REGIONAL WATER RESOURCES SOUTHWESTERN NOVA SCOTIA

by Robert J. Porter

Nova Scotia
Department of the Environment

A joint project with
Canada Department of
Regional Economic Expansion and
Nova Scotia Department of Development

Halifax 1982

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EXECUTIVE SUMMARY

Objectives

The purpose of the Southwestern Nova Scotia Water Resources Evaluation Project was to locate sources of water supply to satisfy the demands of municipalities and industry, primarily fish plants. These sources were identified and examined for both quantity and quality.

The study area consisted of Shelburne County, Yarmouth County, and Municipality of Clare in Digby County.

Funding Agencies and Implementation

The project had a two phased approach, Phase I from April, 1979 to September, 1980 and Phase II from September, 1980 to March, 1982.

It was jointly funded under a Federal-Provincial agreement between the Nova Scotia Department of Development and the Canada Department of Regional Economic Expansion. It was implemented by the Nova Scotia Department of the Environment under the guidance of a Federal-Provincial Project Monitoring Committee.

Scope

The study included the collection, investigation and interpretation of new and existing data on water resources. Aspects of concern were meteorology, surficial and bedrock geology, surface and groundwater, and the supply and consumption of these resources.

Results:

Surface Water

Bathymetric, streamflow and lake volume analyses indicated that sufficient quantities of surface water with some treatment are available to satisfy present and expected future municipal and industrial demands in the area. Of the 17 studied lakes, 12 had volumes less than 10×10^6 m^3. Residence times ranged from 2 weeks to 16 months with a mean of 3.5 months, mean pH was 5.2, and colour had a mean value of 50 TCU. Surface water runoff, according to records of the three hydrometric stations, is indicated to have flows corresponding to an average range from 580 to 1300 mm of water on the drainage area with an average mean of 1000 mm of water on the drainage area for the entire study area. Readily available sources of water supply are some of the rivers which discharge near more populated areas, for example, Roseway, Clyde, Barrington, Tusket, Salmon and Meteghan.

Qualitative analyses revealed that surface water sources are generally characterized by high colour due to organic content, and low pH. Two exceptions are Clearwater Lake in the Meteghan area and Lake George, the Town of Yarmouth water supply.

Groundwater

Groundwater is found mainly in slate and granitic-type rocks and therefore quantity is dependent on fracture flow. Yields can typically be expected to be less than 20 L/min (4.5 igpm), sufficient for normal household use. High yields, up to 590 L/min (130 igpm), may be found in areas where more numerous and possibly larger fracture systems exist, such as those in the zones along faults, or formation contacts between different bedrock types. Also, these high yields may be obtained from sand and gravel deposits. In most cases groundwater does not require treatment.

Groundwater Exploration

A total of 22 test holes were drilled and 8 pump tests were conducted during the two phases of this project. Several test pits were dug to investigate the groundwater potential of surficial deposits. This exploration was done to verify the potential of water supply sources delineated during preliminary studies.

(A) Bedrock

Two areas; one near Great Pubnico Lake, and the other at Popes Road, near both Upper Woods Harbour and Lower East Pubnico were chosen for investigation because of their close proximity to a contact between two different types of bedrock. This situation would allow greater storage in the fractures and greater premeability. Results from these investigations are as follows:

(1) Great Pubnico Lake
Three holes were drilled to depths from 50 to 80 metres (160 to 260 ft.) with pump test yields ranging from 36 to 410 L/min (8 to 90 igpm).
(2) Popes Road
Four holes were drilled to depths ranging from 50 to 75 metres (160 to 240 ft.) with pump test yields ranging from 320 to 385 L/min (70 to 85 igpm). This area is now being used as a source of supply for fish plants in Lower East Pubnico.

(B) Surficial Deposits

An area near Saulnierville, between routes #542 and #544, was investigated by both test drilling and digging. This area of sand and gravel was found to have a thickness of approximately 5 metres (18 ft.) with pump test yields of 590 L/min (130 igpm).

The water quality in all three areas was good.

Data Base Inventory

In conjunction with the preparation and publishing of this Water Resources Evaluation Project, the existing Data Base Inventory System has been expanded. This subject file and map index incorporates all the reference material in the report and information considered useful for any subsequent investigations. Included subjects are 1) well log data, 2) bedrock geological information, 3) surficial geological information, 4) aquifers analyses, 5) water quality data, 6) hydrological information, 7) meteorological information and 8) drainage basin analyses.

This information will aid industrial developers in decision making with respect to water resources. It will assist in reaching decisions regarding municipal and domestic water supply and waste disposal services. Most importantly, it will catalogue water resource areas requiring protection.

Recommendations:

(1) Cape Sable Island

The serious shortages presently encountered on a regular basis by individuals and the several fish plants on Cape Sable Island, can be overcome.

A site-specific program should be undertaken (1) to investigate groundwater potential on the island, (2) to investigate the potential of groundwater on the mainland and the prospect of piping it to the island, and (3) to investigate the prospects of piping surface water from the mainland to the island.

(2) Surface Water Monitoring

At least one streamflow metering site should be established in the area between the Roseway and Tusket Rivers, possibly on the Barrington River or at the outlet of French Lake. This would provide coverage in this large area which presently has no records of surface water runoff.

(3) Conservation

In areas of poor supply, such as Cape Sable Island and Woods Harbour, water use and rates of consumption and supply should be closely monitored. When necessary, conservation measures should be taken, or supplies augmented from alternate sources (i.e. the use of seawater for clean-up operations).

(4) Program Continuation

It is recommended that this type of program be continued to obtain baseline data coverage of provincial government priority areas. Further, it is suggested that these areas be approached on the basis of total water resource studies using major river basin delineations as boundaries, and study for longer durations.

The fundamental nature of this investigation and inventory service by means of its mapping and development of data storage and retrieval system, render it an important planning tool.

CHAPTER 1
INTRODUCTION

1.1 Purpose and Scope

Shortage of water has frequently occurred in towns, villages and rural areas in Southwestern Nova Scotia. Expansion and operation of fish processing plants has been hampered. Any future growth in this and other vital industries may be hampered unless adequate water supplies are available to support these economic and social development priorities of the region.

In April 1979 the Nova Scotia Department of the Environment initiated this project in Southwestern Nova Scotia, including Shelburne and Yarmouth Counties and the Municipality of Clare in Digby County (see Figure 1-1). The project was jointly funded by the Canada Department of Regional Economic Expansion and the Nova Scotia Department of Development.

This is one of twelve studies done in the province over the past 16 years, which in total cover approximately 50% of the province.

In this study, hydrometeorological, geological, soil, and water quality sampling data were collected and analyzed to obtain estimates of the potential supplies of surface and groundwater.

This report deals with the findings of the work carried out during phase I and phase II of this project to its completion March 31, 1982. Attention was focused on the following:

1) bedrock and surficial geology,
2) climatic data,
3) hydrology, including streamflow and aquifer analyses,
4) chemical quality of surface and groundwater,
5) activities which may adversely affect surface and groundwater quality.

1.2 Previous Work

Previous work in Southwestern Nova Scotia covers a broad range of aspects with which this project is concerned. The geology is covered primarily by F. C. Taylor (1967) and D. R. Goldthwaite (1924). Soils Surveys were done by J. D. Hilchey in Yarmouth County (1960) Shelburne County (1961) and Digby County (1962). A. Orlic and Associates Ltd. conducted a study on the water requirements of fish plants (1980) and natural resources the Municipalities of Yarmouth and Clare were both written by R. Belliveau (1968). These sources along with several others were examined into during the writing of this report.

1.3 Location of Study Area

The study area is located at the southwestern end of the province. It covers parts of Shelburne, Yarmouth and Digby Counties, as shown in Figure 1-1. Links with Halifax are Trans-Canada Highway No. 101 through the Annapolis Valley and No. 103 along the South Shore. The Towns of Yarmouth and Shelburne are the major centers of population with 7475 and 2303 persons respectively, according to 1981 census results.

1.4 Physiography and Drainage

The Southwestern Nova Scotia

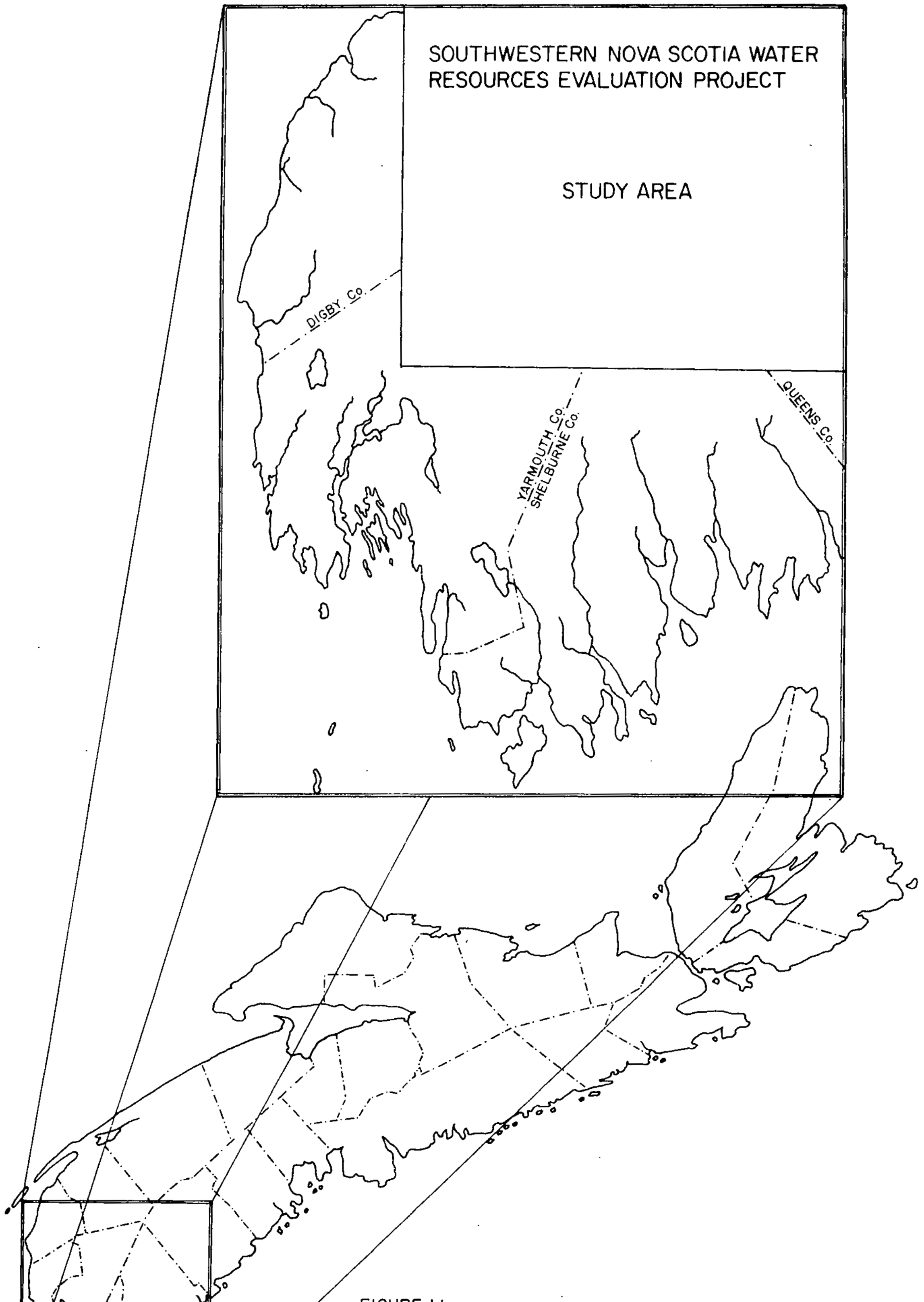


FIGURE I-1

SOUTHWESTERN NOVA SCOTIA WATER RESOURCES EVALUATION PROJECT region is recognized as being part of the physiographic region known as the Atlantic Upland (Goldthwaite, 1924). It is characterized by gently rolling to moderately undulating relief of 183m (600 ft.), rising gradually from the coast inland. The area has been influenced by glacier movement with a variety of glacial deposits evident. Drainage patterns are southward trending with approximately 10 major waterways draining the region. There are many lakes and boggy areas which also influence the drainage systems.

1.5 Climate

The general climate of the Southwestern region is known as humid and temperate. Prevailing winds are usually westerly and bring the area under the influence of continental air masses. Temperature extremes are modified by the surrounding waters.

