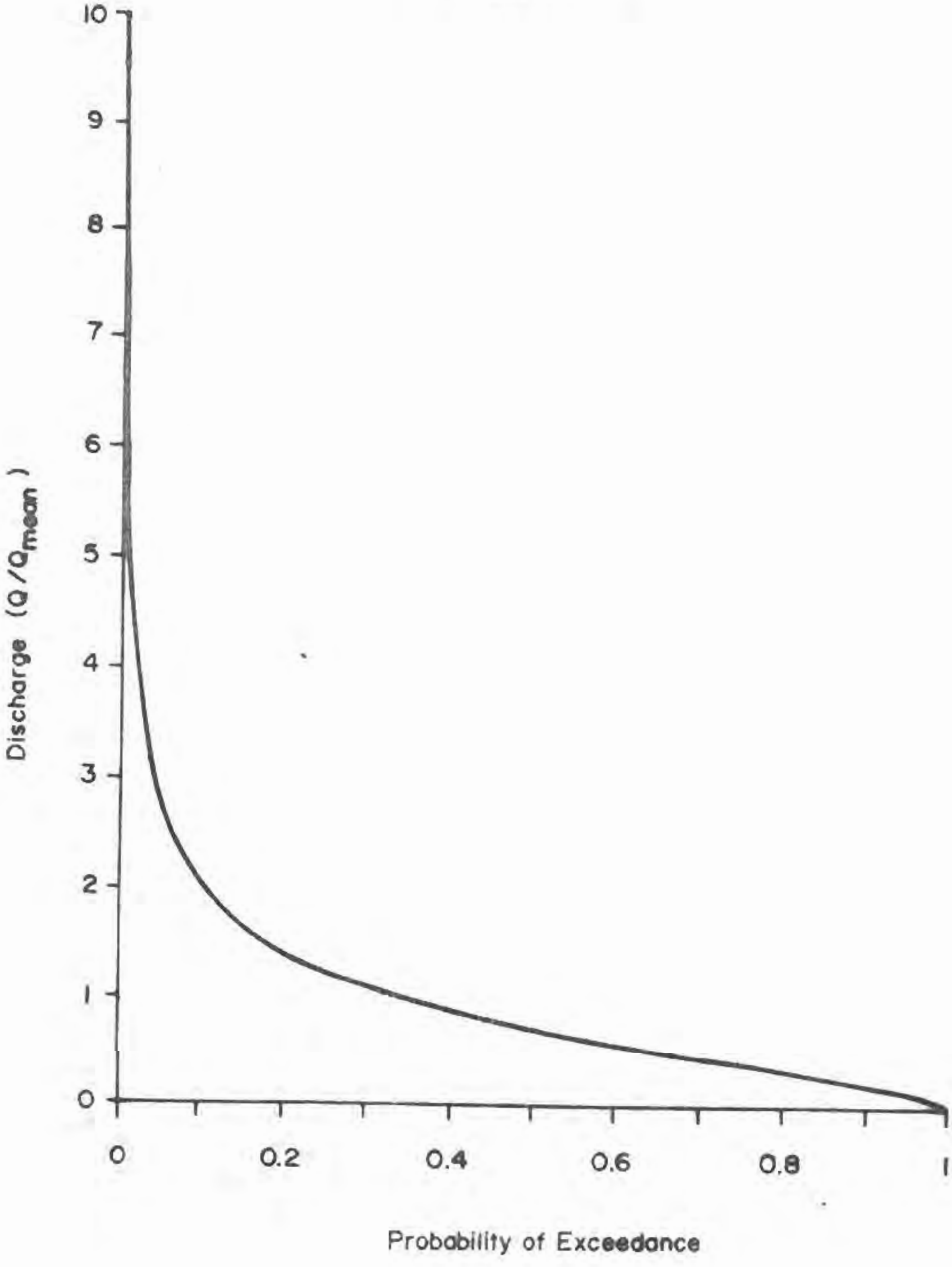
FIG. A2.2

Regional Water Resources Study
Eastern Avalon Peninsula
Flow Duration Curve

Rocky River near Colinet
02ZK001



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Regional Water Resources Study
Eastern Avalon Peninsula
Flow Duration Curve

FIG. A2.3

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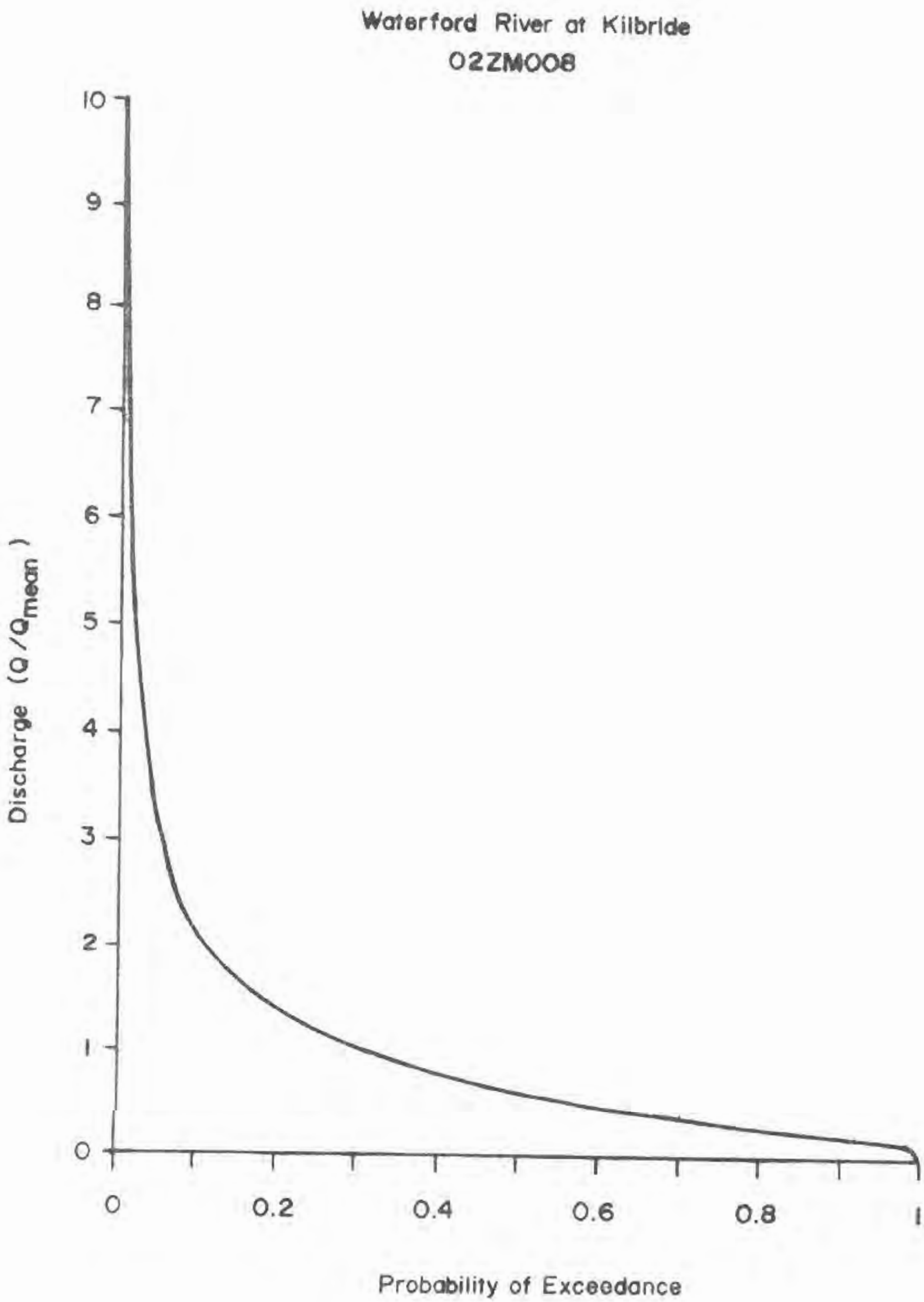

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Eastern Avalon Peninsula

FIG. A2.4

Flow Duration Curve

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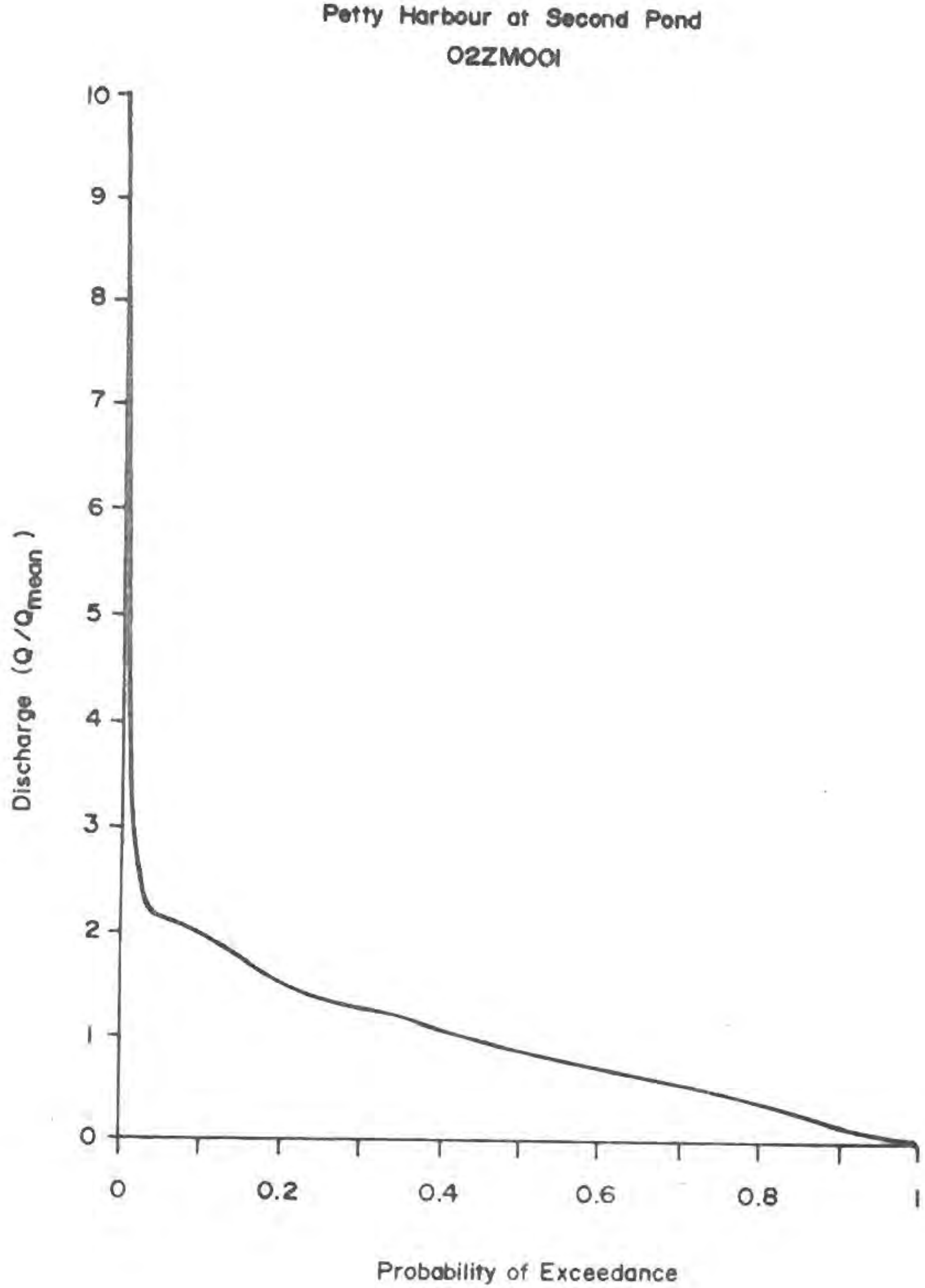