1.6 Population, Land Use and Industries

The population of Southwestern Nova Scotia is approximately 53,300 and is concentrated along the coast. The historical and present day dependence on the sea for a livelihood is reflected in this pattern. Seventy percent of the fish processing plants in Nova Scotia are located in Digby, Yarmouth and Shelburne Counties. The number of fishermen from these three counties accounts for 30% of Nova Scotia's total. Associated with the fishing industry are boatbuilding, marine repair and marine supply industries. Combining all employment opportunities, the ocean's predominance becomes evident.

The two major land uses include farming and forestry. The farming sector is composed of mink, hog and dairy farms. The mink and hog farms tend to be of a highly technical nature and do not rely heavily on the land. The dairy farms are large enough to supply the local markets. The forestry sector largely supplies the Bowater-Mersey Mill in Liverpool with pulpwood. The remaining wood is cut for lumber and local fabrication of lobster traps, fish boxes, and other equipment.

1.7 Field Work and Maps

The Southwestern Nova Scotia Water Resources Evaluation Project was divided into two phases.

Phase I, coordinated by J. Mawdsley, operated from April, 1979 to September, 1980. During this phase water resource information (available from well logs on file with the Nova Scotia Department of the Environment) was plotted on 1 inch to 1,320 foot base maps. Surficial mapping and resistivity mapping were conducted on sand and gravel deposits to determine their extent and permeability. A lake sampling program, carried out on a number of lakes, included secchi disc measurements, bathymetric measurements and chemical quality sampling. Eight rivers in the study area were sampled for chemical quality and metered for flows. Twenty-four drilled wells were sampled to determine groundwater quality. A test drilling program was conducted during the fall and winter of 1979 and 1980, with test holes drilled at Saulnierville, Great Pubnico Lake, and Salmon Lake.

Phase II operated from September, 1980 until March, 1982 coordinated by R. Porter. Field work in this phase was restricted due to reduced funding. It consisted of seismic surveys of several locations to determine the thickness of sand and gravel deposits. Also, a sampling program of 16 lakes and 8 rivers was conducted. Test pits were dug to explore the potential of areas with higher permeabilities, and during the winter of 1981 and 1982 test drilling and pump tests were done near Barrington Passage and at Popes Road near Upper Woods Harbour, both in Shelburne County.

All mappable information has been plotted on 1:15,840 (1 inch to 1,320 ft.) map sheets which are kept on file with the Nova Scotia Department of the Environment (Figure 1-2). A regional map (back pocket) has been prepared at a scale of 1:125,000 which depicts topographic features, trans- portation, and drainage areas.

1.8 Acknowledgements

The study was completed by the Water Resources Planning Section, Water Planning and Management Division, Nova Scotia Department of the Environment. The project team expresses appreciation to John Jones for his continued support and to the members of the Phase II Project Monitoring Committee:
Carol Conrad - Nova Scotia Department of Development;
George Dargie - Department of Regional Economic Expansion;
Don Ambler - Inland Waters Directorate, Environment Canada;
Chang Lin - Nova Scotia Department of the Environment
for their support and direction.

The Phase II Project team, responsible for the completion of this study from the Preliminary Study (1980), included: Wilfrid Byers - Hydrometerorlogical Information;
Elaine Limpert - Drafting, with assistance from John Cameron;
Rob Porter - Project Coordinator. Summer assistance in 1981 was given by Jill Mawdsley and Robert McIntosh.

The work accomplished by all members of the Phase I team (Preliminary Study) is greatly appreciated.

SOUTHWESTERN NOVA SCOTIA
WATER RESOURCE EVALUATION PROJECT

MAP INDEX

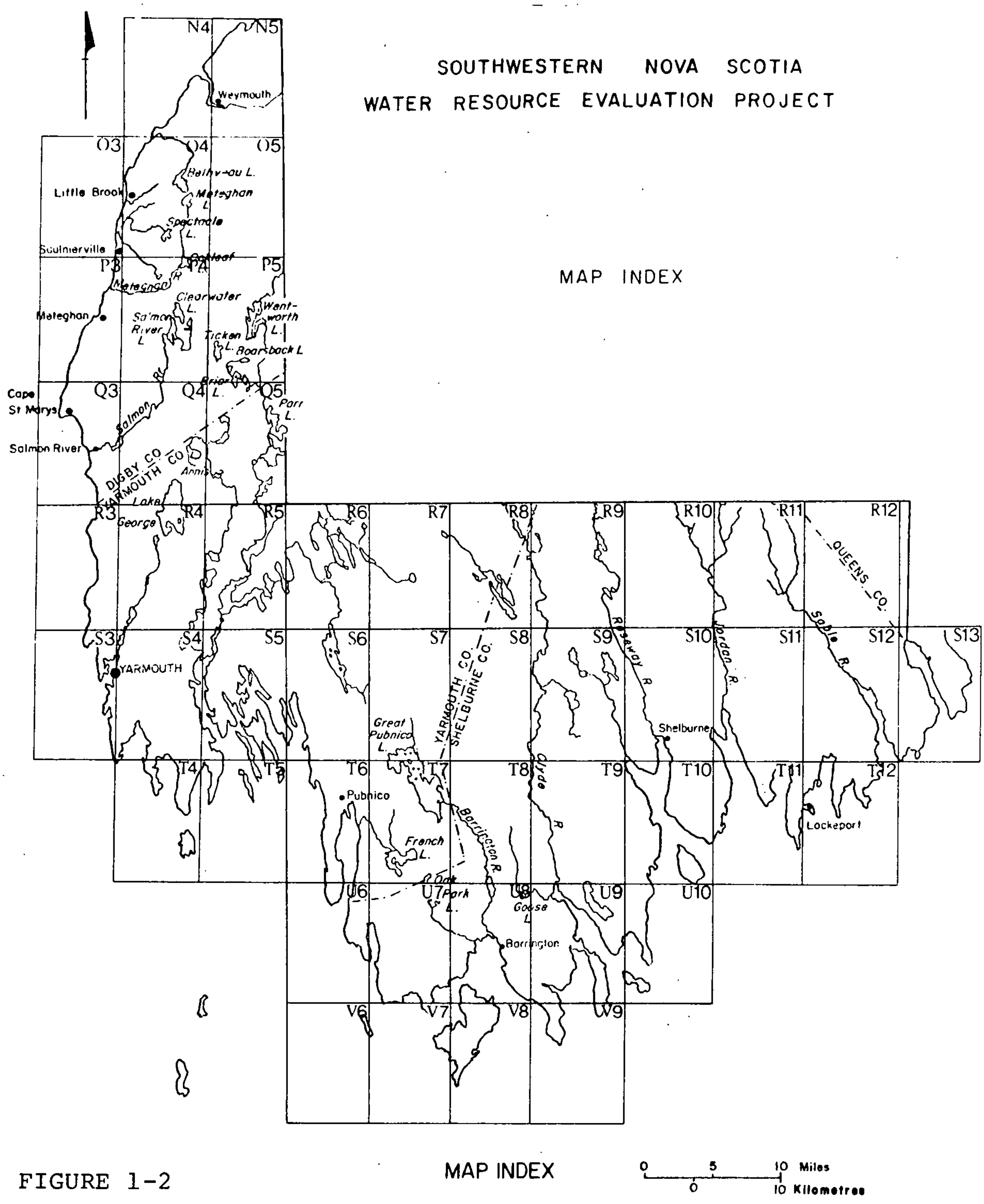


FIGURE 1-2 MAP INDEX

CHAPTER 2
GEOLOGY

2.1 Introduction

The information presented below is summary of existing information pertaining to the bedrock and surficial geology of Southwestern Nova Scotia. It has been compiled from a number of sources and is intended to give an overview of the geology in the study area.

2.2 Regional Setting

The study area is contained within a remnant of the Atlantic Upland which comprises the largest physiographic division of Nova Scotia.

The Atlantic Upland appears today only in detached fragments, separated in places by lowlands of considerable width. The Upland forms a surface which is thought to have been continuous throughout the region. It is believed that the upland originated as a "plain of denudation" formed by the wearing down of mountains to a lowland (Goldthwaite, 1924).

The portion of the Atlantic Upland comprising the study area consists mainly of three rock types: the Meguma Group, the Devonian Granite and the White Rock Formation (Table 2-1). The entire Upland surface was subsequently modified during Pleistocene glaciation.

2.3 Bedrock Units

2.3.1 The Meguma Group

The oldest rocks in the study area belong to the Meguma Group which is subdivided into the Goldenville and Halifax Formations.

The Goldenville Formation consists mainly of greywacke, with small amounts of conglomerate, slate and argillite. In most locations, the argillaceous parts of the formation have been metamorphosed and are now slate or schist (Taylor, 1967). The most common rock type belonging to the Goldenville Formation is a light to medium grey, medium grained biotite greywacke. Bedding ranges in thickness from of 2.5 cm (1 in.) to 6 m (20 ft.) with an average thickness for most beds in the 0.3 to 0.6 m (1 to 2 ft.) range. A common feature of the massive and thick greywacke beds is the presence of pyrite cubes. Rocks of the formation are cut by numerous joints normal or nearly normal to the bedding planes. The slate and argillite of the Goldenville Formation are confined to the upper part of the formation where they are interbedded with greywacke. These slates and argillite members are indistinguishable from the slate and argillite in the Halifax Formation.

The Halifax Formation consists predominantly of thinly laminated, dark to light grey, slate. Strata range from microscopic to three-quarters of an inch in thickness and are commonly traceable only for short distances. In many places cleavage and bedding are parallel or almost so. Slates typical of the Halifax Formation are exposed at the following locations: (1) along the west coast north of Chegoggin Point, forming the west link of a

TABLE 2-1 Table of Formations

ERA	PERIOD	GROUP	FORMATION	LITHOLOGY
Cenozoic	Recent			Tidal, alluvium, stream alluvium, peat, beach sands and gravels, dunes
	Pleistocene			Drift, drumlins, eskers, kames, outwash
UNCONFORMITY				
PALAEOZOIC				Quartz diabase, biotite, diorite, olivine diabase, hornblende-quartz diorite, basalt, diorite
	INTRUSIVE CONTACT			
	Devonian			Granite, granodiorite, quartz diorite, minor hornblende diorite and pegmatite
	INTRUSIVE CONTACT			
				Gabbro, diorite
	INTRUSIVE CONTACT			
	Silurian		White Rock	Andesite, actinolitic gneisses and schists, mafic tuff, slate, quartzite, conglomerate, rhyolite, rhyolite tuff and breccia, minor argillaceous quartzite, greywacke and schists of sedimentary origin
	CONFORMABLE			
	Early Ordovician	Meguma	Halifax	Slate, siltstone, minor argillite; in part re-crystallized to schists and gneisses characterized by andalusite, staurolite, cordierite, and sillimanite
	CONFORMABLE			
	Early Ordovician or earlier, possibly Late Cambrian		Goldenville	Greywacke, minor slate, argillite, conglomerate; in part recrystallized to schists and gneisses characterized by andalusite, staurolite, sillimanite and cordierite

syncline about Yarmouth Harbour, (2) on the east link of the same fold, and (3) north of Pubnico peninsula (Figure 2-1). Secondary structures within the Halifax Formation consist of cleavage joints and drag-folds with cleavage being the prominent structure.

2.3.2. White Rock Formation

The White Rock Formation overlies the Meguma Group and is typified by orthoquartzite interbedded with siltstones, conglomerates, silty shales and dark shales which are sometimes phosphatic (Schenk, 1972, Taylor, 1965, Smitheringale, 1973). Base metal mineralization is associated with acid and basic volcanic rocks near Yarmouth and Cape St. Mary. Volcanoclastic rocks and paraconglomerates are included in the White Rock Formation (Smitheringale, 1973).

Within the study area, the White Rock Formation is confined to the center of a syncline extending from Cape St. Marys to the East Yarmouth Sound through Lake George toward Digby. The thickness of the White Rock Formation near Yarmouth is estimated to be about 4,500 metres and gradually decreases to approximately 1000 metres near Digby (Taylor, 1969).

Volcanic rock formations are divided into two units, one consisting of mafic volcanic rocks that include flows, tuffs, and probable associated sills, and the second consisting of rhyolite, rhyolite tuffs, and some rhyolite intrusive rocks. The volcanic activity associated with the White Rock Formation and further intrusive activity associated with gabbro and diorite dykes and sills apparently set the stage for the widespread intrusion of granitic plutons during the Devonian Period.