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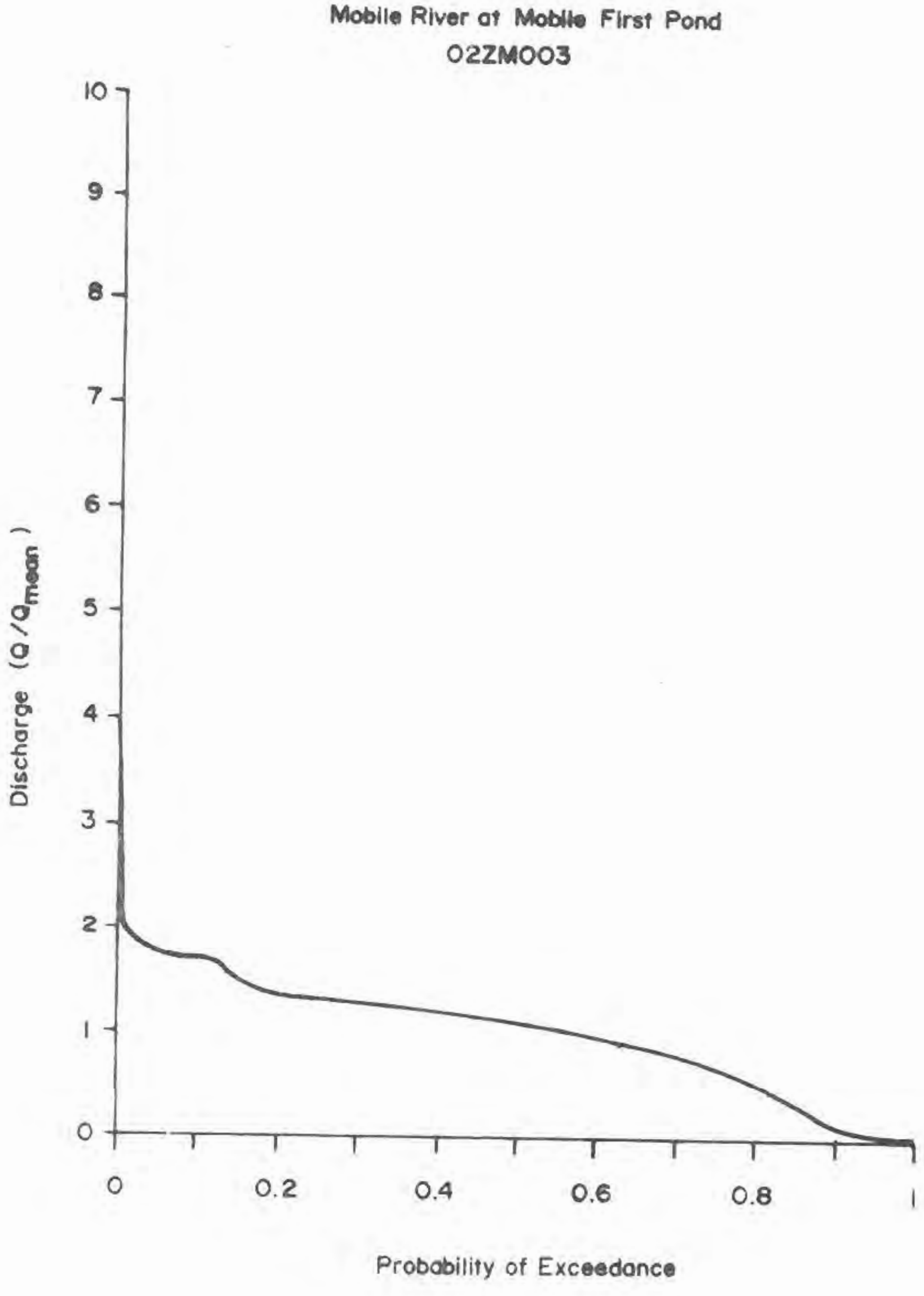
FIG. A2.5

Regional Water Resources Study
Eastern Avalon Peninsula
Flow Duration Curve



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Regional Water Resources Study
Eastern Avalon Peninsula
Flow Duration Curve

FIG. A2.6

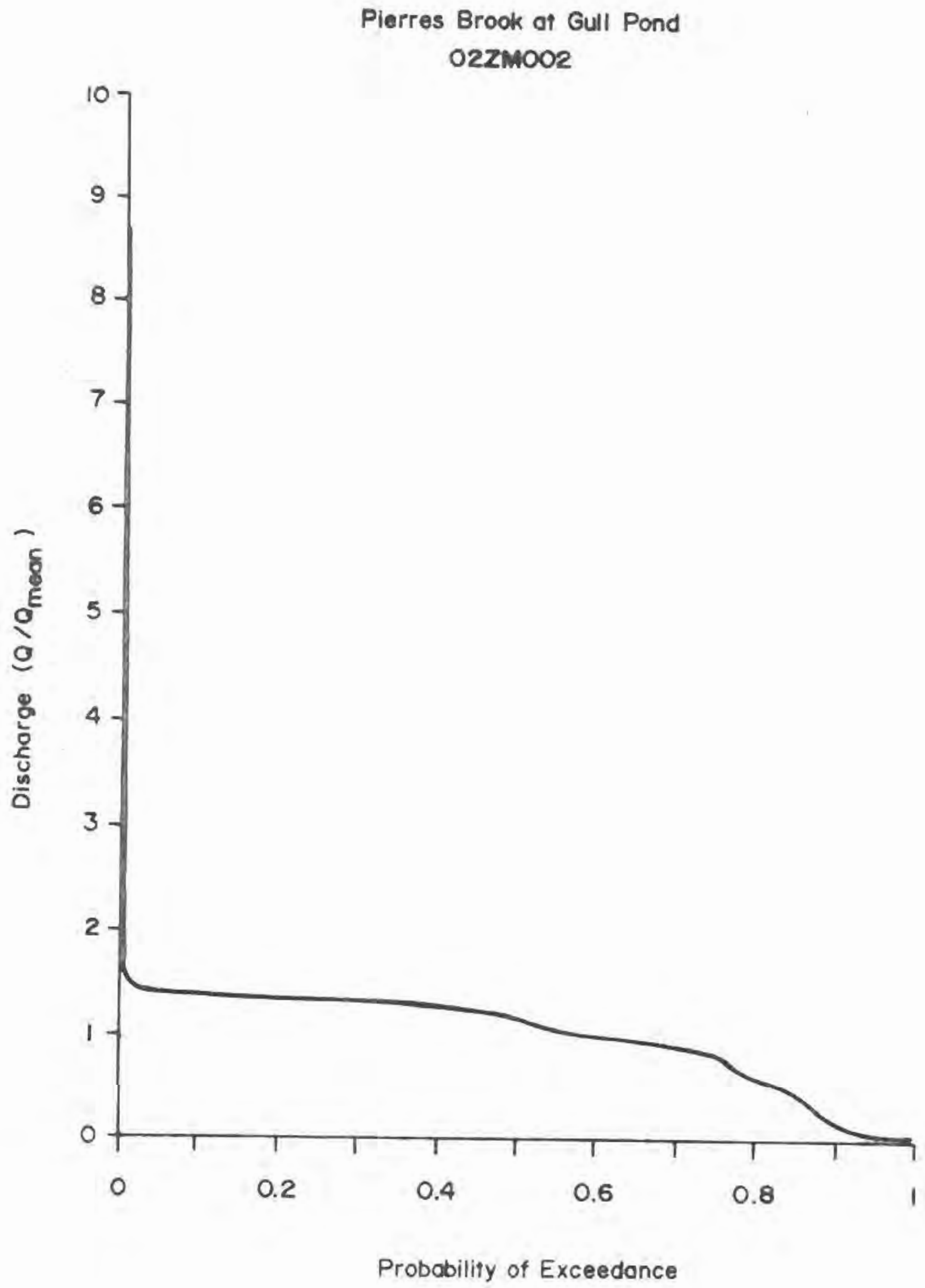

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FIG.A2.7

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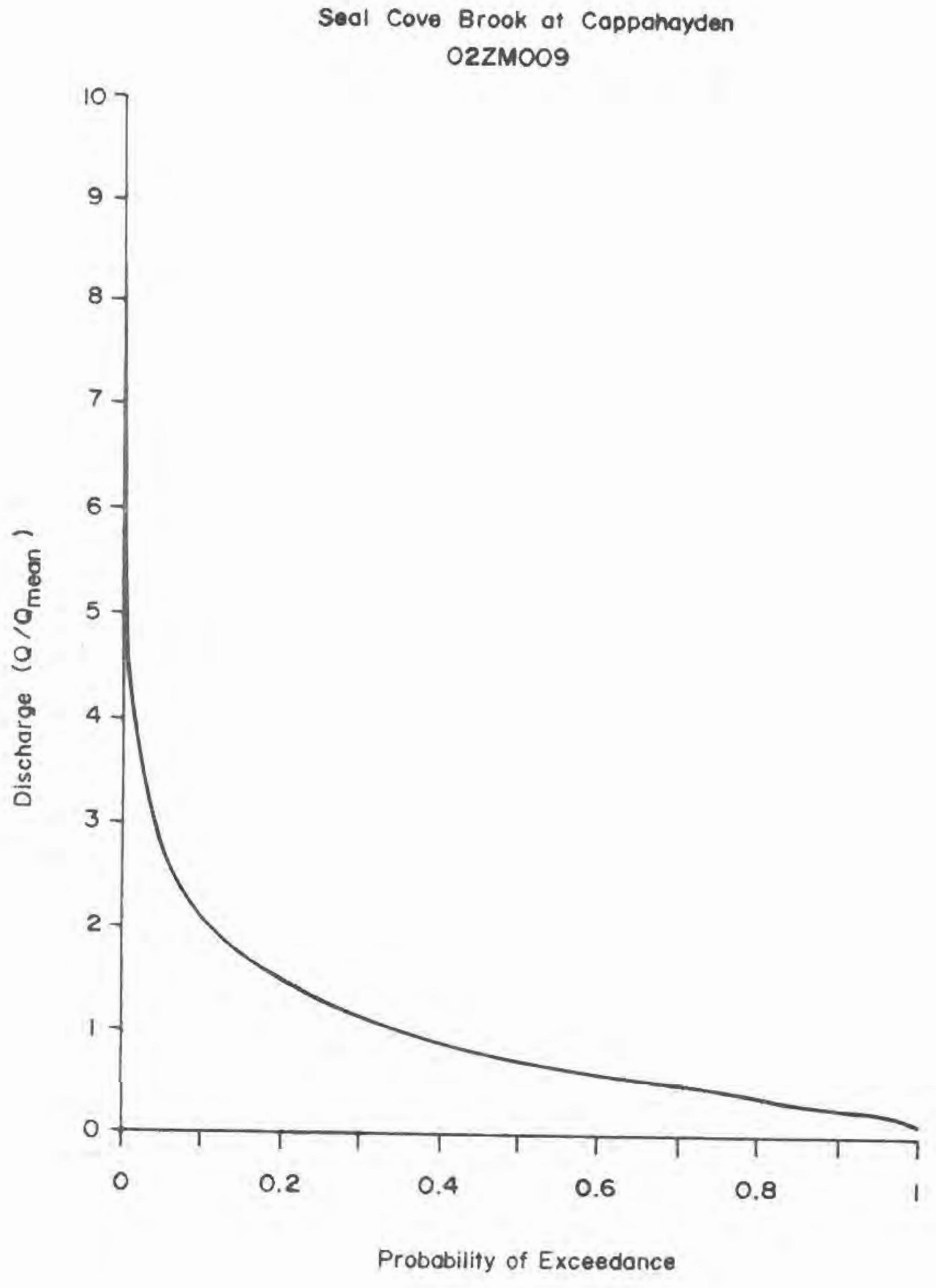
Eastern Avalon Peninsula
Flow Duration Curve



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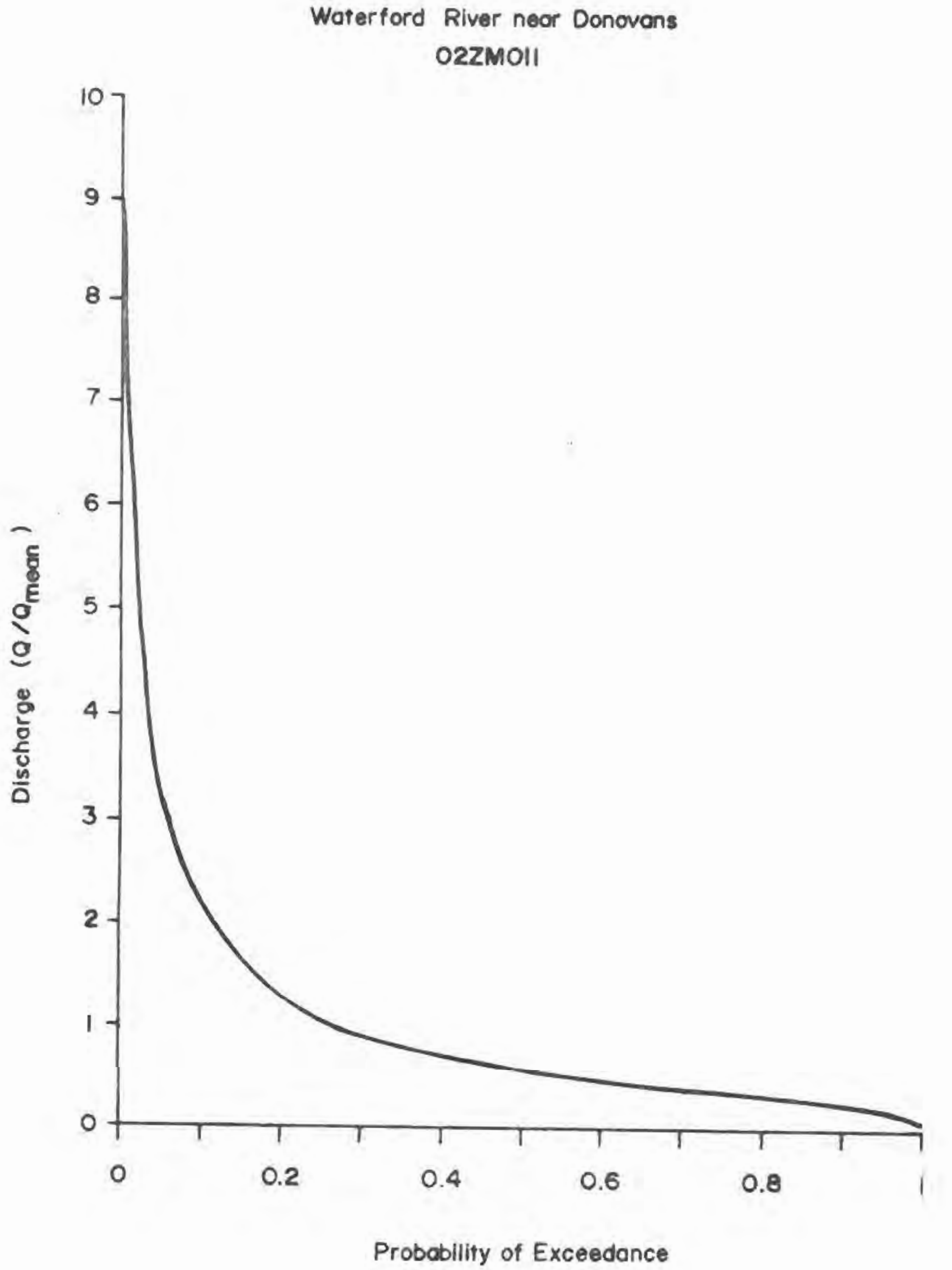
Regional Water Resources Study
Eastern Avalon Peninsula
Flow Duration Curve