2.3.3 Granitic Rocks

Granitic rocks, as shown in Figure 2-1, underlie most of the southern part of the study area, extending from Barrington Passage northward to near Gull Lake. Smaller plutons of granitic rock occur at or near Shelburne, Beech Hill Lake, Deception Lake, Wedgeport and Brenton. The granite regions are typified by vast fields of large "ice-plucked" granitic boulders. Outcrops along the coast are common only at Barrington Passage and Comeau Hill. The granitic rocks located within the different regions of the study area exhibit considerable variations in texture and composition, but generally they are grey with biotite and smaller amounts of muscovite (Taylor 1967). Igneous intrusive activity occurred in stages throughout the study area. This is suggested by the Brenton granite pluton near Yarmouth where foliation indicates a pre-tectonic or syn-tectonic time of intrusion whereas most of the other granitic plutons cut across the major folds and their metamorphic aureoles are superimposed upon them (Taylor and Schiller, 1966, Fyson, 1966). It is in the region of these metamorphic aureoles where the water bearing fractures appear to be most abundant. This will be discussed further in Chapter 6 (Special Projects). Post granitic basic intrusive rocks are known to intrude the Devonian granite in the form of dykes and sills. Other than scouring due to glacial activity during the Pleistocene Epoch, the bedrock has remained virtually unchanged since late Devonian time.

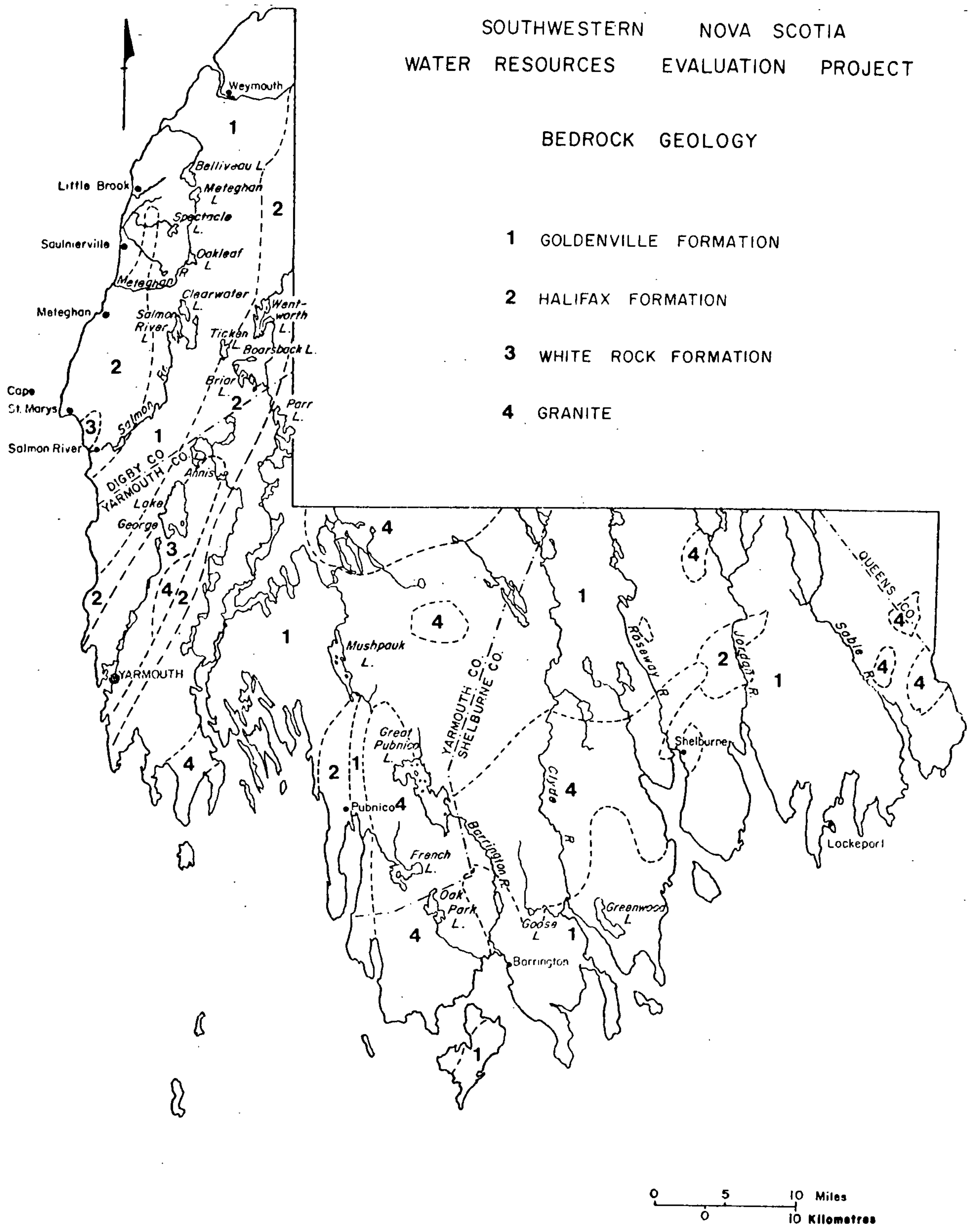


FIGURE 2-1 BEDROCK GEOLOGY

2.4 Surficial Geology

The topographic appearance of the Southwestern study area is that of a gently rolling plain largely the result of glacial activity during the Wisconsin Ice Age. Many of the surficial features and deposits are related directly to the action of the ice (Belliveau, 1968) (Figure 2-2).

Deposits, such as eskers and kames, left by the action of glacial meltwater and running streams, are usually stratified and considered to have good potential as sources of water supply. When these features are saturated and extensive they are often excellent sources of groundwater.

The surficial geology of the province has been mapped extensively from aerial photography by the Nova Scotia Research Foundation (MacNeil, 1972), and this information served as a base for the field mapping program. The field work involved locating, determining thickness and extent, and inspecting the material composition at a number of sites over the study area. Figure 2.2 indicates the areas that have been designated as having high, moderate or low permeability factors.

The most extensively distributed surficial material covering the study area is till. Till is an unstratified, unsorted mixture of various grain sized materials deposited from the base of the glacier in an even covering, or in the form of moraines and drumlins (Flint, 1971). It is generally composed of a large amount of small grain sized materials with a resulting low permeability.

During the summer of 1981, a hammer-seismic program was carried out to delineate the extent and to determine the thickness of till deposits in Shelburne County and in Digby County. The areas investigated were those with apparently high or moderate permeabilities and relatively close to population. A soil test model MD-9 Enhancement Seismograph was used with sample results as shown in Figures 2-3, 2-4, and 2-5. Many other locations were spot checked with the results being, generally, that till cover through the study area is relatively thin, less than 6 metre in most cases.

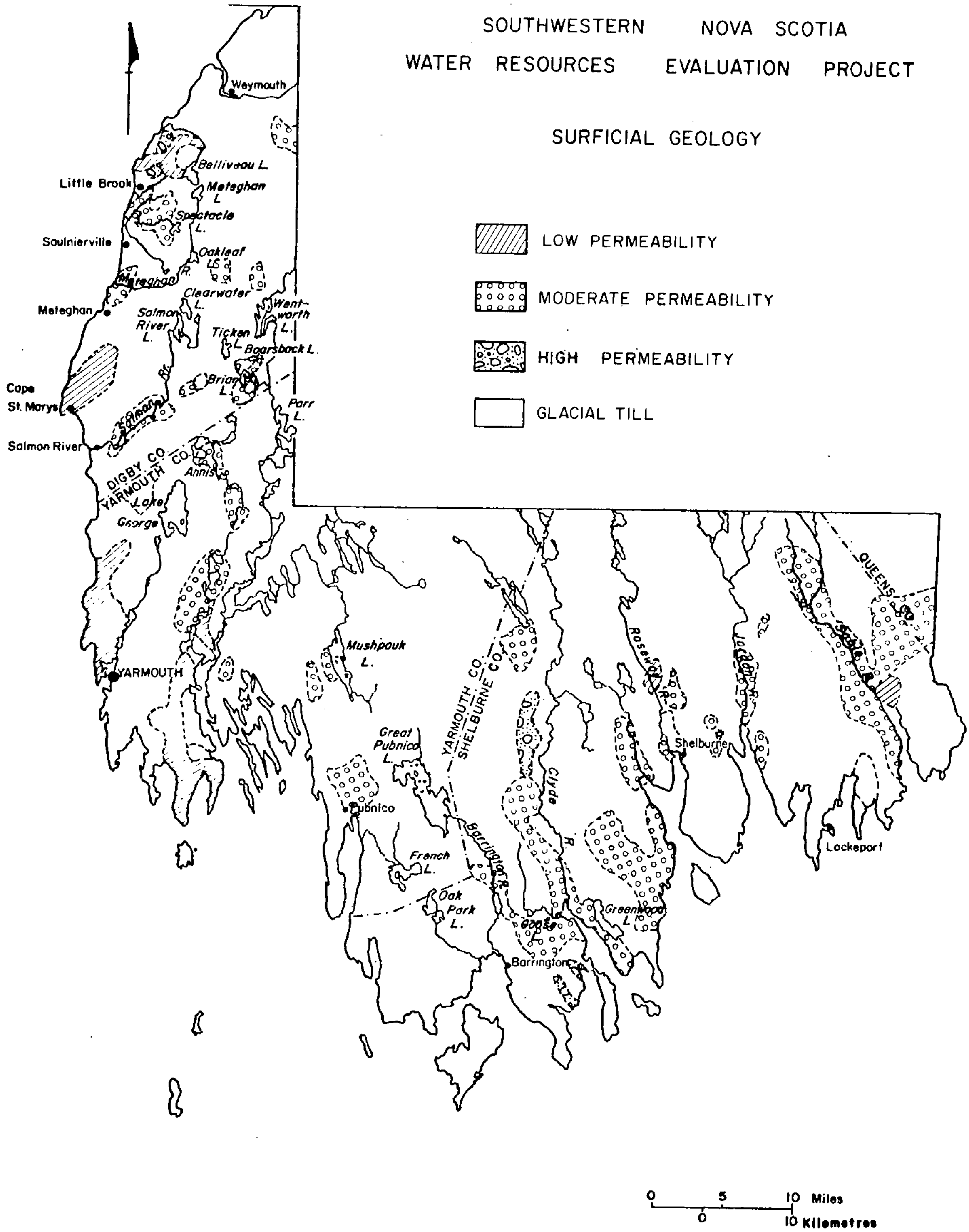
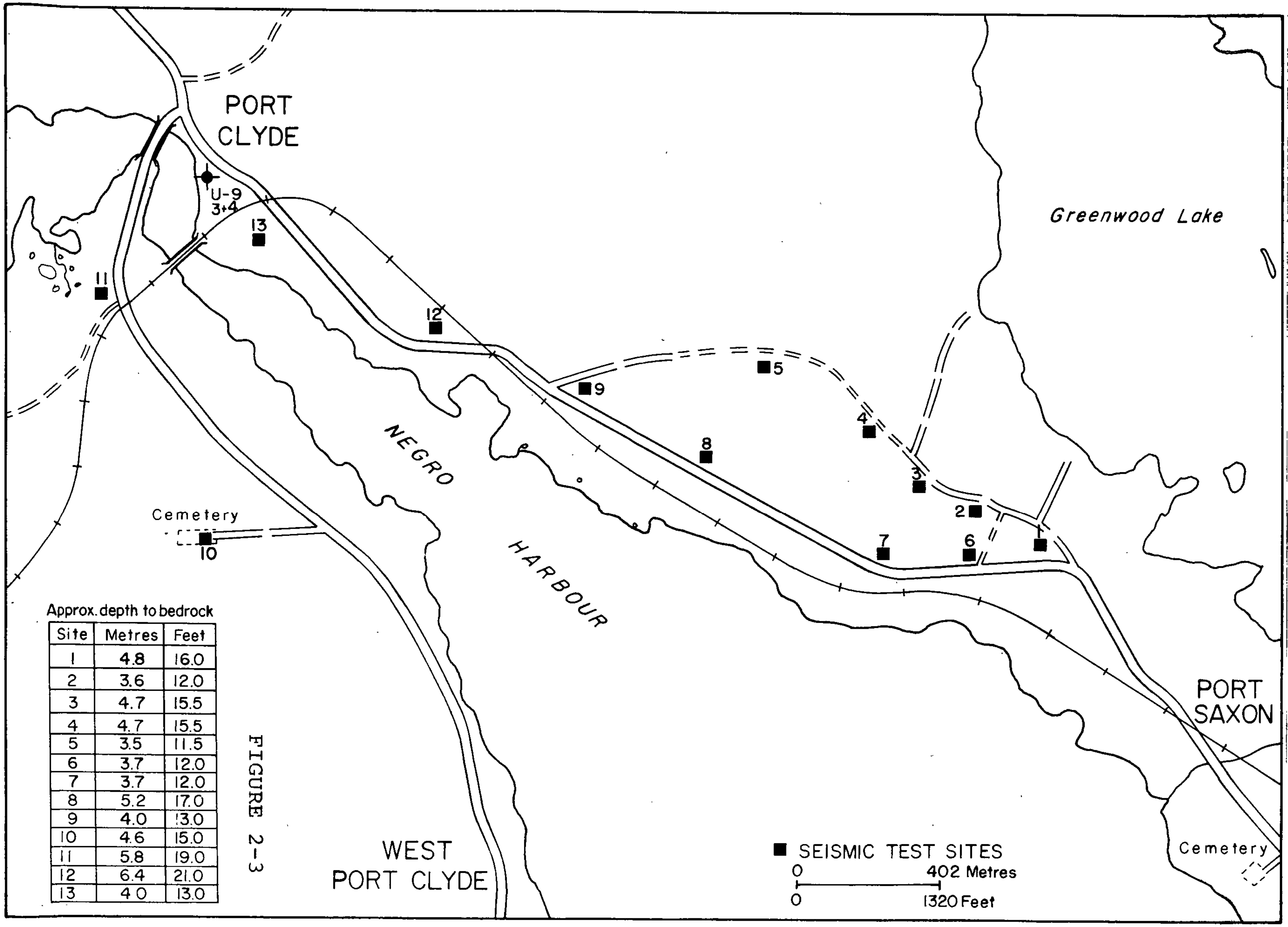