FIG.A2.8



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Regional Water Resources Study
Eastern Avalon Peninsula
Flow Duration Curve

FIG. A2.9

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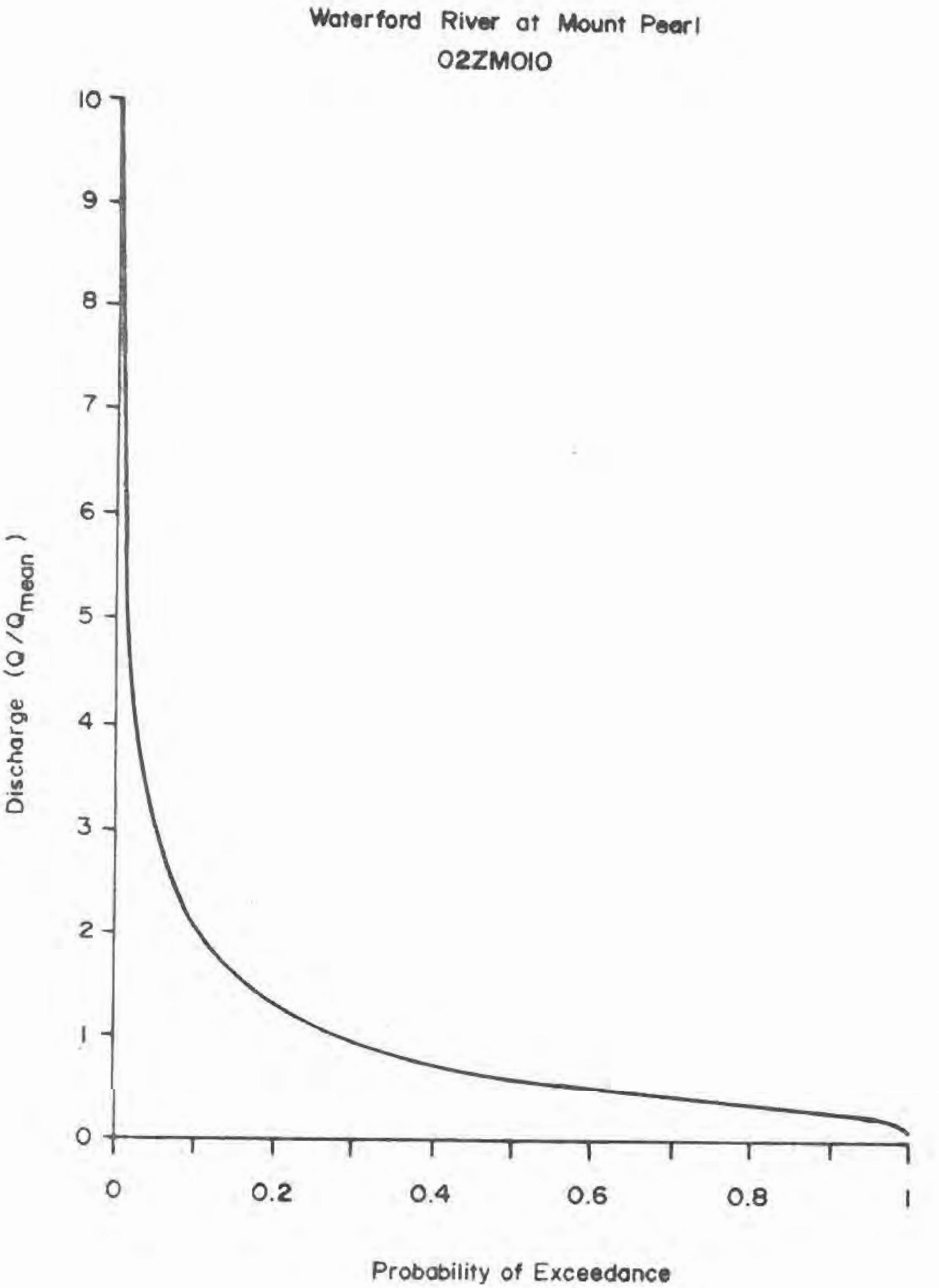

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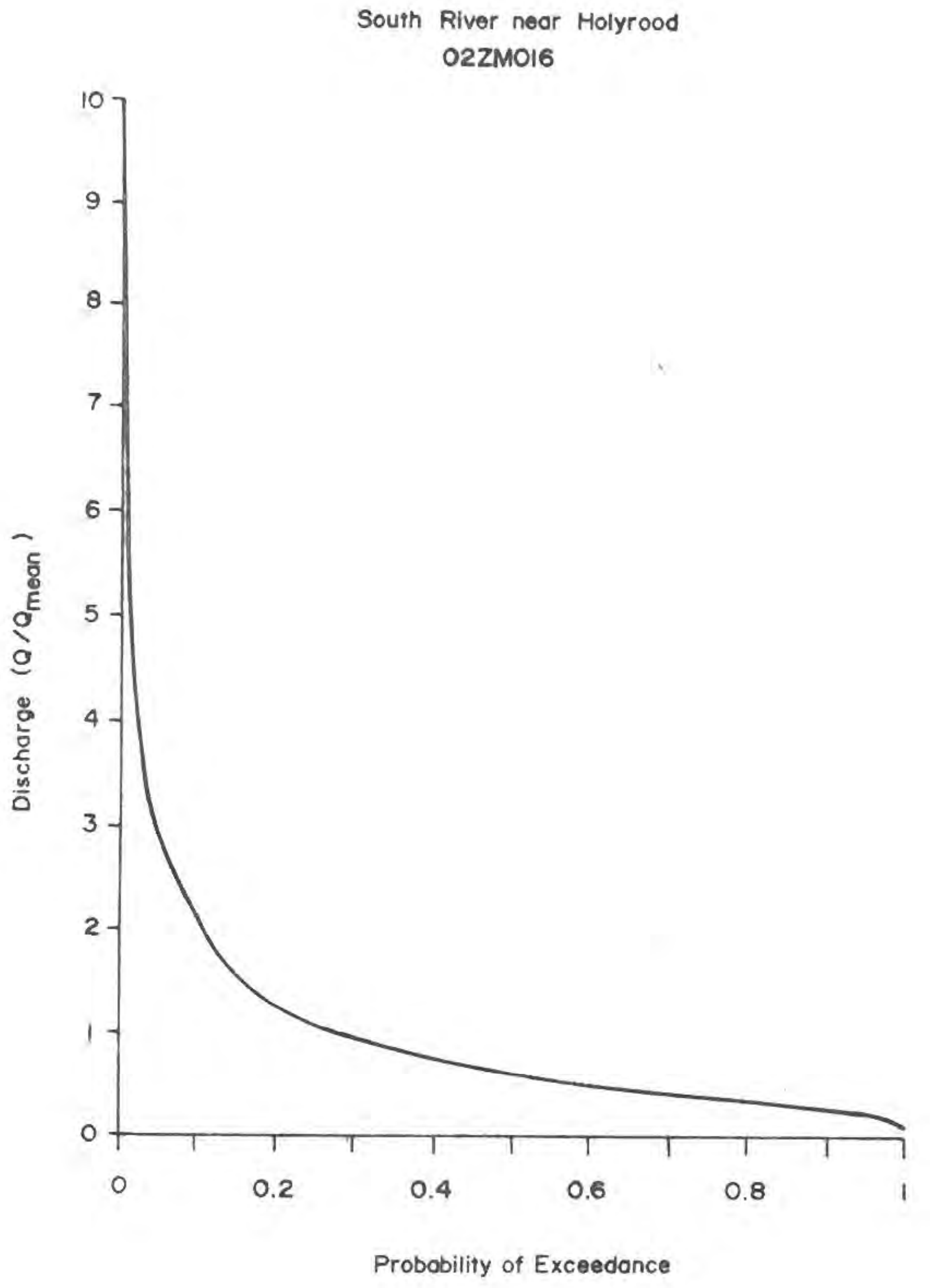
Regional Water Resources Study
Eastern Avalon Peninsula
Flow Duration Curve

FIG. A2.10



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Regional Water Resources Study
Eastern Avalon Peninsula
Flow Duration Curve

FIG. A2.11

ACRES

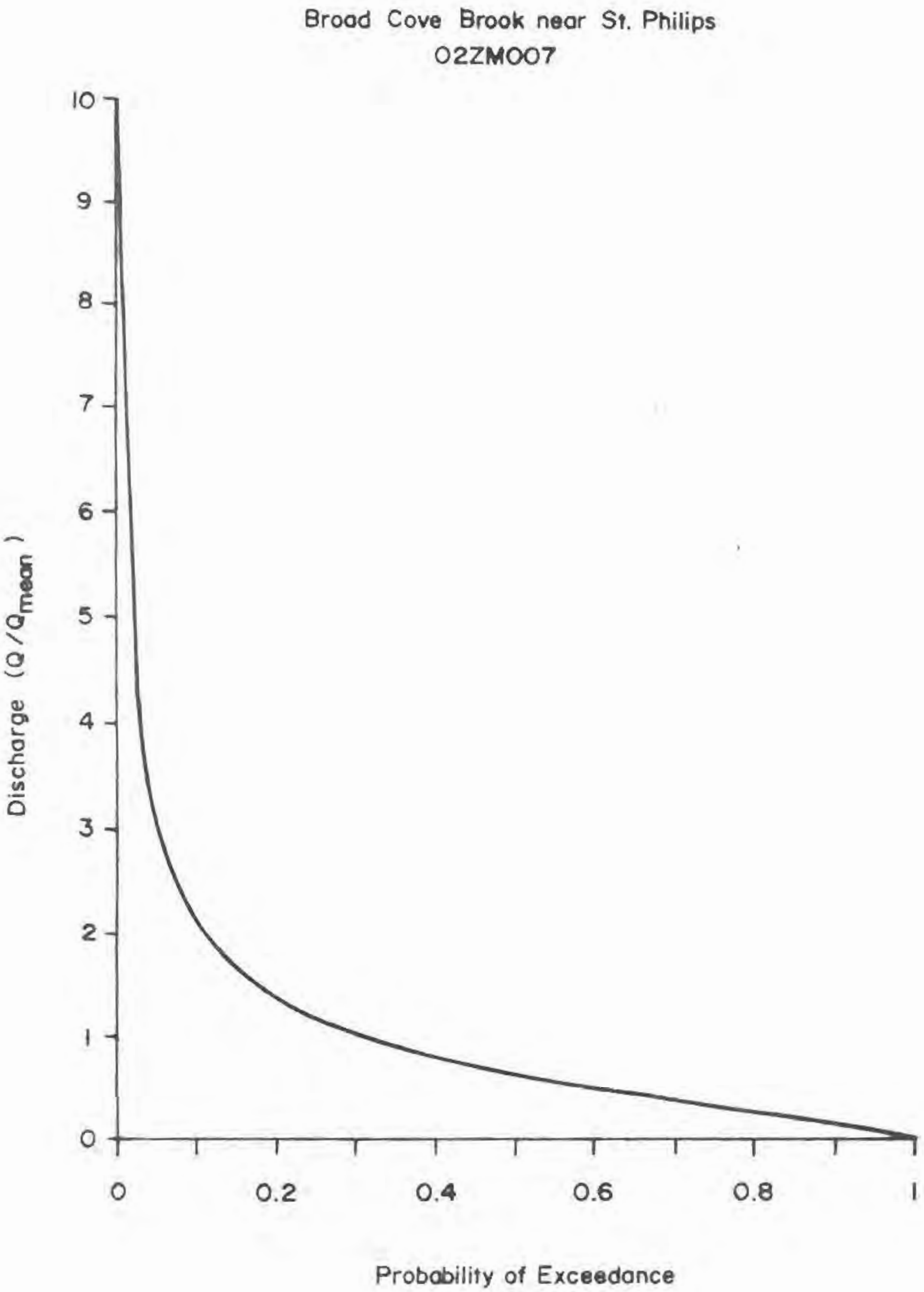

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FIG. A2.12

Regional Water Resources Study
Eastern Avalon Peninsula
Flow Duration Curve

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APPENDIX B

WATER QUALITY

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LIST OF TABLES - APPENDIX B (continued)

APPENDIX B - WATER QUALITY

Appendix B contains two major sections. Section 1 discusses the major parameters sampled in the joint Environmental Canada/Newfoundland Department of Environment water quality program, with specific reference to the study area. Section 2 presents detailed information relating to possible degradation of water due to microorganisms, nutrients, and toxic substances.

1 - Discussion of Parameters

The major parameters can be categorized in five groups, as described below. Only the parameters for which test data are available are included.

1. General - This includes the traditional parameters of importance to water supplies, i.e., the inorganic parameters of pH, alkalinity, hardness, specific conductance, and total dissolved solids (TDS), plus the physical parameters of colour and turbidity.

2. Major ions - The principal cations are from the alkali-earth group, including sodium, potassium, calcium and magnesium. The principal anions include carbonate, bicarbonate, chloride and sulphide.

3. Nutrients - The level of nutrient loading is assessed by measuring such parameters as dissolved oxygen, oxygen demand, and carbon, as well as nitrogen and phosphorus.

4. Metals - Metals tested for usually include aluminum, chromium, manganese, iron, nickel, copper, zinc, arsenic, cadmium, mercury, lead.

5. Microorganisms - Coliform counts (total, faecal, streptoccal) are the most common.

The following sections discuss each of these groups in more detail. The mean values and the range for each parameter for the six rivers are compared with the environmental range measured elsewhere in Canada, usually taken from Canadian Water Quality Guidelines(56). The range for natural freshwaters, where given, is taken from Reference 33. (These other measurements are not necessarily measurements from natural watercourses.)

Tabulated results for each of the six regularly-sampled rivers in the study area are presented in Table 4.1 to 4.6 of the main report. Table B1.1 summarizes the values of some of the major parameters for the Avalon Peninsula, taken from a variety of sources.

1.1 - General Parameters

1.1.1 - pH

The value of pH represents the degree to which the water is acidic or basic. The pH scale is a logarithmic scale from 0 to 14; the low end is very acid, the high end very basic, and 7 is neutral.

Natural surface waters in Newfoundland, including the study area, tend to be acidic. Median values of pH for the six sampled rivers as well as some comparative values, are presented in Table B1.2. The pH in the study area hovers around 6, with the northeastern part tending to be slightly more acid than the southwestern part(51).

TABLE B1.1

SUMMARY OF WATER QUALITY DATA FOR AVALON PENINSULA SURFACE WATERS

Parameter	Units	No. of Samples	Min	Max	Mean	Stan. Dev.
pH	pH units	271	4.7	7.3	6.23	0.44
Alkalinity	mg/L($CaCO_3$)	269	0.50	30.00	3.29	2.62
Conductivity	mS/cm	271	16.00	326.00	45.79	33.12
Hardness	mg/L($CaCO_3$)	244	0.30	6.50	0.89	0.70
Calcium	mg/L	266	0.10	12.00	1.72	1.63
Magnesium	mg/L	70	0.32	2.36	0.88	0.44
Sodium	mg/L	34	2.90	23.35	7.75	5.63
Chloride	mg/L	237	0.85	66.00	10.90	8.04
Sulphate	mg/L	52	1.10	20.50	4.22	3.05
Bicarbonate	mg/L	150	0.00	12.20	4.13	2.23
Colour	TCU*	34	8.00	233.00	51.9	51.5

Source - Scruton, D.A.(51)

*True Colour Units

TABLE B1.2

pH

River	Median 1965-80	Median 1981-85	Low	High
Broad Cove Brook	5.9	6.0	3.7	7.0
Mobile River	5.5	5.9	4.5	6.8
Northeast Pond River	5.7	-	3.9	7.8
Northwest Brook	5.4	5.9	4.4	8.0
Rocky River	6.2	-	3.6	8.2
Seal Cove River	-	6.1	4.1	6.8

Environmental Range	
Western Canada	4.1 - 10.2
Central Canada	2.8 - 9.6
Atlantic Canada	2.8 - 9.2
Natural Freshwaters	4 - 9

Rocky River has the highest median pH; it also has the greatest excursions, with a range from 3.6 to 8.2, but all rivers showed considerable variation. Depressions in pH are related to the annual hydrograph, occurring in late fall as a result of rainfall runoff and in spring in association with snowmelt runoff.

The principal explanation for the acidity appears to be organic acids from terrestrial sources (extensive barrens, scrub forest and bogs) combined with the low capacity of native soils and bedrock to buffer the natural acids. The possibility of acidification due to acid precipitation is discussed in Section 4.4 of the main report.

1.1.2 - Inorganic Alkalinity

Alkalinity is another inorganic parameter, representing the neutralizing ability of water. Since most of this capacity is due to carbonate/bicarbonate/carbon dioxide buffering systems, alkalinity is usually presented as calcium carbonate equivalent ($CaCO_3$). Alkalinity is a function of soil and rock geochemistry, so silicates, borates, phosphates and other components may also supply buffering systems.

Table B1.3 presents the median values for the six rivers as well as the range found elsewhere in Canada.

Alkalinities are very low as expected in the study area, given the natural acidity of the water and the lack of readily soluble alkaline components in soils and bedrock. These values are typical of most of eastern and southern Newfoundland. Alkalinity of the order of 10 mg/L is reported along the west coast of the province, with isolated pockets on the northern peninsula over 20 mg/L(51). In other areas of Canada, alkalinity may reach 500 mg/L; a value of less than 24 mg/L is considered low(56).

TABLE B1.3

ALKALINITY

River	Total Alkalinity as $CaCO_3$ (mg/L) Mean	Low	High
Broad Cove Brook	1.9	0.1	13
Mobile River	1.5	0.2	6.0
Northeast Pond River	1.0	0.4	6.4
Northwest Brook	2.1	0.6	36
Rocky River	3.5	0.0	9.4
Seal Cove River	1.9	0.7	7.0

Environmental Range	
Pacific Canada	0.5 - 162
Western Canada	1.0 - 750
Central Canada	<0.5 - 210.9
Atlantic Canada	<0.5 - 440

1.1.3 - Hardness

The concept of hardness traditionally represents the effect of the water on soap, and as such is important in evaluating potential municipal and domestic water supply sources. Hardness is considered an inorganic parameter because it is a function of the presence of calcium and magnesium ions in solution, and the value of hardness is expressed as equivalent $CaCO_3$.

The surface waters of the Avalon peninsula are very soft, as shown in Table B1.4.. Soft water is generally desirable because hard water results in scaling on pipes and boilers, as well as excessive soap consumption. Soft water, however, tends to be more corrosive than hard water.

These values all indicate soft to very soft water, as can be seen from Table B1.5. Values up to 300 mg/L can be considered normal in waters draining limestone or gypsum. Mean hardness on the island of Newfoundland rarely exceeds 14 mg/L $CaCO_3$ equivalent, still very soft; these values occur on the west coast.

1.1.4 - Specific Conductance/Total Dissolved Solids

Specific conductance, or conductivity, is a measure of the ability of the water to conduct a current. This ability is a function of the relative ionic concentration, so conductivity can indicate changes in a water's mineral composition (although not the relative quantities of components). There is a high correlation between total dissolved solids (TDS) and conductivity. Total dissolved solids is an index of the amount of dissolved substances in water and, like conductivity, gives a general indication of water quality.

TABLE B1.4

HARDNESS

River	Hardness as $CaCO_3$ (mg/L)		
	Mean	Low	High
Broad Cove Brook	13.5	5.6	78.1
Mobile River	8.1	3.9	36.1
Northeast Pond River	6.2	3.6	11.5
Northwest Brook	4.9	3.1	8.9
Rocky River	7.6	2.8	21.5
Seal Cove River	-	-	-

TABLE B1.5

HARDNESS OF FRESHWATER

Hardness as $CaCO_3$ (mg/L)	Degree of Hardness
0-30	very soft
31-60	soft
61-120	moderately soft
121-180	hard
>180	very hard

Source: Thomas, 1953, reproduced in reference 33.

Conductivity and TDS are commonly taken to result from the dissolution of minerals in the watershed, but in coastal areas in Newfoundland, marine aerosols (airborne sea salts) have been estimated to contribute approximately half of all ionic constituents, in the form of sodium and chloride ions(51). Rivers on the island show higher conductivities than Labrador rivers of similar hardness, for example, because of the ions of marine origin.

Despite the additional contribution of marine constituents, conductivity and TDS are low in all waters in the study area (as elsewhere in insular Newfoundland), as shown in Table B1.6.

The normal range of conductivity is about 50-500 uS/cm. A TDS concentration of 10 mg/L is considered very low. TDS >1 000 indicates a slightly saline condition; over 10 000 is considered saline. The values from the study area are low in comparison, and without the estimated marine contribution of approximately 50 percent, they would be even lower. The implications of this low ionic concentration on sensitivity to acidification is discussed in Section 4.4.

1.1.5 - Colour

Colour is a physical parameter, a measure of the optical properties of water. It is measured as either true colour (i.e., sample is filtered to remove turbidity before colour is measured) or apparent colour (sample is not filtered). Much of the long-term reporting has been of apparent colour; the DFO data set for the Avalon Peninsula samples reports true colour. If turbidity is low, the readings for true and apparent colour will be the same. Although comparison of the data sets may be difficult, the conclusion from all data sets is that waters in the study area are in general moderate to highly coloured, and that colour increases with discharge. These results are not surprising since

TABLE B1.6

CONDUCTIVITY/TDS

River	Conductivity (uS/cm)			TDS (mg/L)		
	Mean	Low	High	Mean	Low	High
Broad Cove Brook	46	11	100	44	28	68
Mobile River	27	0	50	24	19	31
Northeast Pond Riv.	52	31	158	25	16	40
Northwest Brook	28	10	170	21	16	28
Rocky River	41	26	144	21	13	32
Seal Cove River	28	10	70	-	-	-

Region	Range	Range*
Pacific	4.8 - 84 600	ND - 990
Western	0.003 - 2 000	0.002 - 5 873
Central	0.008 - 31 000	0.2 - 23 536
Atlantic	-	1 - 3 284

*Range is of filterable residue, taken to be equivalent to TDS.
ND - Not Detected

a common source of colour is organic content such as humic substances, fulvics, tannins and lignins. The coloured organics are derived from the peatlands and bogs which have developed in the poorly drained plateau areas at the headwaters of many of the rivers in the region.

Colour may also come from natural minerals; in the study area, iron and manganese can contribute. Elsewhere, calcium carbonate may add colour. Where nutrient levels are high, algae can also cause colour, but this rarely occurs here. Table B1.7 presents values for one river in the study area and two adjacent rivers, Rocky River and Colinet River(51), in TCU, as well as for the six monitored rivers in apparent colour units.

Values over 10 are readily detected by eye, and the range of about 10-100 is considered moderate to highly coloured. Mean values are all in this range, and some individual samples are much above it.

1.1.6 - Turbidity

Turbidity is a physical parameter, a measure of suspended solids such as clay, silt, algae, other organic and inorganic matter, soluble coloured organic compounds, and microscopic organisms. Like colour, it is higher in periods of high runoff, since it is exacerbated by the influx of organics from bogs and resuspension of bottom sediments. High turbidity is also frequently reported as a result of anthropogenic activity, in particular, construction practices. Table B1.8 shows turbidity levels for the six monitored rivers in the region, measured in Jackson Turbidity Units (JTU).

The highest values were reported from Broad Cove Brook. A high value, 7.2 JTU, was also measured in a sample from Biscay Bay (Back) Brook. The high value at Broad Cove Brook may be due to

TABLE B1.7

COLOUR

River	Mean Apparent Colour	Volume Volume Weighted Mean (TCU)	Range
Broad Cove Brook	24	-	5 - 65
Mobile River	54	-	15 - 135
Northeast Pond River	24	-	5 - 70
Northwest Brook	39	-	10 - 300
Rocky River	71	-	10 - 450
Seal Cove River	47	-	10 - 70
Biscay Bay (Back) Brook	-	44	5 - 75
Colinet River	-	62	25 - 100
Rocky River	-	89	15 - 150
Environmental Range			
Pacific Canada	-	-	25 - 40
Western Canada	-	-	5 - 240
Central Canada	-	-	5 - 200
Atlantic Canada	-	-	65 - 130

TABLE B1.8

TURBIDITY

River	Turbidity (JTU) Mean	Low	High
Broad Cove Brook	1.1	0.1	9.0
Mobile River	0.95	0.1	6.3
Northeast Pond River	0.6	0.1	2.0
Northwest Brook	0.85	0.1	2.9
Rocky River	1.1	0.1	5.
Seal Cove River	0.8	0.3	1.5

Region	Environmental Range
Pacific	0.12 - 360
Western	0.1 - 3 600
Central	ND - 90
Atlantic	ND - 520

land use practices in the watershed. The high value at Biscay Bay (Back) Brook is more likely due to the fact that it is a small watershed with a high proportion of barrens, with a rapid response to heavy rain. The current Canadian maximum acceptable turbidity limit for drinking water 5 NTU (nephelometric turbidity units, comparable to JTU's).

The effects of turbidity on other parameters should be considered when evaluating test results. Elevated turbidity levels will result in higher levels of extractable metals, for example, because the particles in the water will release metals when treated with acid used in the metals analysis.

1.2 - **Major Cations**

The major cations tested in water quality programs are the alkali-earths, calcium, magnesium, sodium and potassium. They enter the surface waters from five sources

- geochemical weathering of rocks and soils.

- deposition of marine aerosols.

- other anthropogenic sources (e.g., sewage and industrial wastes, de-icing salts).

- deposition (precipitation or dry fallout) of atmospheric pollutants of anthropogenic origin.

- dissolved organic constituents of terrestrial origin.

The total sum of constituents in the study area (as in Newfoundland in general) is low by global standards; it is of the order of 10-20 mg/L compared with a world average of 112 mg/L.(Livingstone, 1963, quoted in reference 51) Concentration of these ions is inversely related to runoff, i.e., they are diluted in times of high runoff.

Typically the waters of the Avalon peninsula are sodium dominated, and the order of concentration is

sodium > calcium > magnesium > potassium

The importance of the contribution of the marine aerosols is evident when the marine influence is extracted. As Scruton has shown (ASR), when the contribution of airborne sea salts is removed, the natural waters become calcium dominated, like soft continental freshwaters. The order of domination tends to become either

calcium > sodium > magnesium > potassium

or

calcium > magnesium > sodium > potassium

depending on soil and bedrock geochemistry.

Concentrations of these cations in the rivers of the study area are presented in Table B1.9. Each cation is briefly discussed below.

1.2.1 - Sodium

Sodium is an abundant alkali-earth metal. Its usual natural source in water is geochemical weathering, but in the study area the principal source is airborne sea salts. Concentrations are generally low despite the marine aerosol contribution. The maximum value reported, 195 mg/L, is from Broad Cove Brook. Since the next highest maximum is 38, an anthropogenic source such as road salt seems likely.