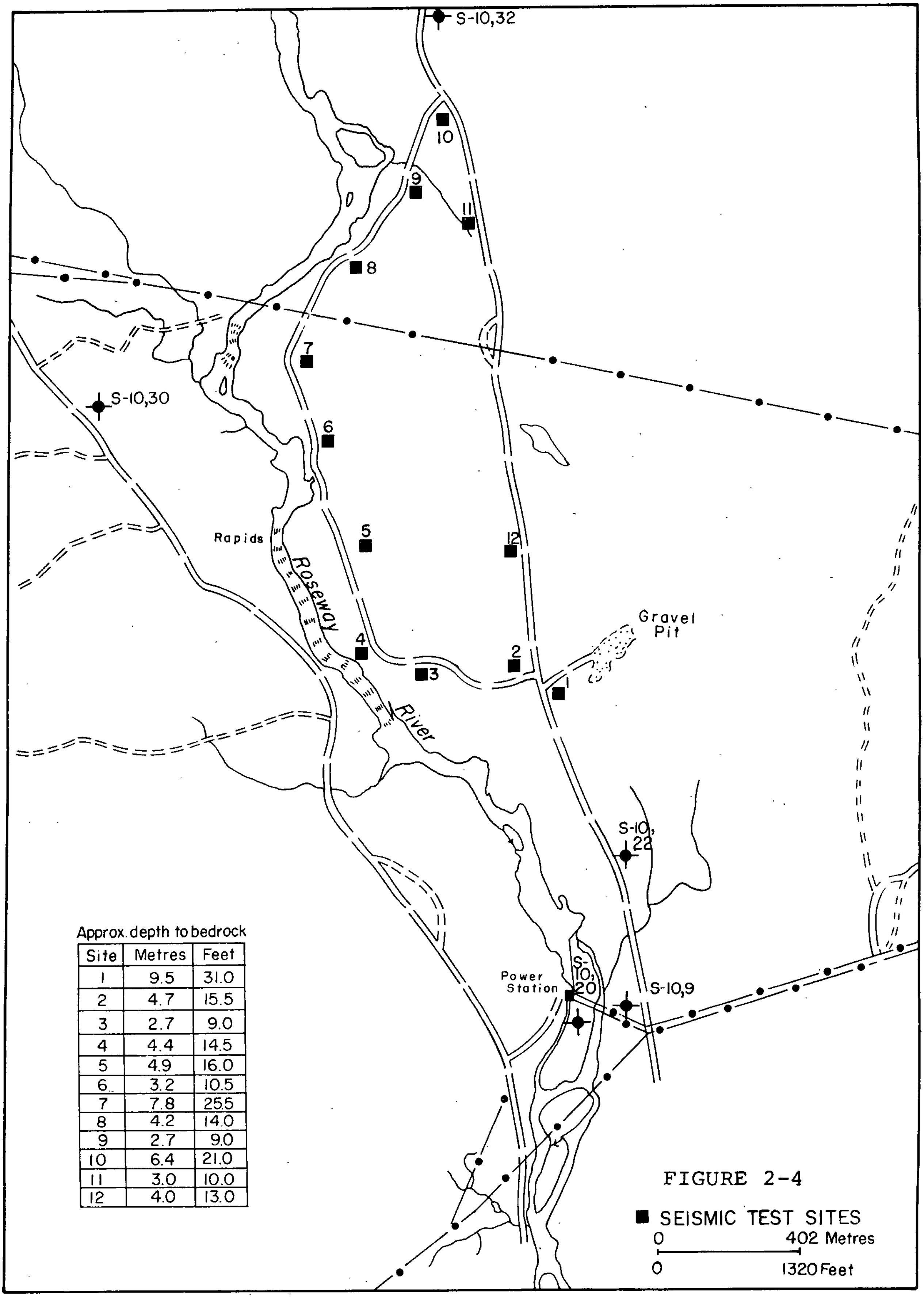
FIGURE 2-2 SURFICIAL GEOLOGY



Approx. depth to bedrock

Site	Metres	Feet
1	4.8	16.0
2	3.6	12.0
3	4.7	15.5
4	4.7	15.5
5	3.5	11.5
6	3.7	12.0
7	3.7	12.0
8	5.2	17.0
9	4.0	13.0
10	4.6	15.0
11	5.8	19.0
12	6.4	21.0
13	4.0	13.0

FIGURE 2-3

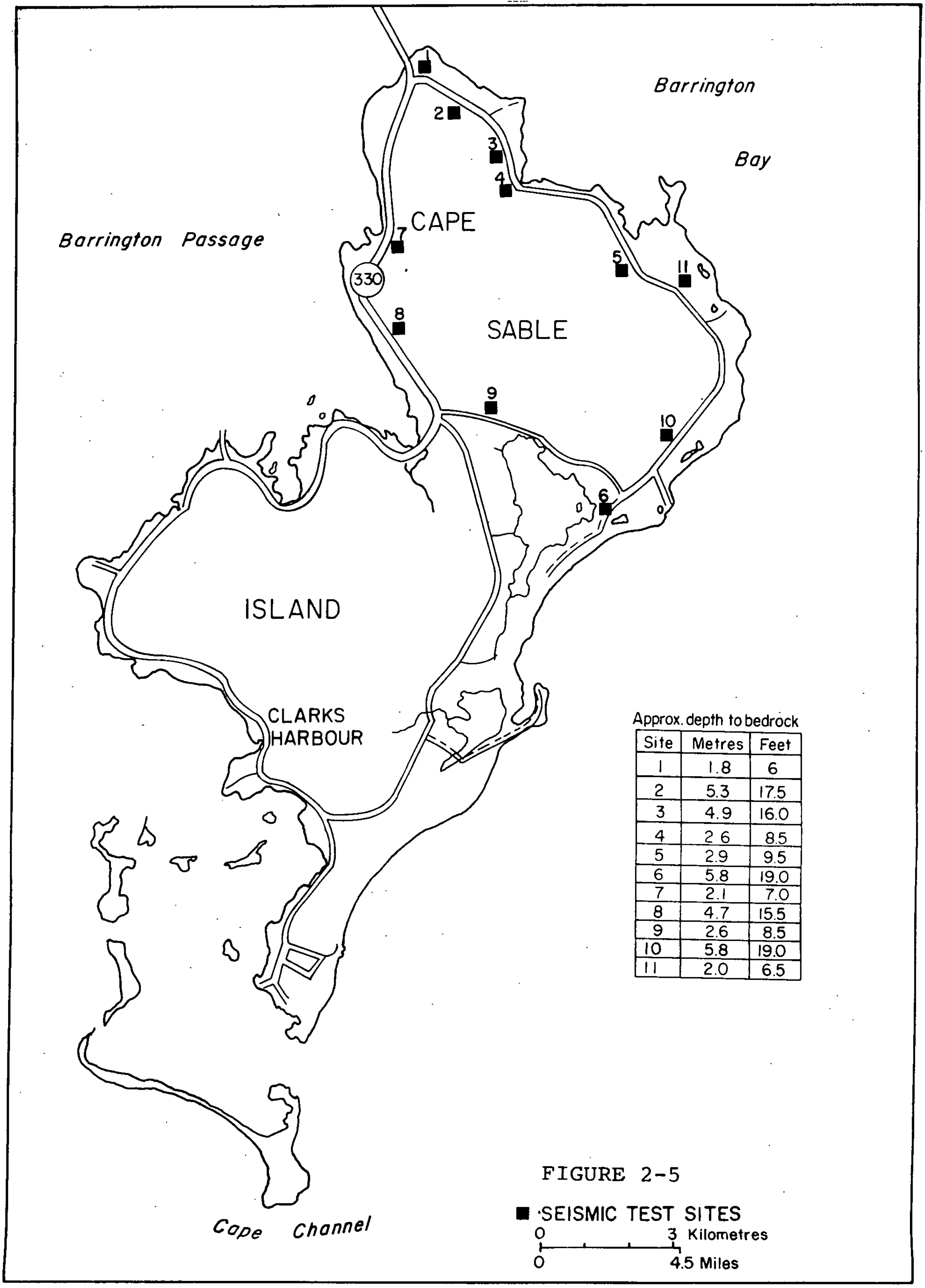


Approx. depth to bedrock

Site	Metres	Feet
1	9.5	31.0
2	4.7	15.5
3	2.7	9.0
4	4.4	14.5
5	4.9	16.0
6	3.2	10.5
7	7.8	25.5
8	4.2	14.0
9	2.7	9.0
10	6.4	21.0
11	3.0	10.0
12	4.0	13.0

FIGURE 2-4

■ SEISMIC TEST SITES



Approx. depth to bedrock

Site	Metres	Feet
1	1.8	6
2	5.3	17.5
3	4.9	16.0
4	2.6	8.5
5	2.9	9.5
6	5.8	19.0
7	2.1	7.0
8	4.7	15.5
9	2.6	8.5
10	5.8	19.0
11	2.0	6.5

FIGURE 2-5

CHAPTER 3
LIMNOLOGY AND VOLUMETRIC LAKE STUDY

3.1 Introduction

The lake sampling program took place during the summer months of 1979 and 1981. The work consisted of collecting samples for chemical analyses from 16 lakes chosen for size and proximity to more populated areas. Initial work involved conducting bathymetric surveys and, from that information choosing the lakes useful for sampling purposes (Figure 3-1). Additional data were obtained Inland Waters Directorate, Environment Canada, and from H. J. Porter and Associates Limited (1978) and, ongoing work by the Nova Scotia Department of the Environment.

3.2 Methodology

A data base on the study lakes was developed to identify the following parameters; (1) surface area, (2) volume, (3) mean and maximum depths, (4) watershed area, (5) residence time (months). A bathymetric survey of 15 lakes was conducted during the summer of 1979. During the survey, depth was related to surface water elevation at the time of the survey while horizontal control was related to identifiable features on the shoreline. The survey vessel followed transects on the lake at a constant speed using a compass and appropriate land marks. Continuous water depths were recorded using an echo-sounder. The transects with their interpreted depths were plotted on base maps of the lakes. Isobaths were interpreted and plotted at 1.5 metre (5 ft.) intervals.

The area (A) within each isobath, was computed and the lake volumes were calculated using the formula:

$$V = \sum_{i=1}^{n} \tfrac{1}{2}(A_{(i)} + A_{(i+1)})D$$

Where V = Volume
$A_{(n)}$ = Area within a contour
n = the number of contour intervals
i = the increment of the contours
D = the contour interval (5 ft.)

The mean depth (Z) of each lake was determined by the formula:

$$Z = V/A_{(surface)}$$

The residence time (RT) was determined by the formula:

RT=V/TAF

Where TAF = Total Annual Flow

A perspex Kemmerer-type sample bottle was used to collect water samples from spot locations and from the deepest point in the lakes. Each sample was divided into a 250 ml portion fixed with nitric acid and a 1 litre portion not touched. Temperatures were determined by telethermometry. Dissolved oxygen and pH were determined on site. Transparency was measured by a standard 20 cm black and white Secchi disc.

3.3 Major Ion Chemistry

Major ion data are summarized in Table 3-1. Piper tri-linear

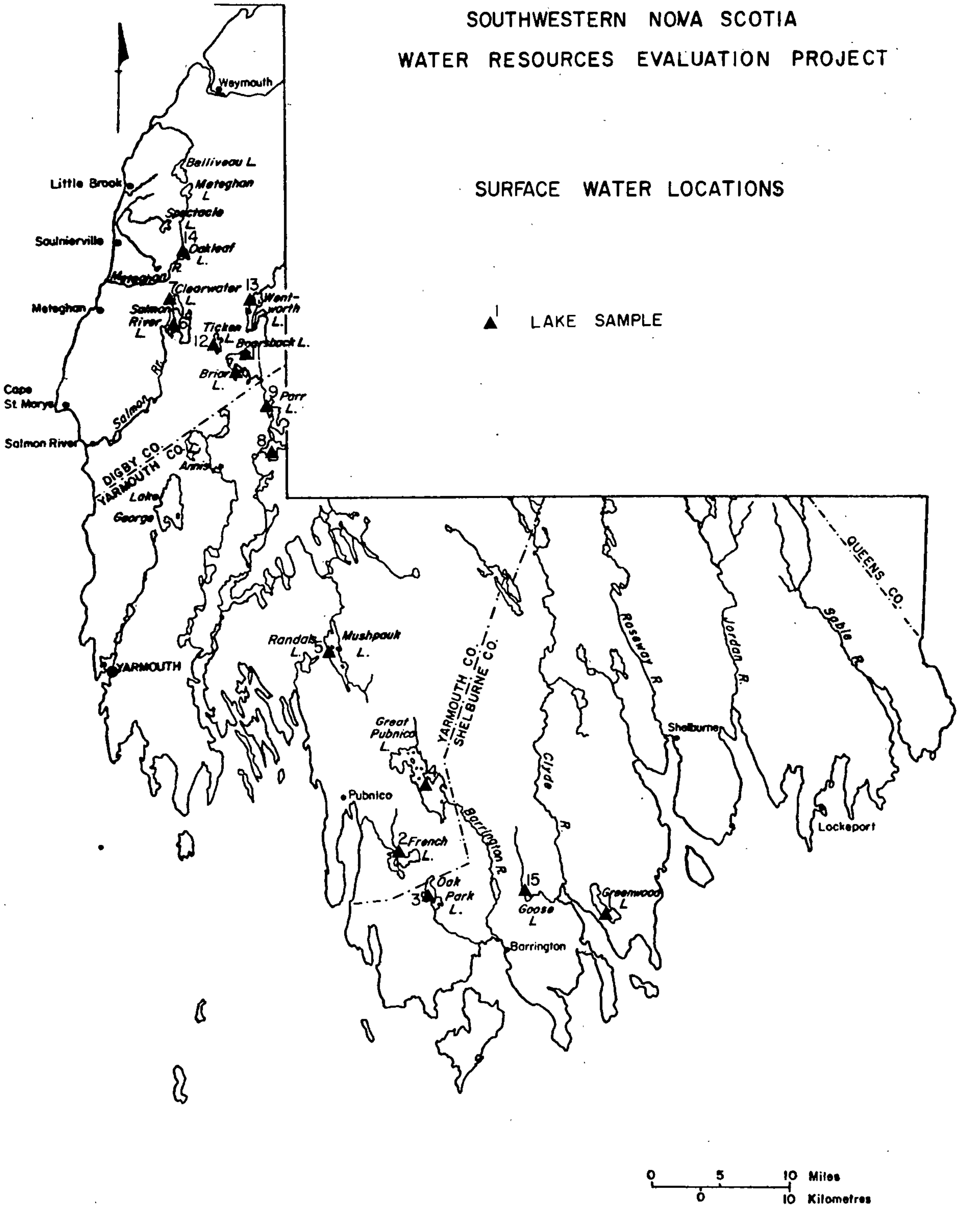


FIGURE 3-1 SURFACE WATER LOCATIONS

diagrams using % milliequivalent balances of the major ions indicated that the lakes are predominantly sodium chloride waters (Figure 3-2). Sodium has a mean value of 52% of the cations. Chloride has a mean value of 74% of the anions. This is shown, with other ionic concentrations in Table 3-1.

During the 1979 sampling period there was considerable more precipitation than during that of 1981, which was virtually dry. This caused elevated stream flows in the 1979 sample period. This indicates the contributions of surface runoff and groundwater to the rivers and lakes, were primarily surface runoff in the first period and groundwater in the second. The results of the two sets of sample analyses were relatively close indicating no significant change between the surface and subsurface elements and their rates of dissolution.

3.4 Alkalinity and pH

Alkalinity has a mean value of 11% of the anions. All the study lakes have very low alkalinities ranging from 1.0 mg/l to 3.7 mg/l with low pH (4.3 to 6.0).

3.5 Turbidity, Suspended Solids, Total Dissolved Solids, Conductivity

Overall, waters of all the lakes are low in turbidity, suspended and total dissolved solids. Conductivity is within the suggested limits (40-60 uMHO/cm) for principally undisturbed lake water in Nova Scotia (Ogden, 1972). Conductivities of bottom waters were generally the same or lower than surface waters suggesting little stratification with depth.

3.6 Nutrients

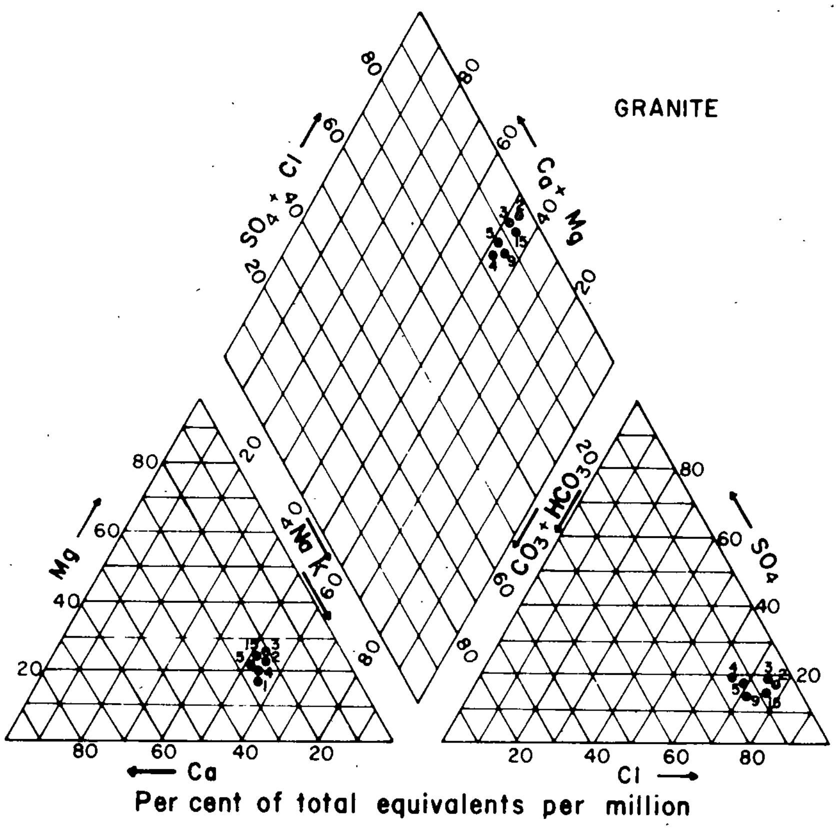
Suggested trophic classification of the various study lakes were determined by considering various combinations of nutrient levels (N and O), Chlorophyll 'A' concentration, secchi disc transparency, basin morphometry and dissolved oxygen distribution. Vollenweider and Kerekes (in press) suggest that phophorous (as P) in oligotrophic lakes is generally below 0.008 mg/l (0.024 mg/l as PO_4), while nitrogen (as N) seldom exceeds 0.66 mg/l in such waters. Chlorophyll 'A', an approximate expression of relative biomass, seldom exceeds, 3.0 mg/m^3 in oligotrophic lakes such as these. Secchi disc transparency should exceed 3.0 m and oxygen should be predominantly uniform. Basin characteristics have a strong influence on physical and chemical aquatic processes and must be considered while formulating conclusions.

Total phosphate concentrations in all the study lakes except Great Pubnico Lake, Ticken Lake and Clearwater Lake, exceed the suggested limit and can therefore be expected to support increased algal growth. Total phosppate concentration ranged from 0.06 mg/l in Goose Lake to 1.6 mg/l in Briar Lake.

Nitrate plus nitrite concentrations in all the study lakes are below the suggested critical concentration of 0.03 mg/l for oligotrophic lakes and could limit those algae with no ability to fix atmospheric nitrogen.

3.7 Chlorophyll 'A'

Chlorophyll 'A' concentrations in the studied lakes ranged from 2.7 mg/m^3 in Oakleaf Lake to 39



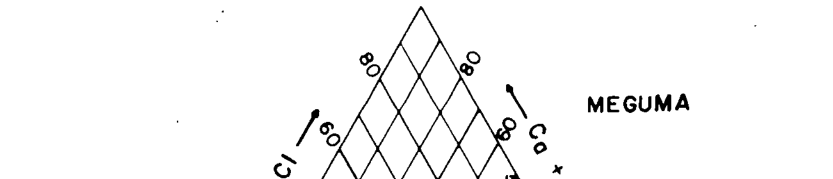


FIGURE 3-2 LAKE SAMPLES TRILINEAR PLOT

TABLE 3 - 1

Major ionic concentrations in Nova Scotia Lake Waters, with respect to typical salt water and freshwater of the World.

Ionic Proportions (% meq.)

Lake Type	Na	K	Ca	Mg	Cl	SO_4	ALK.
On Granite	52	3	23	23	74	18	8
On Meguma	52	2	23	22	75	24	10
Average Freshwater of the World (Gorham, 1957)	16	3	64	17	10	16	74
Average Seawater (Chow, 1964)	77	2	3	18	90	9	.5

mg/m^3 in Boarsback Lake. With the exception of Oakleaf Lake, all had excessively high Chlorophyll 'A' concentrations which can be expected to reduce clarity and limit sunlight penetration in these waters.

3.8 Colour

All the study lakes except Clearwater Lake are highly coloured. Colour values ranged from 12 TCU in Clearwater Lake to 500 TCU in Oak Park Lake. Ticken Lake at 50 TCU is considered average for lakes for this area of the Province.

3.9 Secchi Disc Transparency

Secchi disc transparency in all lakes except Clearwater Lake did not exceed 1 metre (3.5 feet) and, in most cases, was measured at 0.5 metre (1.5 feet). A secchi disc transparency of 3.6 metres (12 feet) suggests reasonably high water clarity in Clearwater Lake. Transparency of lake waters is related to turbidity. If phytoplankton levels are quite low, the presence of suspended sediments in the water column is the major control of transparency. The studied lakes have very low turbidity values (0.44 JTU to 1.9 JTU) and high chlorophyll 'A' concentrations. It would appear that extremely high algal populations in conjuction with high colour values and high iron and manganeses concentrations are responsible for the low secchi disc transparencies encountered in these lakes.

3.10 Thermal and Oxygen Regimes

The studied lakes are relatively shallow with a mean depth 3.7 m (12.2 ft) and as a result showed little evidence of thermal stratification. The isothermal conditions suggest the lakes were in a condition of near continuous turn-over resulting in their levels of dissolved oxygen being almost constant from surface to bottom. Disolved oxygen levels ranged 8.0 to 9.7 mg/l (Table 3-2).

3.11 Lakes as Potential Sources of Water Supply

This section deals primarily with the physical volumetric aspects of the lakes in the study area. Using the bathymetry, previously discussed, estimates of volumes and yields have been made.

3.11.1 Estimates of Lake Yield

Bathymetric measurements were made on 16 lakes. The summary of these data are shown on Table 3-3 and the storage curves on Figure 3-3, 3-4 and 3-5.