TABLE B1.9

PRINCIPAL CATIONS

River	Mean Dissolved Sodium (mg/L)	Mean Dissolved Calcium (mg/L)	Mean Dissolved Magnesium (mg/L)	Mean Dissolved Potassium (mg/L)
Broad Cove BRook	12.9	2.4	0.8	0.9
Mobile River	5.9	1.8	0.6	0.3
Northeast Pond River	6.5	1.0	0.9	0.5
Northwest Brook	4.4	1.1	0.6	0.3
Rocky River	4.6	1.7	0.8	0.4
Seal Cove River	5.1	1.5	0.9	0.3
Range for Study Area	2.1 - 195	0.5 - 30	0.1 - 2	0 - 27
Environmental Range	0->10000*	0-15	0-100	0-10

*in waters with saline intrusions

1.2.2 - Calcium

Calcium is one of the most abundantly occurring cations, and is a major contributor to the hardness of water. A small amount of calcium is deposited from marine aerosols, but the primary source is geochemical weathering of rocks and soils. Calcium can occur naturally in concentrations up to 100 mg/L in waters draining carbonate rocks. Calcium is released into the atmosphere in combustion, so atmospheric anthropogenic sources are also a source. An increase in the acidity of rain, which also may occur as a result of combustion and other industrial activities, will further increase calcium loadings by increasing the rate of leaching from the soil.

Calcium concentrations tend to be low in the study area, as they are all across the island. They are slightly higher on the west coast, and mean values of about 25 mg/L have been reported on the Northern peninsula.

1.2.3 - Magnesium

Magnesium is less naturally abundant than calcium. Although it is more soluble, it is usually found in smaller concentrations than calcium in surface water samples. Like calcium, it is a major contributor to the hardness of water. Magnesium concentrations are very low throughout the island, with the exception of the Northern Peninsula, where mean concentrations are in the range of 1 to 10 mg/L.

1.2.4 - Potassium

Potassium is usually found with sodium in ratios of sodium to potassium of about two or three to one. A major difference from sodium is that it does not readily remain in solution, and concentrations are usually less than 10 mg/L. In the study area potassium concentrations are very low, as they are everywhere on the island. Again, the maximum value reported, 27 mg/L, is from the most developed watershed, Broad Cove Brook. All the other streams have much lower maximums, so an anthropogenic source seems likely.

1.3 - Major Inorganic Anions

The major inorganic anions commonly measured are chloride, sulphate, carbonate and bicarbonate. Concentrations of all are low in the study area, as Table B1.10 shows, except for chloride.

Sources of anionic constituents include

- weathering of soils and rocks
- deposition of marine aerosols
- anthropogenic sources (atmospheric deposition, waste water, de-icing salts).

1.3.1 - Chloride/Fluoride

Chloride is one of the halides, together with fluoride, bromide, and iodide. In most waters chloride is a major constituent, and the others are usually only present in trace quantities. Chloride concentrations are relatively high in the study area because of the contribution from airborne sea salt. (Scruton ASR,HL) Geochemical weathering may be a significant source of chloride in some areas, but in general chloride is not abundant naturally in rocks and soils. It is unusual to find chloride as the dominant anion, as it is in the study area. The low levels of other anionic constituents, combined with deposition of chloride from marine sources result in its relative importance.

TABLE B1.10

PRINCIPAL ANIONS

River	Mean Dissolved Chloride (mg/L)	Mean Dissolved Fluoride (mg/L)	Mean Dissolved Sulphate (mg/L)	Mean Carbonate (mg/L)	Mean Bicarbonate (mg/L)
Broad Cove Brook	14.5	–	4.0	0	2
Mobile River	9.1	–	3.1	0	2
Northeast Pond River	11.3	0.08	3.6	0	2
Northwest Brook	9.5	–	3.0	0	4
Rocky River	8.4	–	3.7	0	4
Seal Cove River	8.4	–	3.0	–	–
Range in Study Area	1.1-68	<0.01-6.9	1-20	0	0-44
Environmental range	0-10	<1	10-80(1)	–	0-5(2)

(1) May range from a few to 1 000.
(2) 500 in limestone-rich areas

1.3.2 - Sulphate

Sulphate is the predominant inorganic form of sulphur, highly oxidized as SO_4 to form a major anion, and readily soluble. The sources of sulphate can differ widely from one geographic region to another. In addition to weathering and atmospheric deposition, they can include bacterial oxidation and leaching from organic deposits.

Scruton (50, 51) discusses the sources of sulphate in insular Newfoundland. Deposition from marine aerosols is estimated to supply about a quarter of the total sulphate (50). The most likely sources of the remaining sulphate are acid precipitation and sulphate releases from bogs. It is difficult to assess the relative proportions contributed by these two sources, and the situation is complicated by the fact that coloured water can affect the analysis of sulphate concentrations. Anthropogenic sources probably contribute much of the non-marine sulphate, with the remainder coming from organic deposits (51). Higher level of sulphate occur in western and southwestern parts of the island, closer to the sources of pollution, suggesting anthropogenic sources for at least some of the sulphate. The increase in sulphate concentrations with runoff suggests that flushing of organics is also contributing.

1.3.3 - Carbonate/Bicarbonate

Bicarbonate is the principal buffering ion. The relative amounts of carbonate, bicarbonate and carbonic acid in water are a function of pH. Carbonates are not present unless the pH is above 9. The dissolution of carbon dioxide is a source of carbonates and bicarbonates, in addition to weathering of rocks and soils. Since carbonate and bicarbonate bearing rocks and soils do not occur in the study area, the levels are very low.

This finding is in keeping with the generally low values of alkalinity.

1.4 - Inorganic Nutrients

Inorganic nutrients include compounds of nitrogen and phosphorus, and have typically been measured as dissolved nitrate and nitrites, dissolved and total ammonia, Kjeldahl nitrogen, dissolved phosphate and dissolved total phosphorous. The level of nutrients can also be assessed indirectly by such measures as dissolved oxygen and biological oxygen demand (BOD). If nutrients are available in abundance, aquatic biota will proliferate, consuming oxygen in the process. A superabundance of nutrients, leading to consumption of virtually all the available oxygen, results in a condition called eutrophication. This type of water quality degradation is discussed further in Section 4.4 of the main report.

The mean levels of various nutrients, dissolved oxygen are listed for the five rivers in Table B1.11. The principal source of nutrients is rock and soil leachate. Since soils in the study area are generally lacking in nutrients (large applications of fertilizer are required for any agriculture), it is not unexpected to find nutrient levels low, and dissolved oxygen levels high. These results indicate excellent water quality for water supply, recreation, and fish habitat.

TABLE B1.11

NUTRIENT AND OXYGEN LEVELS, MEAN VALUES

River	Nitrogen Dissolved NO_3,NO_2 (mg/s)	Dissolved Nitrate (mg/s)	Total Ammonia (mg/s)	Total Kjeldahl (mg/s)	Phos- phorus Total (mg/s)	Dis- solved Oxygen Total (mg/L)
Broad Cove Brook	-	0.05	0.01	0.26	0.10	1
Mobile River	-	0.03	0.01	0.26	0.05	10.5
North- east Pond	0.04		0.03	0.1	.008	7.5
North- west Brook	-	0.01	0.01	0.26	0.04	10.7
Rocky River	0.06	-	0.02	-	0.02	10.2
Seal Cove River	-	0.01	0.008	0.3	0.03	11.1
Range in Study Area	.001-2.2	0.002-1.32	0.004-0.08	0-2.1	0.001-4.3	3.9-16.6
Environ- mental Range		>5	<0.1	0.1-0.5		

1.4.1 - Nitrogen

Nitrogen is the largest constituent of the atmosphere, and nitrogen compounds are present in most organic material. The nitrogen cycle in water, briefly stated, is as follows. Bacteria and algae in water convert elemental nitrogen (N_2) to ammonia (NH_3) and ammonium ions (NH_4^+). Other bacteria then convert the ammonia to nitrite and nitrate (NO_2^- and NO_3^-). In the denitrification, nitrate is converted back to nitrite and then to elemental nitrogen.

Ammonia is a very soluble form of nitrogen. Its principal natural sources are decomposing organic matter or leaching of certain clay soils. High levels of ammonia generally indicate anthropogenic sources, such as sewage, industrial waste waters or agricultural residues.

Nitrate is the principal form of combined nitrogen found in surface water. The principal source is oxidized organic matter. Like ammonia, high levels of nitrate may indicate pollution (particularly sewage and fertilizers). It is highly soluble and stable.

Total Kjeldahl Nitrogen measures both ammonia and organic nitrogen. Organic nitrogen levels are naturally very low. Both ammonia and organic nitrogen are derived from organic wastes, and both are necessary for biological activity. The potential for eutrophication can be indicated by levels of Kjeldahl nitrogen.

1.4.2 - Phosphorus

Phosphorus is rarely found in significant quantities in surface water. Like nitrogen, it is in short supply in Newfoundland, and is actively taken up by plants. Rocky River and Northeast Pond

River show total phosphorus levels typical of uncontaminated lakes, less than 0.01 mg/L. The remaining rivers are below the level at which slime and excess growth of algae and macrophytes might be expected (0.1 mg/L)(33). Phosphorus levels are highest in Northwest Brook and Mobile River. This could be because decomposition of organic matter is releasing phosphorus, but at the same time lack of nitrogen is limiting plant growth, so there is no uptake. High phosphorus levels will only lead to excess growth of aquatic plants if the nitrogen supply is not limited.

1.4.3 - Dissolved Oxygen

Dissolved oxygen (CO) concentrations are all generally above minimum values for the protection of aquatic life. These minimum levels are temperature and saturation dependent.

1.4.4 - Organic Carbon

Most organic carbon in water is composed of plant and animal materials and humic substances. Photosynthesis is also a source of dissolved organic carbon. Organic carbon is often taken as an indicator of basin productivity and degree of urbanization. In the study area, however, organic carbon levels can be elevated due to flushing of terrestrial organics even in undeveloped areas. A value of less than 3 mg/L is assumed to indicate clean water, although the total organic carbon content in natural waters may range from 1-30 mg/L. Only two rivers have reports of organic carbon. At Rocky River, the median level is 13 mg/L, out of 10 samples. The range was from 1 to 18. Only one sample result was reported from Northeast Pond River; the total organic carbon concentration was 6.2 mg/L.

1.5 - Metals

Levels of most metals in the study area are at or below detectable limits, or present in only trace amounts, with the exception of iron and manganese. Metal concentrations reported include aluminum, arsenic, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, and zinc, although not all rivers have been sampled for all those. Aluminum, manganese and iron are the only three consistently detectable.

Certain trace metals are of concern because of their toxicity. Although present levels are low, increasing acidification leads to increased leaching of metals. Elevated levels of aluminum, manganese, zinc, cadmium, lead, copper and nickel have all been documented in European and North American studies of acidification of surface waters.

High levels of some metals can occur when turbidity is high, suggesting that the metals are bound to particulates, and may not be toxic. On this question, the Ontario Ministry of Environment recognized that metals may not be toxic in bound form, and that it is quite possible for the total concentration to exceed its objective without damaging any aquatic life. However, in the absence of any standard technique to measure the toxic components, the Ministry assumes that all the metal is in a toxic form unless specific data show otherwise (29).

1.5.1 - Aluminum

Aluminosilicate materials are abundant in most rock types and soils, especially clay. Aluminum is normally leached from the upper soil horizons by natural processes, e.g., carbonic acid and organic acid weathering. It can also enter surface waters by atmospheric deposition; it is one of the principal particulates emitted where coal is burned. High aluminum levels are associated with acid rain. Acidified lakes in the U.S., Ontario, Sweden and Finland show aluminum levels of 0.200-0.65 mg/L, compared with natural values of less than 1 mg/L.

Data on aluminum levels in waters of the study area are sparse. A 1981 study of headwater lakes in insular Newfoundland(50) reported total aluminum values ranging from 0 mg/L to 0.430 mg/L, with a mean of 0.112 mg/L. Data for three other rivers in a follow-up study of Atlantic salmon rivers in Newfoundland(51), includes the results in Table B1.12 for three rivers in or adjacent to the study area. Sampling of Rocky River by Environment Canada from 1980-1984 (total of 47 samples) showed concentrations typically ranging from 0.02 to 0.19 mg/L.

Aluminum concentrations have been found to be significantly correlated with colour, suggesting that much of the available aluminum is present as organic complexes. Additional evidence comes from finding that aluminum levels are also low in clear water lakes(50). The effect of turbidity on assessment of levels of metals was also observed in the Waterford River Study(24). The addition of acid to a turbid sample appears to release aluminum from the particles in the sample, resulting in high values. It is likely that at present much of the available aluminum reported from Newfoundland samples forms part of organic complexes, and is non-toxic (Scruton).

1.5.2 - Manganese

Manganese enters surface water through geochemical weathering; it is frequently found in association with iron. It may also run off from decaying vegetation. Levels reported in the rivers of the study area are given in Table B1.13. About 20 per cent of the samples had undetectable manganese concentrations.

TABLE B1.12

ALUMINUM

River	Weighted Number of Samples	Range (mg/L)
Biscay Bay (Back) Brook	4	0.03 - 0.055
Colinet River	4	0.029 - 0.075
Rocky River	4	0.029 - 0.075

TABLE B1.13

MANGANESE

River	Mean Manganese (Range in Parentheses) Extractable Manganese (mg/L)	Dissolved Manganese (mg/L)	Total Manganese (mg/L)
Broad Cove Brook	-	-	2.05(.01/.12)
Mobile River	-	-	0.06(.01/.237)
Northeast Pond Riv.	.04(.01/.12)	.018(.01/.07)	-
Northwest Brook	.03(.01/.16)	.013(.01/.05)	-
Rocky River	.03(.01/.16)	.013(.01/.05)	-
Seal Cove River	-	-	0.023(.005/.08)
Newfoundland Lakes(#)	-	-	0.052
Natural Range (Canada)	-	-	< 0.2

Manganese is undesirable in water supplies because concentrations above about 0.15 mg/L can cause staining (e.g., of clothes and plumbing fixtures) as well as an undesirable taste. Deposition on pipes can occur at smaller concentrations, above 0.05 mg/L. Because of these aesthetic concerns, the drinking water standard is 0.05 mg/L. Unlike aluminum and heavy metals, much higher concentrations are acceptable on health considerations alone. In fact, manganese is an essential item for growth of humans, animals and plants.