The lakes are usually shallow often with rocky shore and small rocky islands. Frequently, bordering swamp vegetation extends out into water, making the shoreline indefinite. Usually the greater portion of the useful storage is in the first metre of depth below the normal surface elevation.

Figures 3-3 and 3-4 show a number of storage curves with flat slopes at the upper end. For example, if the elevation of Oak Park Lake were lowered 0.5 m, the storage available would be in the range from 2.8 to 4.3 x 10^6 m^3 or 1.5 x 10^6 m^3. To drop another 0.5 m would yield storage ranging from 1.8 to 2.8 x 10^6 m^3. At the lower depths storage per unit drawdown decreases rapidly.

This suggests that instead of depending on volume below 1 to 1.5

TABLE 3 - 2

Dissolved Oxygen and Associated Temperatures of Lake Samples

Lake	Station/Depth (feet)	Temp. (°C)	D.O. mg/l	Theoretical D.O. (%) Saturation
Greenwood	Deep/0	21.8	9.0	99
	Deep/5	21.1	8.8	96
French	Deep/0	22.0	8.6	96
	Deep/5	21.9	8.7	97
Oak Park	Deep/0	23.1	8.5	96
Pubnico	Deep/0	21.5	8.7	96
	Deep/10	21.5	8.6	95
	Deep/20	21.0	8.9	95
Mushpauk	Deep/0	22.2	8.8	98
	Deep/7	20.1	9.7	104
Salmon River	Deep/0	21.0	8.6	93
	Deep/15	20.2	8.8	95
	Deep/30	20.4	8.6	93
Oak Leaf	Deep/0	19.8	9.2	98
	Deep/10	18.9	8.0	104
Ogden	Deep/0	20.0	8.9	95
	Deep/10	19.5	9.4	100
Parr	Deep/0	20.8	8.8	95
	Deep/10	18.8	9.1	95
Briar	Deep/0	21.2	8.6	94
	Deep/10	18.8	8.4	94
Boarsback	Deep/0	21.8	9.2	102
	Deep/10	18.5	9.2	96
Ticken	Deep/0	19.9	9.2	99
	Deep/5	19.2	9.0	96
Wentworth	Deep/0	19.9	9.2	98
	Deep/5	19.9	9.0	96
Goose	Deep/0	23.0	8.7	95

August 1979

TABLE 3-3

Bathymetric Data

Summary

Lake		Watershed Area (km^2)	Lake Area (km^2)	Depth Max. (m)	Depth Mean (m)	Volume (m^3x10^6)	Mean Annual Runoff (m^3x10^6)	Residence Time (months)
Barren		113	8.08	5.5	3.05	24.67	107	2.8
Beaver		31.1	1.76	5.5	2.24	3.95	29.5	1.6
Belliveau		6.89	2.23	7.1	1.85	4.12	6.54	7.6
Canada Hill		27.1	1.82	2.5	1.10	2.01	25.7	0.9
Clearwater		4.67	1.62	10.	3.75	6.08	4.93	16.
French		44.0	5.12	4.0	1.06	5.45	41.8	1.6
George (Shel)		5.49	1.22	4.0	1.27	1.55	5.22	3.6
George (Yar)*		29.1	12.92	16.	5.32	68.83	27.6	4.8
Greenwood		24.6	5.01	5.5	2.19	10.99	23.3	5.7
Gt. Pubnico		155	16.2	8.6	1.53	24.79	14.7	2.0
Meteghan		49.2	1.33	5.5	2.92	3.88	46.7	1.0
Muspauk		41.7	7.00	4.0	2.41	16.87	39.6	5.1
N Churchover*		8.3	1.00	12.	1.00	1.25	7.9	1.9
Oakleaf		41.9	1.11	7.0	2.63	2.93	39.8	0.9
Oak Park		18.1	3.72	2.5	1.17	4.36	17.2	3.0
Salmon River		44.0	2.23	10.	3.45	7.70	41.8	2.2
Spectacle		12.3	0.29	4.0	1.86	0.54	11.7	0.6
	$\bar{x}$	38.6	3.68	6.7	2.13	7.59	36.6	3.5
N = 17	s	39.6	3.91	3.6	0.87	7.59	37.5	3.8
	C_V	1.02	1.06	0.54	0.41	1.00	1.02	1.08

*by J. Underwood

Mean Depth = Volume/Area of Lake Surface

Uniform mean annual runoff assumed as 950 mm.

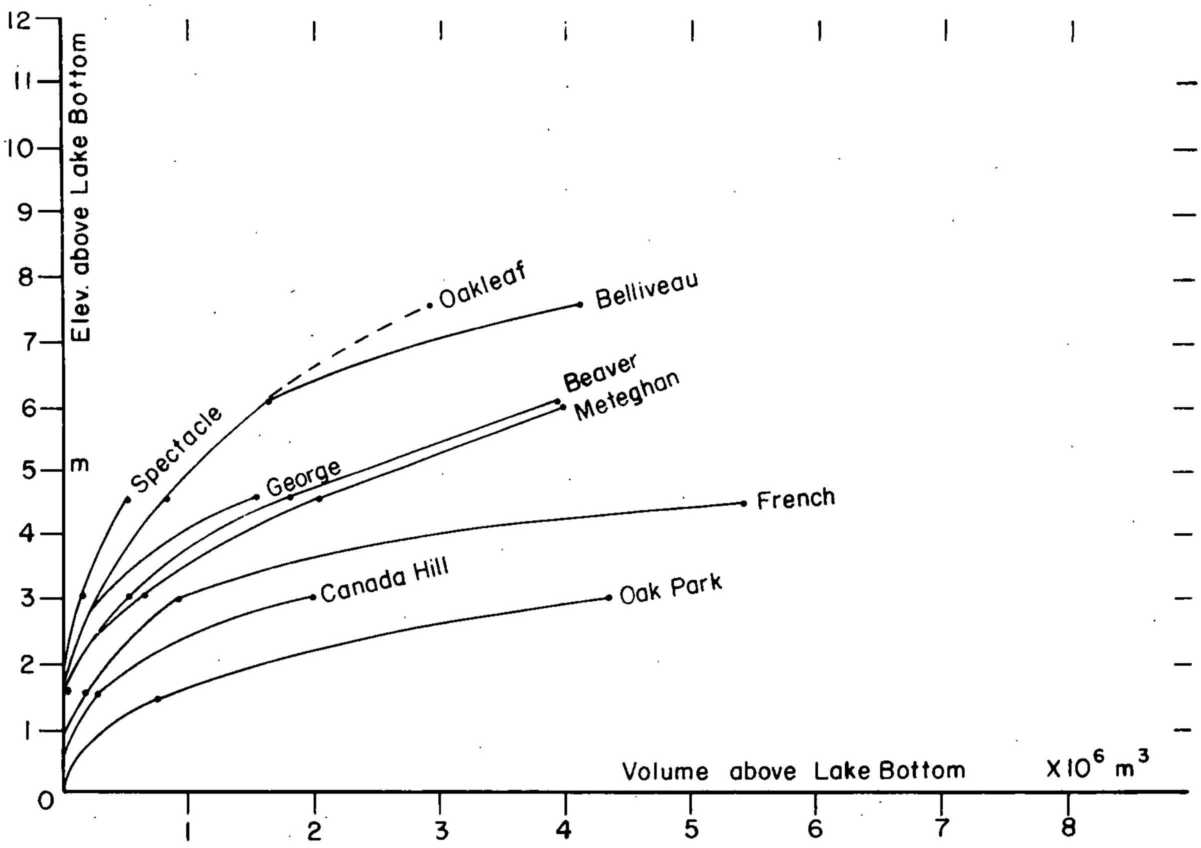


FIGURE 3-3 LAKE STORAGE CURVES

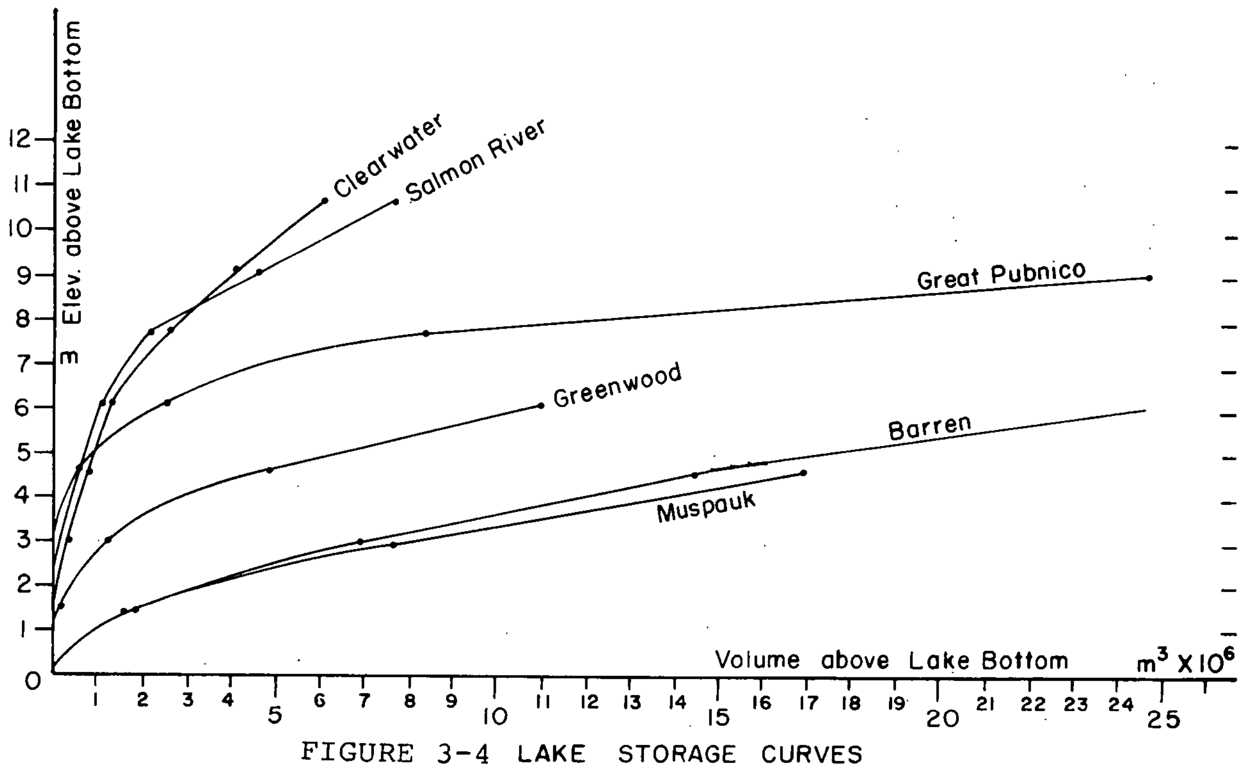


FIGURE 3-4 LAKE STORAGE CURVES

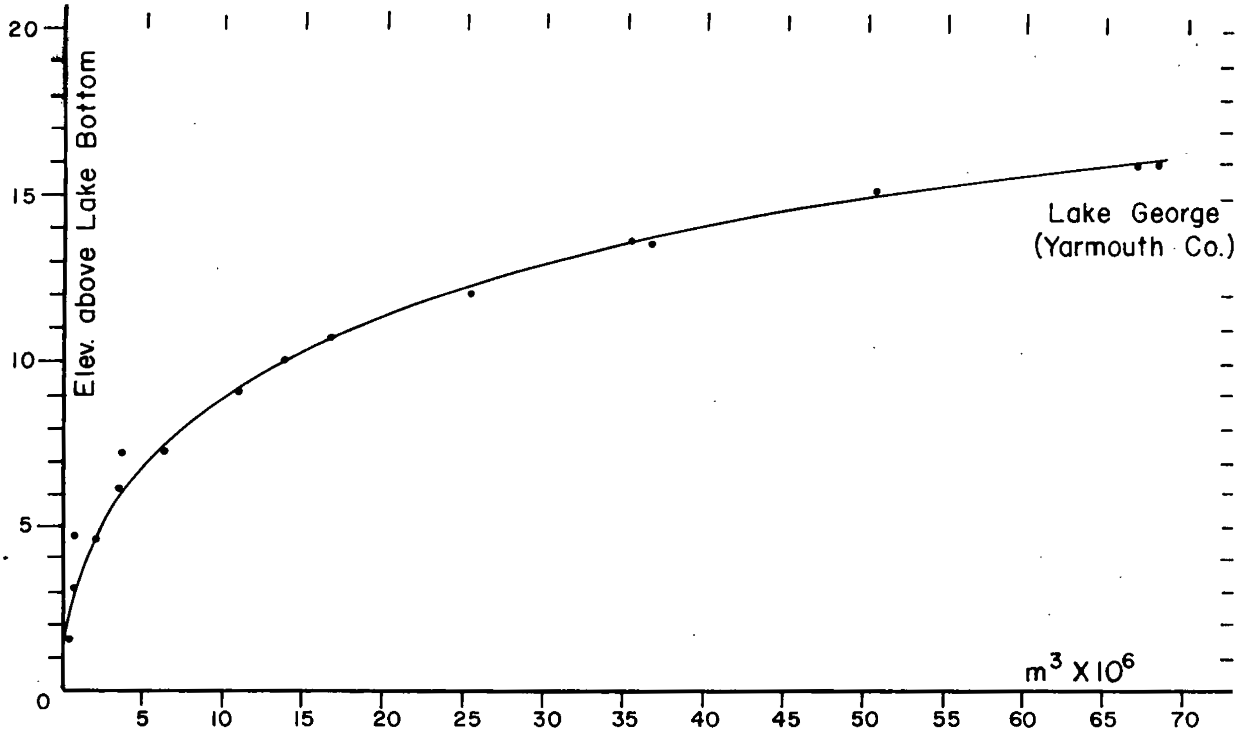


FIGURE 3-5 STORAGE CURVE

m, it would be preferable to place a dam at the outlet and raise the lake level and creating additional water storage. Flooding a swampy border might affect the water quality. Each lake would require an individual study if it were being considered as potential storage.

To obtain an estimate of the potential yields of the lakes the following assumptions were made:

(a) There is a drawdown of 0.92 m (3.0 ft) below lake surface elevation at the beginning of summer because of the shallowness of the lakes.

(b) If the lake were drawn down to the proposed depth of 0.92 m during the summer months of June to September, precipitation is sufficient during the fall to spring period to raise the lake to spill elevation.

(c) For lakes near the Meteghan River, the summer yield of that hydrometric station is used; for basins near the Roseway River, Roseway data are used. For lakes at the mid-point between the stations, the average yield is used.

(d) Lake evaporation calculations are based on evaporation recorded at the Truro Class 'A' pan, since this has the longest period of record.

The ratio of watershed area to lake area is an important parameter in estimating the capacity of a lake. A lake may have a good volume of storage, but the area feeding the lake is small. For example, the ratios of the following three lakes are:

Lake	Ratio
Clearwater	2.9
French	8.6
Great Pubnico	9.6

A smaller ratio indicates a greater risk of depleting the available supply in the lake, if it is used as a source of water supply.

CHAPTER 4
WATER QUALITY OF RIVERS AND GROUNDWATER

4.1 River Water Quality

4.1.1 Introduction

In the late summer of 1979 and 1981, a brief water quality sampling program was conducted on 8 rivers in the study area. Sample station locations are shown on Figure 4-1. Chemical data are listed in Table 4-1. The following river systems were sampled and analyzed to obtain water quality data with a view to their use by fish processing plants; Spectacle Brook, Salmon River, Meteghan River, Barrington River, Clyde River, Roseway River, Jordan River and Sable River. Water type, predominant characteristics and suitability in terms of the Guidelines for Canadian Drinking Water Quality, 1978, are assessed.

4.1.2 Methodology

Water samples were taken upstream of tidal and cultural influences. Temperatures were determined by telethermometry. Dissolved oxygen was determined by use of a YSI 51B Oxygen Meter. Due to financial constraints, sampling was limited to one occasion per river in both summers.

4.1.3 Major Chemistry

Examination of % milliequivalence data reveals that sodium and chloride are the dominant ions (Table 4-2). Sodium has a mean value of 55.0% of the cations. Chloride has a mean value of 73.0% of the anions, as shown in Figure 4-2(a) Spectacle Brook has the highest sodium and chloride concentrations at 7.3 mg/l and 12.0 mg/l respectively.

Figure 4-2 also indicates that lake and river waters from Meguma and Granite resemble each other in sodium and chloride concentrations. Figure 4-2(b) and Figure 4-2(c) show that rivers overlying both the Meguma and Granite exhibit considerable enrichment of calcium and magnesium.

4.1.4 Thermal and Oxygen Regimes

The mean sample point depth was 3 feet. Temperatures ranges from 15 ^{o}C in Spectacle Brook to 24^{o}C in Sable River. All the rivers displayed near saturated or supersaturated levels of dissolved oxygen greater than 8.8 mg/l on the sampling date.

4.2 Chemical Quality of Groundwater

During the summer of 1979, 24 groundwater samples were taken for analysis from the locations shown in Figure 4-3 to gain an appreciation of groundwater quality from the major hydrostratigraphic units.

4.2.2 Goldenville Formation

Figure 4-3 shows 3 of 11 samples as calcium bicarbonate type water, 7 calcium sulphate to calcium chloride and one sample sodium chloride. Mean values for iron (0.34 mg/l) and manganese (0.19 mg/l)(Table 4-3) are somewhat in excess of the limits of 0.3 mg/l for iron and 0.05 mg/l for manganese recommended in the Guidelines for Canadian Drinking Water Quality, 1978. Iron ranges from 0.03 to 1.1 mg/l and manganese from 0.01 to 0.44

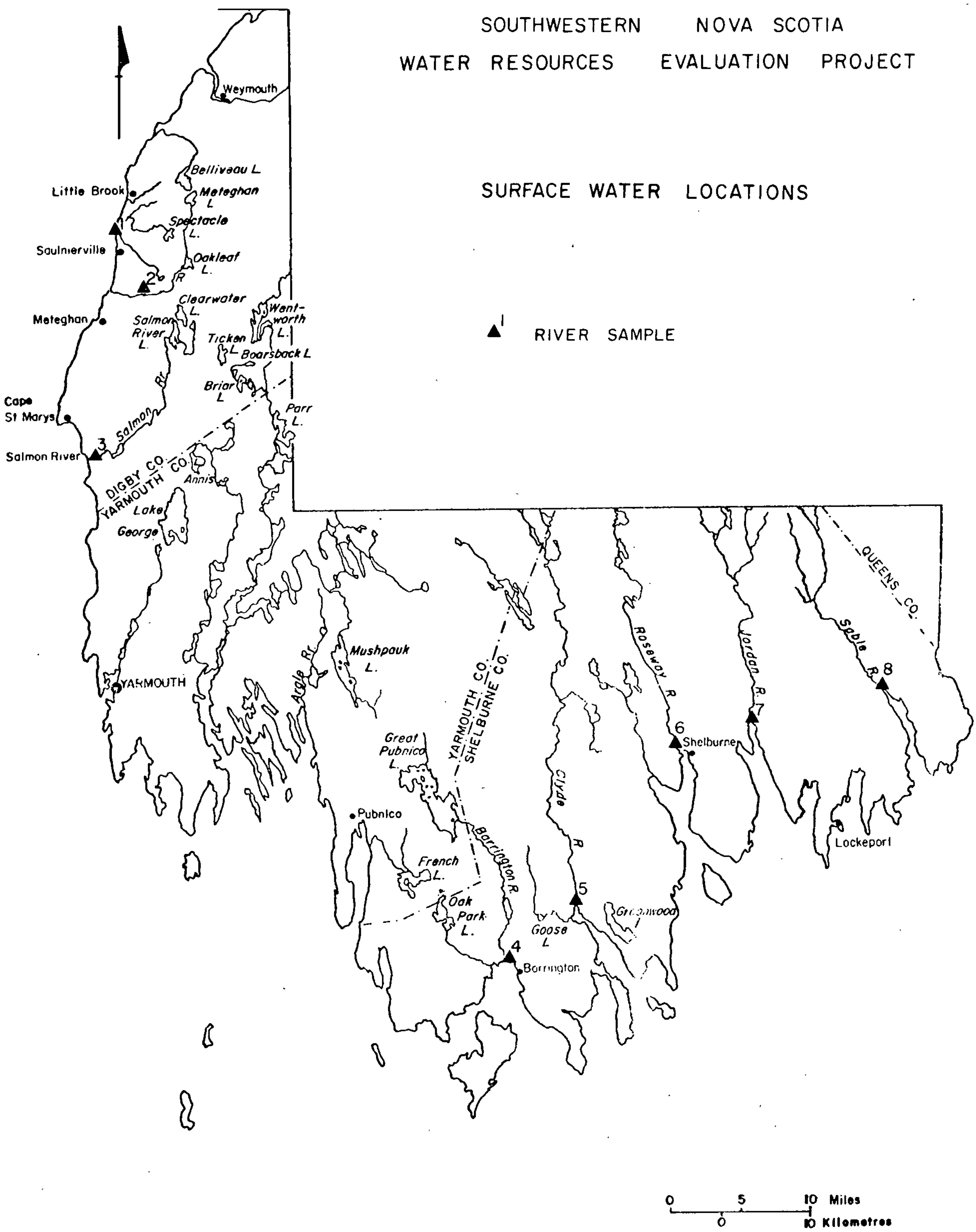
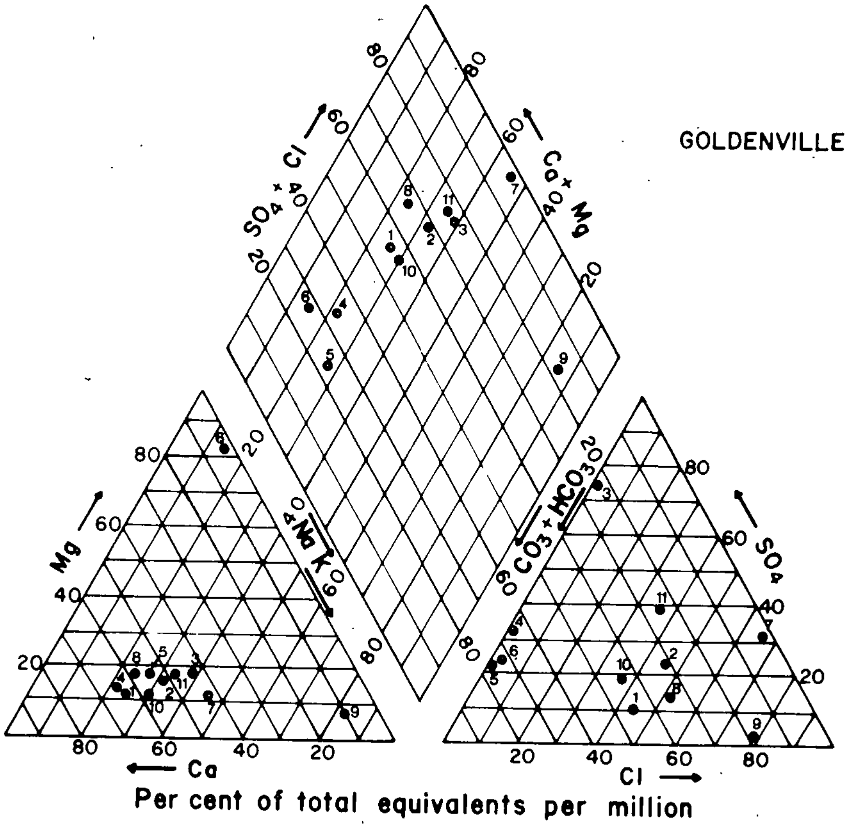