1.5.3 - <u>Iron</u>

Iron is almost always present in detectable levels in waters in the study area. It is naturally released into surface waters from weathering of native soils and rocks. Its solubility increases with increasing acidity of the water. Concentrations of iron in natural surface waters are generally less than 0.5 mg/L; 0.3 mg/L is the maximum acceptable concentration in drinking water for aesthetic reasons. Like manganese, iron can cause rust-coloured staining and unpleasant taste. In addition, it adds colour and can promote certain types of biological growths. Natural surface waters in the study area will occasionally exceed this level, as Table B1.14 shows, although they will not be harmful to health.

1.5.4 - <u>Other Metals</u>

The other metals tested for, i.e., arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc, are generally present only in trace quantities, and are frequently undetectable. (Arsenic is sometimes classed separately from metals, but is included here for convenience.) For example, at Rocky River, in about 70 per cent of the tests, concentrations of the metals tested for were outside detectable limits. Table B1.15 indicates the mean levels detected, as well as the highest values reported in the study area. Many samples had undetectable concentrations, as can be seen in Tables 4.1 to 4.6 of the main report.

TABLE B1.14

IRON

River	Mean Iron (Range in Parentheses) Extractable (mg/L)	Dissolved (mg/L)	Totals (mg/L)
Broad Cove Brook	-	-	0.24(.01/.74)
Mobile River	-	-	0.45(.08/3.1)
Northeast Pond River	.23(.05/.66)	.06(.01/.13)	-
Northwest Brook	-	-	0.16(.02/1.07)
Rocky River	.28(.05/.59)	.09(.02/.24)	-
Seal Cove River	-	-	.23(.004/1.7)
Newfoundland Lakes	-	-	0-0.400*
Environmental Range	< 0.5	< 0.5	< 0.5

*as high as 1.197 in areas with anomalously high excess sulphate values, probably containing gypsum and/or pyrite deposits.

TABLE B1.15

OTHER METALS: MEAN CONCENTRATIONS

River	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
Broad Cove Brook	-	0	.01	.02	.01	-	.01	.02
Mobile River	-	0	.01	.01	-	-	.07	.01
North-east Pond	.005	.001*	.0012*	.01*	.003*	.06*	-	.017*
North-west Brook	-	0	.01	.02	.01	-	.01	.02
Rocky River	.005	.001	.0005*	.01*	.002	.08*	-	.01
Seal Cove River	-	0	-	.01	.004	-	.13	4.42
Maximum	-	.02	.01	.14	.054	-	.13	4.42
Location of Max		Broad Cove Brook	N/A	Broad Cove Brook	North west Brook	Rocky River	Mobile River	Mobile River
Environ-mental Range	<0.10	<0.01	<0.001	<0.05	<0.04	<0.00005	0.01	<0.05

Interpretation Key

As - Arsenic
Ca - Cadmium
Dr - Chromium
Cu - Copper

Pb - Lead
Hg - Mercury
Nc - Nickel
Zn - Zinc

*Extractable

Arsenic, cadmium, mercury and lead are the four metals of most concern to health, and are discussed in Section 2 of this Appendix. High levels of these metals in surface waters usually suggest anthropogenic sources. The other metals are briefly discussed below.

Chromium

Chromium occurs in rocks and soils, often as insoluble chromium oxide. Natural chromates are rare, and few waters contain natural chromium. Some forms of chromium are essential to health, others have adverse effects. Natural surface waters tested in the study region have only trace or undetectable chromium concentrations.

Copper

Unlike many other metals, copper has a beneficial health effect, and is non-toxic. It is a common metallic element present in greater concentrations in igneous rocks than sedimentary. Its presence in water affects aesthetic qualities; in concentrations greater than 1 mg/L it can cause staining and affect taste. Levels in samples from the study area are much lower than this and are frequently below detection limits. Dissolved total copper concentrations rarely exceed 0.005 mg/L; if they are higher than about 0.020 mg/L, an anthropogenic source is likely, such as copper piping, industrial processes, and pesticides.

Nickel

Nickel levels are also typically low in the study area, although few samples have been tested. Nickel enters the surface waters primarily through weathering of rocks and minerals. This contribution is slight and natural levels would be expected to be low; the environmental range in the Atlantic region is less than 0.003 mg/L. Wherever elevated levels occur, they are probably due to anthropogenic sources, in particular the burning of coal and oil, which releases nickel to the atmosphere.

The high value of 0.13 reported in Table B1.15 for Mobile River is anomalous. Only two samples were taken from Mobile River; one had a level below the detection limit, the other was the high value of 0.13 mg/L.

Zinc

Zinc is a metal essential to health, and acceptable concentrations are set by aesthetic considerations, not health concerns. The amount of zinc entering surface waters through natural weathering of rocks and soils (sulphide ores), is low. Elevated concentrations may indicate authropogenic sources such as zinc, iron or steel production, wood combustion, waste incinerators, and effluent discharges.

Zinc levels in the study area are low usually at or below detection limits of 0.01 mg/L for total zinc. Levels above about 0.5 mg/L will start to present aesthetic concerns, such as undesirable taste. Concentrations above 25 mg/L will have adverse effects. At large concentrations zinc is both acutely and chronically toxic.

Some anomalously high values (over 4 mg/L at Mobile) have been reported. Since otherwise levels are often undetectable, the most likely explanation is that zinc ions absorbed on sediments and soils are dissolved by chemicals used in the analysis.

2 - TYPES OF DEGRADATION

This appendix provides discussion and data on three types of degradation.

- micro organism
- nutrients
- toxic chemicals.

2.1 - Micro-organisms

A number of sampling programs have been undertaken in St. John's and environs to assess bacteriological contamination. One such survey was a survey of ponds in St. John's conducted in 1984 by the Provincial Department of Environment(26). Results are shown in Table B2.1.

A series of surveys of the Waterford River conducted by the Provincial Department of the Environment from 1981-84 showed excessively high bacteriological counts in the Waterford River, occasionally as high as millions of total coliforms and hundreds of thousands of faecal coliforms per 100 mL at certain outfalls. The explanation for these serious local problems appears to be storm and sanitary sewer cross-connections.

The Waterford River Study(24) confirmed high coliform counts in the Waterford River, although none were as high as some of the previously recorded values. The ranges found in monthly coliform counts over a one-year period (May 1983 - June 1984) for three locations, two upstream and one downstream, are given in Table B2.2. The two most upstream locations were near Donovan's Industrial Park on the main stem, and at Ruby Line on South Brook (the major tributary), and the most downstream location was Kilbride.

TABLE B2.1

RESULTS OF BACTERIOLOGICAL SURVEYS, ST. JOHN'S

Pond	Results
Kenny's Pond	- All sites within swimming limits
Kent's Pond	- 4 of 5 sites within swimming limits
Long Pond	- Variable - 3 of 7 sites within swimming limits
Mundy Pond	- Levels generally high, 3 of 5 sites greatly exceeded swimming limits, 2 of 5 within limits
Quidi Vidi	- Locations sampled near inflows from Rennie's River, Virginia River, and major culvert in excess of swimming limits

TABLE B2.2

BACTERIOLOGICAL DATA, WATERFORD RIVER BASIN

Location	Total Coliforms no./100 ml	Faecal Coliforms no./100 ml	Strepto-coccus no./100 ml
Ruby Line	<20 - 300	<10 - 100	0 - 410
Donovans	220 - 160 000	180 - 22 000	80 - 3 200
Kilbride	1 600 - 120 000	800 - 26 000	

No specific patterns were identified; peak densities were generally recorded in June, July and August, with some high counts in September.

The most upstream station, Ruby Line, had uniformly low bacterial density, generally of non-human origin. The faecal counts at the Donovan's site indicate mixed human and animal pollution. Occasionally high counts of high coliforms were noted, attributable to other sources such as discharge of feed residue. The levels of total and faecal coliforms at the Kilbride Station were high and relatively stable. The bacteriological pollution was attributed mainly to human sources.

2.2 - Nutrients

Nutrient loadings were examined in a study of the water quality of the Waterford River.

The two major nutrients sampled for were nitrogen and phosphorus. The study found that the water from the main stem of the river usually had higher nitrite-nitrate concentrations and total nitrogen concentrations than the less developed South Brook tributary. The sites with the highest total nitrogen levels were generally those located near pasture lands and farms. Typical results were as follows.

Source of Sample	Total Nitrogen (mg/l)
Waterford River Main stem (developed)	0.5
South Brook Tributary (less developed)	0.2

As discussed in Section 1 of Appendix B, samples from non-urban rivers in the study area typically have total Kjeldahl nitrogen values of 0.2 mg/l, similar to South Brook.

Total phosphorus levels are also an indicator of nutrient loading. As Table B2.3 shows, phosphorus measurements indicate a similar trend, with South Brook levels lower than those in the main stem. The sources of phosphorus in the developed areas were identified as fertilizers, animal wastes, grass clippings, and the like. Very high levels were recorded on the Waterford River between Donovans and Commonwealth Avenue. No explanation was given, although discharges from the Donovan's Industrial area seem likely.

In rural areas, agricultural activity is the main source of nutrient loadings. The extent of agricultural activity in the study area, as reported by Agriculture Canada, is shown in Table B2.4 for St. John's Agricultural Development Area (ADA) and Table B2.5 for the remainder of the region. These tables give some indication of the areas where non-point pollution may occur.

TABLE B2.3

TOTAL PHOSPHORUS, WATERFORD RIVER BASIN

Station	Per cent of Samples >0.10 mg/l	Median Total Phosphorus (mg/l)	Max. Obser. Conc. (mg/l
Donovans	20%	0.048	0.47
Commonwealth Ave.	32%	0.040	1.70
Dunn's Road	22%	0.034	0.85
Ruby Line*	–	0.01	–

*Represents typical natural level

TABLE B2.4

FARM ACTIVITY

COMMERCIAL FARMS ST. JOHN'S ADA (1983)

Area	Dairy Cows	Swine	Poultry	Broilers	Vegetables (ha)
Portugal Cove	276	6 748	133 015	-	5.0 ac.
Torbay	297	28	400	200	-
Logy Bay/Middle Cove/Outer Cove	385	-	-	-	-
Goulds/Kilbride	1 353	2 373	16 300+	-	18.3 ac. 2 green-houses

In addition, there are a number of other greenhouses and non-commercial farms.

TABLE B2.5

FARMS IN STUDY AREA OUTSIDE ST. JOHN'S ADA

Area	Comment
Conception Bay South	- No large operators but several small mixed vegetable farms
Bay Bulls/Witless Bay	- Several existing farms plus recent applications for new farms or expansions
La Manche	- Fox Farm
Ferryland	- Hog Operation
St. Mary's Bay	- Sheep Operations
Colinet	- Vegetable farming

Source: Department of Agriculture

2.3 - Toxic Substances

Very little sampling has been done for toxic substances in the study area, although some metals are included in the regular monitoring program. Environment Canada and the Newfoundland Department of Environment have carried out a program of testing for toxic chemicals in water supply systems in Atlantic Canada. St. John's and Trepassey were included in the 1985 survey. Results were uniformly very low, usually below detectable limits.

2.3.1 - Substances of Concern

The Ontario Ministry of the Environment has proposed guidelines for releases of a number of substances of concern. It categorizes them in three groups.

- Hazardous substances with specified tolerances.

- Substances with zero tolerance limits, i.e. particular hazardous, no new releases permitted.

- Substances with undefined tolerance limits, i.e. of concern, but not enough information is available to establish specific objectives. Releases must be evaluated on a case-by-case basis.

The substances listed in Tables B2.6 to B2.8 indicate those that are currently of most concern. As far as is known, none of these substances is a chronic problem in the study area, but their use is widely distributed, and sporadic or intermittent exposure could be occurring with unknown effects. Pulses of toxic substances have caused fish kills in rivers in St. John's.

TABLE B2.6

CATEGORY 1: SUBSTANCES WITH ESTABLISHED TOLERANCE LIMITS

Metals	Maximum Concentration of Unfiltered Sample, ug/L	Pesticides	Maximum Concentration of Unfiltered Sample, ug/L
Arsenic	100	*Dicamba (Banvel)	200
Beryllium	11 (hardness < 75)	*Diquat	0.5
	1100 (hardness > 75)	Diuron	1.6
Cadmium	0.2	Dalapon	110
Chromium	100	Simazine	10
Copper	5	*2,4-D (BEE)	4
Iron	300	Chlordane	0.06
Lead	5 (low alkalinity)	*Chlorphyrifos (Dursban)	0.001
	25 (high alkalinity)	*Diazinon	0.080
Mercury**	0.2	Endosulphan	0.003
Nickel	25	*Fenthion (Baytex)	0.006
Selenium	100	Guthion	0.005
Silver	0.1	*Malathion	0.1
Zinc	30	Methoxychlor	0.04
Unspecified		Pyrethrum	0.01
Substances	0.05 of 96 hr LC50		

*Most commonly used in study area

**Also in Category 2-Zero Tolerance Limit

Source: Ontario Ministry of the Environment(29)

TABLE B2.7

CATEGORY 2: SUBSTANCES WITH ZERO TOLERANCE LIMITS (NO NEW RELEASES)

Mercury

Dichlorodiphenyltrichloroethane (DDT) and metabolites

Polychlorinated Biphenyl (PCB)

Polybrominated Biphenyl (PBB)

Dechlorane - C_{10} Cl_1 (Mirex)

Source: Ontario Ministry of the Environment(29)

TABLE B2.8

CATEGORY 3: SUBSTANCES WITH UNDEFINED TOLERANCE LIMITS

There is insufficient information to set guidelines; releases must be assessed on a case by case basis.

Metals

- Aluminum
- Antimony
- Barium
- Boron
- Cesium
- Cobalt
- Manganese
- Molybdenum
- Strontium
- Thallium
- Tin
- Vanadium

Organics

- Acrylonitrile
- Alkyl Amines
  - diethylamine
  - dimethylamine
- Aryl Amines
  - Benzidine
  - -Naphthylamine
- Aryl Chlorides
  - Dichlorobenzene
  - Hexachlorobenzene
  - Trichlorobenzene
  - Tetrachlorobenzene
- Aryl Solfonic Acids
  - Dodecylbenzene
- Azo and Diazo Compounds
- Benzene and Aliphatic Derivatives
  - Toluene
  - Xylene
  - Diethylbenzene
  - Dimethylbenzene
- Carbon Tetrachloride
- Chlorinated Ethylenes
  - Trichloroethylene
  - Tetrachloroethylene
- Chlorophenols
  - Pentachlorophenol
- Furfural
- Haloforms
  - Chloroform
  - Chloro-Bromomethanes
- Mercaptans
  - Methylmercaptan

Pesticides

- Bayer'73
- Benomyl (Benilate)
- Dichlorobenil
- Disulfoton (Disyston)
- Kelthane (Dicofol)
- Methyl Parathion (Metaphos)
- Naled (Dibrom)
- Rotenone
- PMA (turf fungicide)
- TFM (lampracide)

Organics (continued)

- Nitrosamines
  - Dimethyinitrosamine
- Nitro Aromatice
- Phenols and Derivatives
  - Cresols
- Polycyclic Aromatic Hydrocarbons
  - Napthalene
  - Benzo(a)Pyrene
- Quinoline
- Styrene
- Sulphonates
  - dimethylsulphonate
  - diethylsulphonate

Environment Canada has also identified toxic chemicals of concern in the Atlantic Region(14). These substances are briefly discussed below, with reference to implications in the study area.

2.3.2 - Metals

The four metals identified by Environment Canada as being of most concern are mercury, cadmium, lead, and arsenic.

Mercury

Mercury compounds are highly toxic, some forms being more toxic than others. Methyl mercury is among the most toxic forms; intake can lead to brain damage. Generally, mercury accumulates in bottom sediments, but even if it settles out in an innocuous form, it can be converted to methyl mercury when associated with organic material. Low pH water increases the hazard, because it is associated with increased solubility, increased rate of methylation and increased rate of uptake.

Mercury levels are almost always very low in natural freshwaters, and elevated levels always suggest anthropogenic sources. There are no reports of mercury in the freshwaters of the study area, and there are no industrial point sources. However, mercury is widely used, and possible local sources include

- atmospheric transport (coal from combustion)
- sewage
- miscellaneous, e.g., paint application, fluorescent tubes, slimicides, fungicides.

Elevated levels of mercury have been reported in bottom sediments in St. John's harbour(14), probably from sewage. Industrial activity around the harbour may also contribute. Mercury was not a sampled parameter in the Waterford River Study, so there is no indication whether it is being carried into the harbour from rivers.

Cadmium

Cadmium can be highly toxic. It is used in electroplating, manufacture of batteries and other products, and some fertilizers. Atmospheric releases from thermal power plants and smelters are also a source. Elevated levels have been reported in St. John's harbour, probably as a result of sewage outflow, and possibly harbour activity.

Lead

Lead is a toxic metal whose toxicity decreases with increasing alkalinity. Since natural waters in the study area have very low alkalinities, any lead present would have high toxicity. Lead is a commonly used substance because of its pliability and corrosion resistance properties. The most likely sources of lead in the study area are

- atmospheric deposition from automobile exhausts, thermal power plants,

- sewer outfalls or surface runoff containing lead from gasoline additives, pipes, bearings, various alloys, batteries, paints, ceramics, and miscellaneous uses.

Lead levels reported from the six regularly sampled rivers are low, as are levels in the St. John's water supply system. No information is available on lead levels in rivers draining urban areas, which would be the most likely to be affected.

Arsenic

Arsenic contamination is not likely to be a major concern in the study area since the major anthropogenic sources are ore smelting and processing. Atmospheric deposition of products of fossil fuel combustion is a possible source, as well as arsenical pesticides.

2.3.3 - Organic Chemicals: Industrial, Commercial, and Domestic Use

There are no identified industrial processors in the study area using organic chemicals as a raw material. The use of such chemicals as products and additives for industrial, commercial and domestic purposes is ubiquitous, however.

The major chemicals of concern and their possible sources in the study area are briefly discussed below.

PCB's

Polychlorinated biphenyls (PCB's) are highly stable and resistant to degradation by either heat or biological action. They have been assigned a zero tolerance limit by the Ontario Ministry of the Environment. Their excellent insulating and thermal properties led to widespread use, most notably in transformers and other electrical equipment, but also in such applications as

- heat transfer fluids
- hydraulic fluids
- paints, adhesives, inks
- cutting oils, lubricants
- flame retardants
- waterproofing materials.

They are now banned from all new uses. Any remaining quantities are likely to be very small and dispersed.

Dioxins

Chlorinated dibendioxins (dioxins) are not likely to present a problem in surface waters in the region. The main sources were the herbicides 2,4-D and 2,4,5-D, which are no longer used. The wood preservative pentachlorophenol (PCP) may leach into streams adjacent to utility poles and structures with treated wood foundations.

PAH's

Polycyclic aromatic hydrocarbons (PAH's) are a large group of compounds, which are of concern because they include known carcinogens. The main source in the study area is probably atmospheric transport and deposition of products of combustion, entering the watercourses directly or through surface runoff. Non-local sources include thermal power plants (especially coal-burning), coke ovens and vehicle exhausts. Local atmospheric sources include vehicle exhausts, gases from wood burning applications, and incinerators. Sewage, runoff from oil spills, and leaching from creosoted timber piles and foundations may also contribute PAH's to surface water. There is no evidence of problems locally, but low level effects episodic events are possible.

2.3.4 - Pesticides

Pesticides are defined in the Pesticide Control Act to include substances used to control animals, insects, or weeds. Insecticides and herbicides are thus included in the following discussion.

The chief pesticides used in the study region are listed in Table B2.9 based on a inventory carried out by Environment Canada's Environmental Protection Service (EPS) in 1982(60), and information from Agriculture Canada. Additional data are expected to become available in 1987. The EPS study reports that insecticides used for crops such as potatoes, turnips, cabbage and carrots represent the highest percentage of total pesticide sales. Herbicides are the next most commonly sold group; these are also the ones used for brush control. Crop fungicides and insecticides used on livestock do not contribute significantly to the overall sales of pesticides.

The EPS study identified 4 locally used pesticides of concern Table B2.10, and recommended soil and water sampling. The report also noted that overapplication may be occurring, since quantities purchased exceeded the use expected from recommended rates of application.

In general, the use of pesticides is relatively low in the study area. The concentration of population in the study area leads to a dense network of rights-of-way for highways and utility lines; herbicides are used for brush control in these areas. There is no commercial forest harvesting, so no forestry herbicides are used. Commercial agricultural activity is also low; many home gardeners may use pesticides in small applications. The most likely source of entry of pesticides into the water systems in the study area is improper washing and handling.

TABLE B2.9

AGRICULTURAL PESTICIDES USED ON VARIOUS CROPS

Purpose	Products Used	
1. Protection of root crops (potatoes, carrots, turnips)	Furadan) Dasanit) Birlane)	Insecticides
2. Protection of leafy crops (cabbage, cauliflowers, greens)	Atox Dust) Sevin)	Insecticides
3. Weed Control	Gramoxone) Reglove) Premerge) Round-up)	Herbicides

TABLE B2.10

AGRICULTURAL PESTICIDES OF CONCERN

Type	
Furadan (Carbofuran)	- largest use - persistent in soils with low pH,organic content (typical) - toxic to birds, fish, mammals
Dasanit (Fensulfothion)	- commonly used - quite persistent - highly toxic to mammals - toxic to birds and fish
Sevin (Carbaryl)	- usually not persistent but may persist in aquatic environment - may affect aquatic invertebrates
Granoxone (Paraquat)	- quite persistent - may affect aquatic vegetation and invertebrates

APPENDIX C

POPULATION PROJECTIONS

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APPENDIX C - POPULATION PROJECTIONS

1 - Population Projections

Population projections were prepared for the communities in the study area in 3 groups.

(1) Communities served (or likely to be served) by the St. John's regional water supply system. All these communities, with the exception of Holyrood, are located within the St. John's Census Metropolitan Area (CMA).

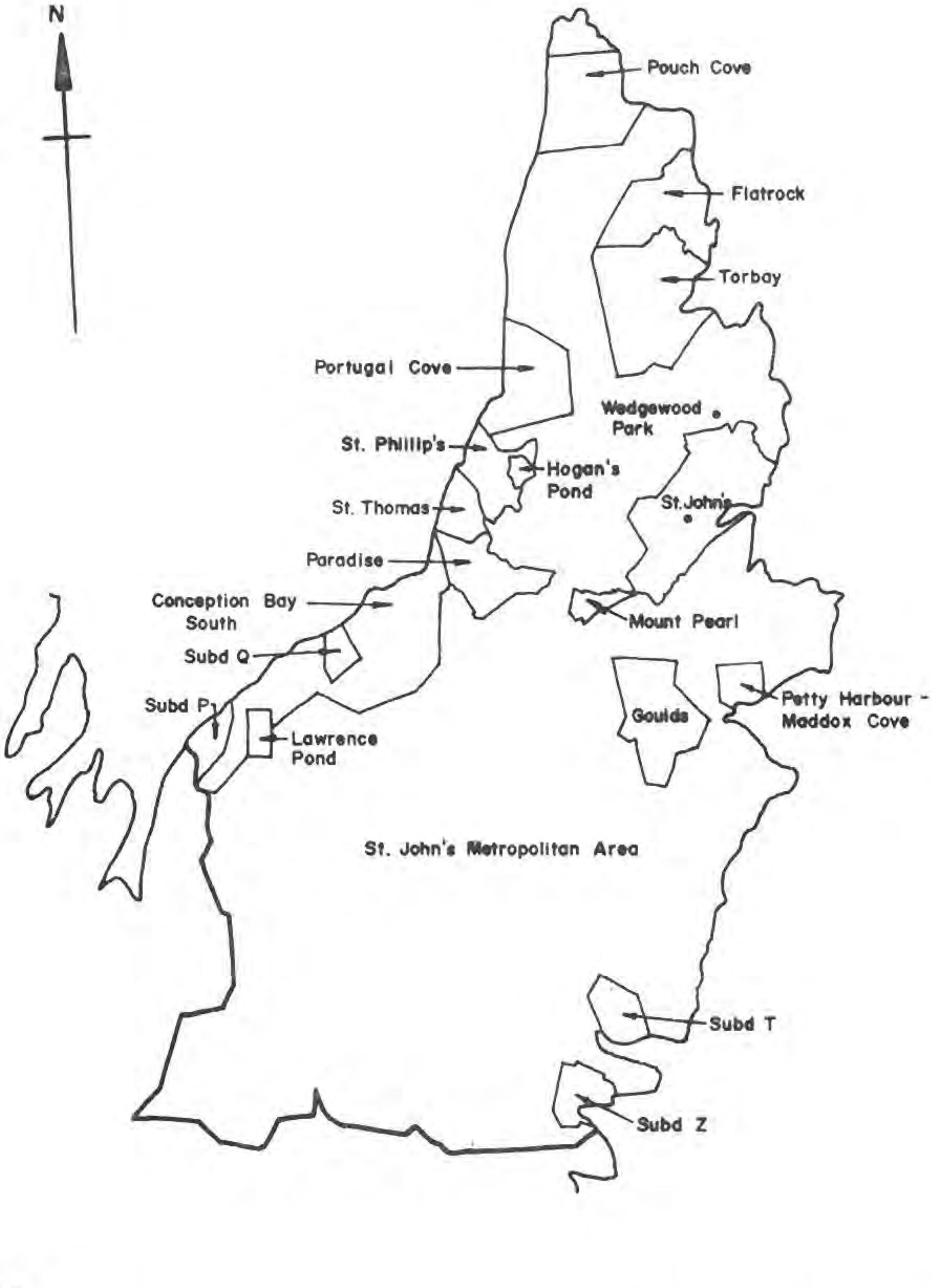
(2) Other communities in the CMA.

(3) Communities outside the CMA.

The boundaries of the St. John's CMA are shown in Figure C1. Most of the population in the study area lives in the St. John's CMA, and recent population projections are available for the CMA from the Community Resource Services (CRS) study of the demographic implications of Hibernia(9). The St. John's CMA population projections for the present study are based on the CRS methodology, and discussions with its authors.

Two scenarios are presented, the first a base case, and the second extremely high. The rate uses the average intercensal growth rate for the last 10 years of 5.5 per cent.

The extremely high projection uses an intercensal period growth rate of 12.4 per cent, the highest rate ever recorded (1966-1971).



Department of Environment
Water Resources Division

Regional Water Resources Study
Eastern Avalon Peninsula
St. John's CMA

FIG. C.1

ACRES

About 85 per cent of St. John's CMA is assumed to be served by the regional water supply system. This was taken from 1976 and 1981 data on populations in the urban core and urban fringe areas. The 1986 figures are not yet available for this breakdown.

Communities Served by Regional System

Most of the population in the St. John's CMA is served by the regional water supply system. The estimate of population to be served was thus made as a proportion of the total projected CMA population. It was assumed that all the population in the areas will be served by the regional water supply system.

Presently, about 84 per cent of the St. John's CMA is served by the regional water supply system (135 000 of a total CMA population of 160 714). If the populations of the adjacent communities which might eventually be served by the regional water supply system are added, the proportion rises to about 88 per cent. These figures suggest that it would be reasonably conservative to expect about 95 per cent of the St. John's CMA to be served by the regional water supply system.

Using this proportion, Table C.1 provides population and demand estimates for the regional water supply system. A demand rate of 780 l/c/d is used, assuming that 135,000 people consume just over 38 Mm^3/a. Demand seems unlikely to drop, and no major technological changes are foreseen.

Since present reliable yield is estimated to be over 160 000 m^3/d, the existing system should have adequate capacity to serve for the next 25 years. If growth rates are extremely high, however, the system will have reached its limit by the year 2006.

TABLE C.1

POPULATION AND DEMAND FORECAST, BASE CASE

Year	Population St. John's CMA	Estimated Population Served by Regional System*	Estimated Demand (m^3/d)
1986	161 901	135 000	105 600
1991	170 805	162 300	126 600
1996	180 200	171 200	133 500
2001	190 111	180 600	140 900
2006	200 574	190 500	148 600
2011	211 598	201 000	156 800

*assuming 95 per cent of CMA served after 1991

POPULATION AND DEMAND FORECAST, EXTREMELY HIGH CASE

Year	Population St. John's CMA	Estimated Population to be Served by Regional System*	Estimated Demand (m^3/d)
1986	161 901	135 000	105 600
1991	181 977	172 900	134 800
1996	204 542	194 300	151 600
2001	229 905	128 400	170 400
2006	258 413	245 500	191 500
2011	290 456	275 900	215 200

*assuming 95 per cent of CMA served after 1991

Communities in the CMA,
Outside the Regional Water Supply System

For communities outside the regional water supply system, the intercensal period growth rates vary widely for the different communities. Although projections could have been attempted for individual communities using these data, it seemed more consistent to examine all the rates, and select uniform, reasonably optimistic rates for communities within the CMA.

Growth rates were therefore taken to be 17 per cent per intercensal period for communities near the urban centre 4 per cent for the more remote communities (Bay Bulls, Witless Bay, Bauline and Pouch Cove).

Communities Outside the CMA

Little growth has occurred in the last decade in the communities outside the St. John's CMA, with the exception of Holyrood. Since no new developments are anticipated in these areas, a realistic projection is declining growth rates. To be reasonably optimistic, however, a base population was assumed.

Holyrood was kept separate. It is outside the CMA, but shows consistent growth, so the same growth rate of 17 per cent was used as for communities near St. John's.

Table C.2 shows populations for communities in the region from 1971 to 1986, and Table C.3 shows the projections used for this study.

TABLE C2

POPULATION

Communities Outside Regional System (within Census Metro Area)	Pop 1971	Pop 1976	Pop 1981	Pop 1986
Bauline	297	163	423	423
Bay Bulls	1011	1104	1150	1114
Flatrock	680	743	808	884
Hogan's Pond	191	110	129	139
Holyrood	1282	1610	1789	2118
Indian Pond near Holyrood	87	99	129	129
Outer Cv/Middle Cv/Logy By	588	429	1163	1300
Petty Harbour/ Maddox Cove	940	930	853	974
Portugal Cove	1411	1527	2361	2497
Pouch Cove	1483	1543	1522	1576
St. Phillip's	573	807	1365	1604
St. Thomas	155	461	448	648
Torbay	2090	2908	3394	3730
Witless Bay	771	895	1058	1022

Communities Outside CMA	Pop 1971	Pop 1976	Pop 1981	Pop 1986
Admiral's Beach	402	370	362	361
Admiral's Cove	121	109	99	99
Aquaforte	186	172	200	201
Biscay Bay	87	88	92	99
Brigus South	78	74	112	112
Burnt Cove	147	134	173	173
Calvert	470	436	482	482
Cape Broyle	677	711	698	698
Fermeuse	503	531	584	546
Ferryland	716	780	795	762
Forest Field/New Bridge	95	109	98	98
Gaskiers/Point Lahaye	300	633	505	517
Mall Bay	78	75	71	71
Mobile	95	150	171	171
Mt. Carmel/St. Catherine's	674	675	699	651
O'Donnel's	268	275	297	297
Port Kirwin	159	140	164	142
Portugal Cove South	371	354	371	375
Renews/Cappahayden	497	528	578	587
Riverhead, S.M.B.	445	426	431	407
St. Joseph's, S.M.B.	305	294	262	213
St. Mary's	445	485	701	712
St. Shott's	226	221	239	260
St. Vincent's/St. Stephen's	838	850	796	727
Tors Cove	325	364	332	332
Trepassey	1443	1427	1473	1460

TABLE C3

POPULATION PROJECTIONS

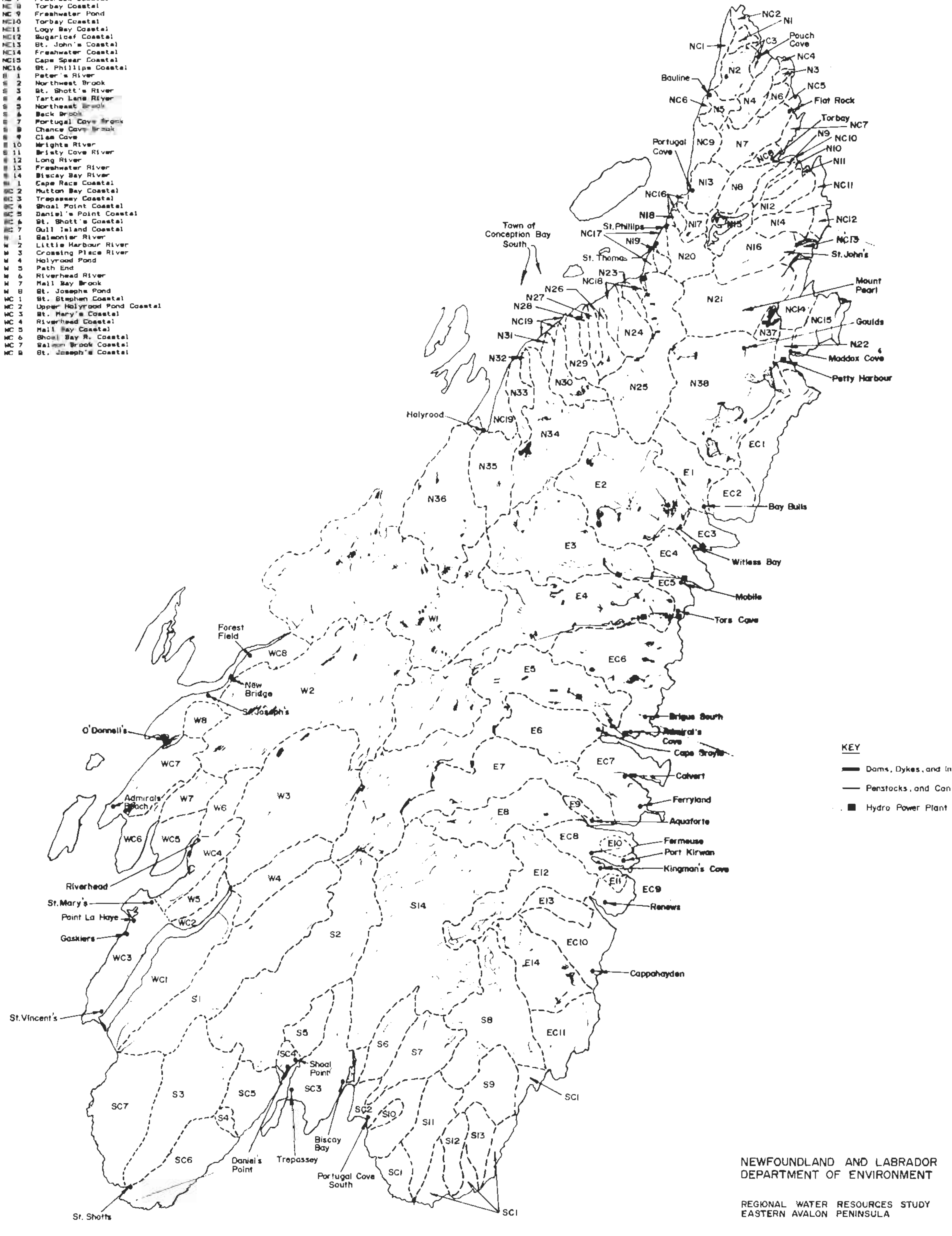
Census Metro Area	Pop'n 1986	Pop'n 2011
St. John's	135,000	201,000

Communities Outside Regional System (within Census Metro Area)		
Bauline	423	535
Bay Bulls	1,114	1,705
Flatrock	884	1,927
Hogan's Pond	139	305
Holyrood	2,118	4,613
Indian Pond near Holyrood	129	288
Logy By/Middle Cv/Outer Cv	1,300	2,984
Petty Harbour/Maddox Cove	974	2,136
Portugal Cove	2,497	6,054
Pouch Cove	1,576	1,925
St. Phillip's	1,604	3,499
St. Thomas	648	1,414
Torbay	3,730	8,705
Witless Bay	1,022	1,565

Communities Outside CMA		
Admiral's Beach	361	361
Admiral's Cove	99	111
Aquaforte	201	201
Biscay Bay	99	99
Brigus South	112	126
Burnt Cove	173	195
Calvert	482	543
Cape Broyle	698	786
Fermeuse	546	546
Ferryland	762	836
Forest Field/New Bridge	98	110
Gaskiers/Point LaHaye	517	517
Mall Bay	71	80
Mobile	171	193

KEY

REF. NO.	Drainage Basin	REF. NO.	Drainage Basin
E 1	Bay Bulls River	N 35	Mahers River
E 2	Pierre's Brook (Gull Pond)	N 36	Daniels / North Arm River
E 3	Mobile (Mobile First Pond)	N 37	Petty Harbour
E 4	Tors Cove	N 37	Petty Harbour Long Pond
E 5	Horse Chops	NC 1	Cape St. Francis West
E 6	Cape Broyle River	NC 2	Cape St. Francis East
E 7	Spout River	NC 3	Pouch Cove Coastal
E 8	Aquaforte River	NC 4	Blackhead N Coastal
E 9	Little River	NC 5	Red Head
E 10	Chance Pond River	NC 6	Cove Pond Brook
E 11	Bear Cove Pond	NC 6	Bauline Coastal
E 12	Renews River	NC 7	Flatrock Coastal
E 13	Old Woman's Brook	NC 8	Torbay Coastal
E 14	Cappahayden	NC 9	Freshwater Pond
EC 1	Motion Head Coastal	NC10	Torbay Coastal
EC 2	Bull Head Coastal	NC11	Logy Bay Coastal
EC 3	Witless Bay Coastal	NC12	Sugarloaf Coastal
EC 4	Witless Bay Brook Coastal	NC13	St. John's Coastal
EC 5	Tors Cove Coastal	NC14	Freshwater Coastal
EC 6	La Manche Coastal	NC15	Cape Spear Coastal
EC 7	Ferryland Coastal	NC16	St. Phillips Coastal
EC 8	Fermeuse Coastal	S 1	Peter's River
EC 9	Renews Coastal	S 2	Northwest Brook
EC10	Cappayhayden Coastal	S 3	St. Shott's River
EC11	Chance Cove Coastal	S 4	Tarten Lane River
N 1	Northeast Pond	S 5	Northeast Brook
N 2	Pouch Cove Brook	S 6	Back Brook
N 3	Brook at Beall Point	S 7	Portugal Cove Brook
N 4	Shoe Cove Brook	S 8	Chance Cove Brook
N 5	Bauline Brook	S 9	Clam Cove
N 6	Half Moon Pond	S 10	Wrights River
N 7	Piccos Brook	S 11	Bristy Cove River
N 8	Island Pond Brook	S 12	Long River
N 9	North Pond Brook	S 13	Freshwater River
N 10	Jones Pond Brook	S 14	Biscay Bay River
N 11	Kennedys / Soldiers Brook	SC 1	Cape Race Coastal
N 12	Outer Cove Brook	SC 2	Mutton Bay Coastal
N 13	Main Northeast Pond River	SC 3	Trepassey Coastal
N 14	Virginia River	SC 4	Shoal Point Coastal
N 15	Windsor Lake	SC 5	Daniel's Point Coastal
N 16	Rennie's River	SC 6	St. Shott's Coastal
N 17	Beachy Cove Brook	SC 7	Gull Island Coastal
N 18	Goat Cove Brook	W 1	Salmonier River
N 19	Norse Cove Brook	W 2	Little Harbour River
N 20	Broad Cove River	W 3	Crossing Place River
N 21	Waterford River	W 4	Holyrood Pond
N 22	Petty Harbour Coastal	W 5	Path End
N 23	Fowlers Brook	W 6	Riverhead River
N 24	Manuels River	W 7	Mall Bay Brook
N 25	Topsail River	W 8	St. Josephs Pond
N 26	Conway Brook	WC 1	St. Stephen Coastal
N 27	Steadywater Brook	WC 2	Upper Holyrood Pond Coastal
N 28	Foxtrap River	WC 3	St. Mary's Coastal
N 29	Kelligrews River	WC 4	Riverhead Coastal
N 30	Lower Gullies River	WC 5	Mall Bay Coastal
N 31	Upper Gullies River	WC 6	Shoal Bay R. Coastal
N 32	Billy Brook	WC 7	Salmon Brook Coastal
N 33	Quarry Brook	WC 8	St. Joseph's Coastal
N 34	Seal Cove River		



NEWFOUNDLAND AND LABRADOR
DEPARTMENT OF ENVIRONMENT

REGIONAL WATER RESOURCES STUDY
EASTERN AVALON PENINSULA

PLATE I
MAP OF DRAINAGE BASINS IN STUDY AREA

SCALE = 1 250,000