FIGURE 4-1 SURFACE WATER LOCATIONS



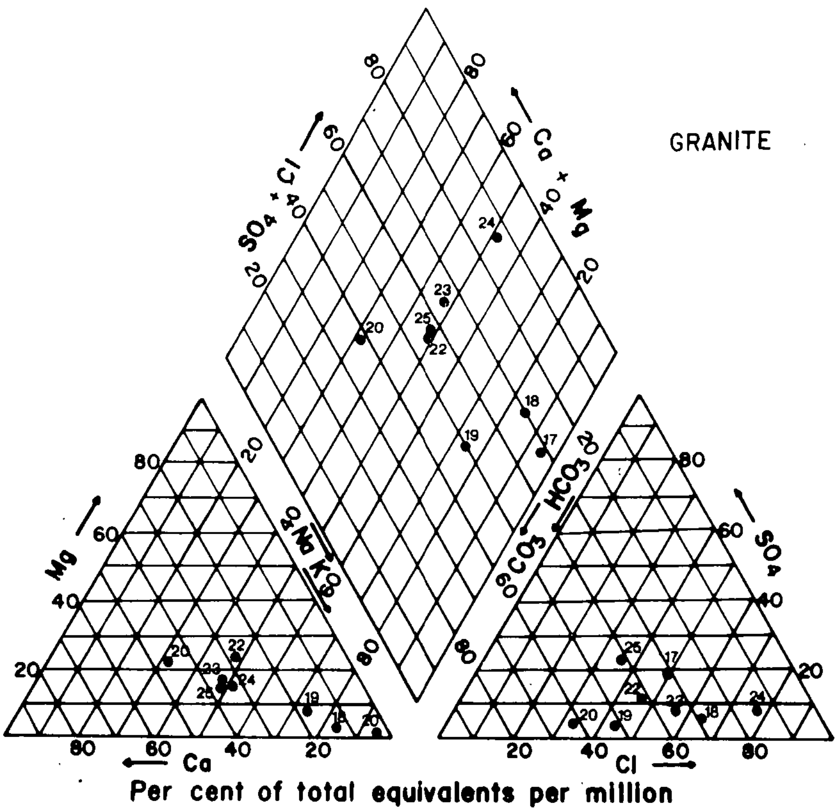


FIGURE 4-2 GROUNDWATER SAMPLES TRILINEAR PLOT

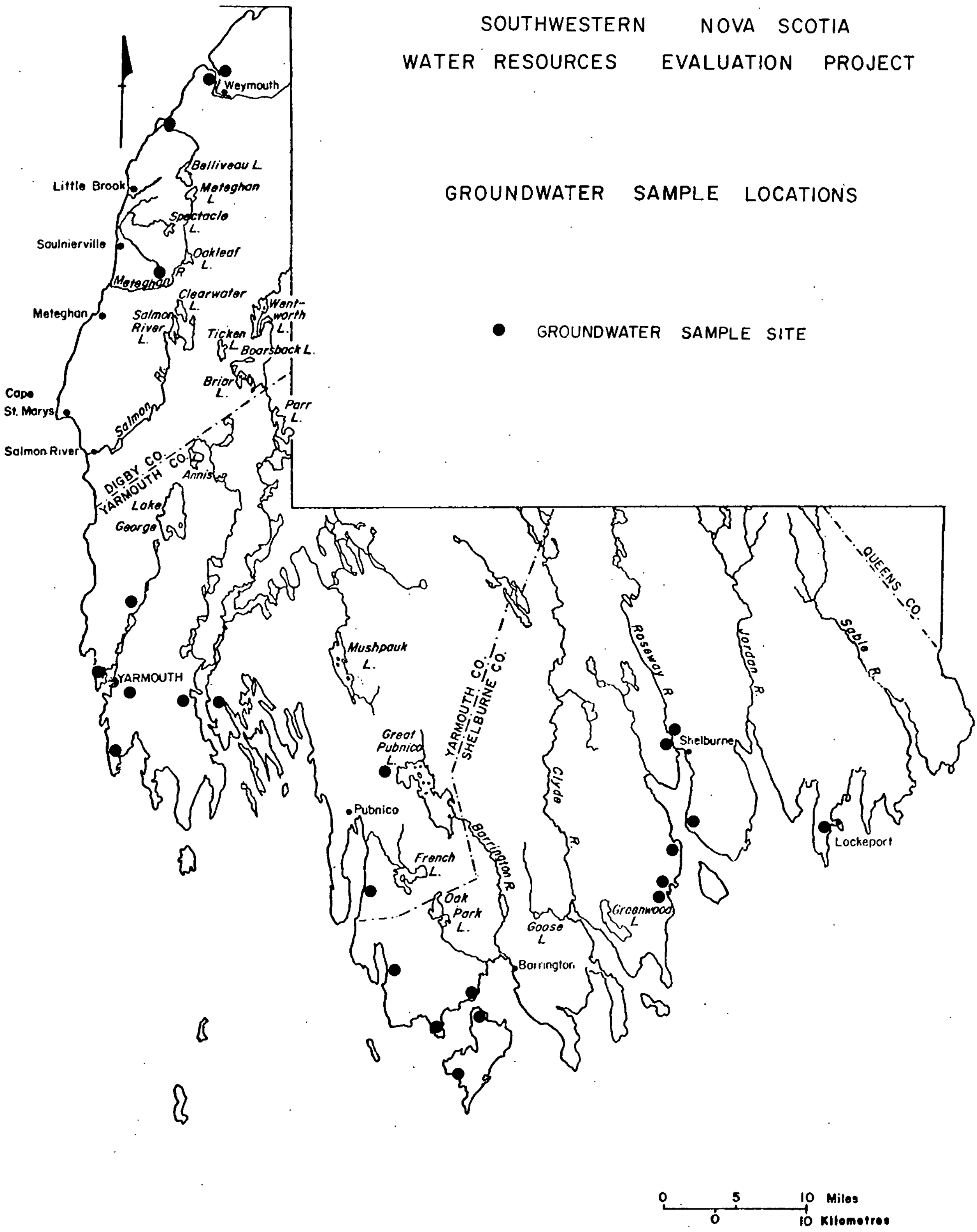


FIGURE 4-3 GROUNDWATER SAMPLE LOCATIONS

TABLE 4-1

Water quality of 8 rivers sampled in August, 1979 in Southwestern Nova Scotia

River		Ca	Mg	Na	K	Alk	SO_4	Cl	PO_4	Total Phosphate	NO_3 + NO_2 as N	NH_4 as N	Fe	Mn	TDS	SS	Colour	Turbidity	Conductivity	pH	TDC	Humic Acids	T
Spectacle Brook	1	2 8	1 5	7.3	0.6	7.0	2.0	12	0.09	0.12	0 09	<0.05	0 59	0.08	70	1.5	500	1.2	56	6 0	28	51	15
Salmon River	2	2 2	1 6	6 0	0 4	2.0	2 0	10	<0 02	0.08	<0.05	<0 05	0.62	0.07	68	2 5	550	1 7	51	4 8	31	52	19 5
Meteghan River	3	1.8	1 2	5.2	0.4	3 0	1.5	9	<0 02	0 09	<0.05	<0 05	0 49	0 08	53	2.5	350	1.2	44	5.7	19	32	19.8
Barrington River	4	1 3	1.2	5 2	0 3	<1.0	1.5	9	0.05	0.09	<0.05	<0.05	0.56	0.03	67	1.8	550	1.5	50	4 3	34	53	19.8
Clyde River	5	2.8	1.2	4 0	0 2	3.5	1.5	6.2	<0.02	0.08	<0 05	<0 05	0 62	0.02	57	1.0	450	1.6	40	4.3	32	50	20.2
Roseway River	6	1.6	0.9	3 3	0 2	<1 0	2 0	5	<0.02	0.04	<0.05	<0 05	0 36	0.02	53	1.3	500	1.7	35	4.3	31	48	21
Jordan River	7	1.8	1.0	3.3	0.2	1.0	1.5	5	0.04	0 05	<0 05	<0.05	0 42	0.02	53	1.0	600	1.4	36	4 4	34	52	22 5
Sable River	8	1 6	1.2	4 1	<0 2	<1.0	2 0	7	<0.02	0.05	<0.05	<0 05	0 87	0 04	7 7	0 8	700	1.2	46	4.1	43	73	24
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	TCU	JTU	µmho/cm	unit	mg/l	mg/l	°C

TABLE 4-2

Major ionic concentrations in Nova Scotia Lake Waters, with respect to typical salt water and freshwater of the World.

	Ionic Proportions (% meq/1)						
Lake Type	Na	K	Ca	Mg	Cl	SO_4	Alk.
On Granite	55	3	14	28	73	11	16
On Meguma	55	3	15	26	73	13	14
Average Freshwater (Gorham, 1957)	16	3	64	17	10	16	74
Average Seawater (Chow, 1964)	77	2	3	18	90	0	.5

TABLE 4-3

Mean Groundwater Quality, Goldenville Formation and Granite

Hydrostratigraphic Unit	Na	K	Ca	Mg	$CaCO_3$ (Hardn)	$CaCO_3$ (Alkal)	SO_4	Cl	F	SiO_2	NO_3 + NO_2 as N	NH_4 as N	As	Fe	Mn	Copper	Zinc	Lead	PO_4 as Ortho	Suspended Solids	Total Dissolved Solids	Colour TCU	Turbidity JTU	Conductivity Umhos	pH (Lab)
Goldenville Formation	26 3	2 8	27 5	5 1	84 3	66 1	16 9	47 9	<0 1	13.9	0 4	<0 05	<0005	0 34	0 19	0 03	0 2	0005	0 07	4 0	19 1	13 6	2 8	299 6	7 4
Granite	32.1	1.7	9 6	2.9	36 3	60 3	6 1	31 4	0.9	18 0	<0 05	0 07	0005	0 62	0 10	0 06	0 04	0 01	0 13	8.9	147.3	18.2	6 1	213 5	7.14

mg/l. The mean hardness is 84 mg/l (as $CaCO_3$) which is in the low to moderate range. Hardness ranges from 35 to 275 mg/l.

Total dissolved solids average 191 mg/l and range from 103 to 491 mg/l. Alkalinity averages 66 mg/l (as $CaCO_3$) and ranges from 40 to 132 mg/l. The average pH is 7.4 and the range varies from 5.2 to 8.2.

4.2.3 Granite

The waters appear to be calcium and sodium chloride to calcium and sodium bicarbonate. Iron and manganese average 0.62 and 0.10 mg/l respectively and range from 0.03 to 3.1 mg/l for iron and 0.04 to 1.4 mg/l for manganese. Hardness averages 36 mg/l and ranges from 3.5 to 330 mg/l. Average alkalinity is 60 mg/l ranging from 19 to 146 mg/l. Total dissolved solids averages 147 mg/l and ranges from 60 to 803 mg/l. The average pH is 7.1, ranging from 6.1 to 8.4.

4.2.4 Other Hydrostratigraphic Units

Too few water samples were taken from the Halifax Formation, Whiterock Formation and adjacent volcanics to allow meaningful interpretation. It should be pointed out that the number of potential sampling points appears limited in these groups in that there is poor regional distribution of drilled wells.

CHAPTER 5
HYDROMETEOROLOGY DATA

5.1 Introduction

Hydrometeorological data have been collected and analyzed to obtain estimates of available surface and groundwater resources.

Basic meteorological data were obtained from the Atmospheric Environment Service (Environment Canada, 1967 and later editions). Hydrometric data were obtained from Water Resources Branch, Inland Waters Directorate (Environment Canada, 1977, and later editions). The stations are shown on Figure 5-1.

An attempt was made to get hydrometric data from two streams in the gap between the Meteghan and Roseway Rivers. Due to changes in the controls (channel characteristics) and the absence of streamflows that were low enough to provide satisfactory rating curves, no useful data could be collected. Along with the information presented in this chapter, an exploration of different approaches for estimating groundwater flow has been made. The mechanics of the methods are set forth along with their results, and comparative conclusions.

5.2 Methodology

Using the 14 years of streamflow records available, tabulations and calculations were made to find maxima, means and minima of runoff and water loss. Drought frequency curves of the Meteghan and Roseway Rivers were also calculated. Curves of firm flow as a function of lake storage were calculated from the mass curve for 1964-65 for both rivers, with emphasis placed on low summer discharges during the four months of June, July, August and September.

5.3 Precipitation

Precipitation is comparatively uniform over the study area. Table 5-1 shows the average annual precipitation recorded at Baccaro, Cape Sable, Roseway, Tusket, and Yarmouth is 1259 mm. The average at Kemptville, New Grafton and Lake Rossignol is 1335 mm. The overall average is 1273 mm. In round numbers, the annual precipitation is in the order of 1200 mm along the coast, with the exception of Roseway at 1400 mm. In the watersheds of northerly and southerly flowing streams, the annual precipitation is in the order of 1400 mm.

5.4 Temperatures

The mean annual temperature, 1941-70, for Baccaro, Cape Sable, Meteghan, Roseway and Yarmouth "A" ranges from 5.9 °C at Cape Sable to 7.0 °C at Yarmouth "A". The overall average was 6.5 °C. A similar pattern of temperatures for the basins of the Meteghan and Roseway Rivers is shown in the 1971-72 hydrothermographs in Figures 5-5 and 5-6.

5.5 Hydrometric Stations

At the present time (1982), there are two active stream gauging stations, one at Meteghan River and the other at Roseway River. The locations of these stations are indicated on Figure 5-1 and in Table 5-2 which also shows mean discharge. A third station exists on the Tusket River but flows are

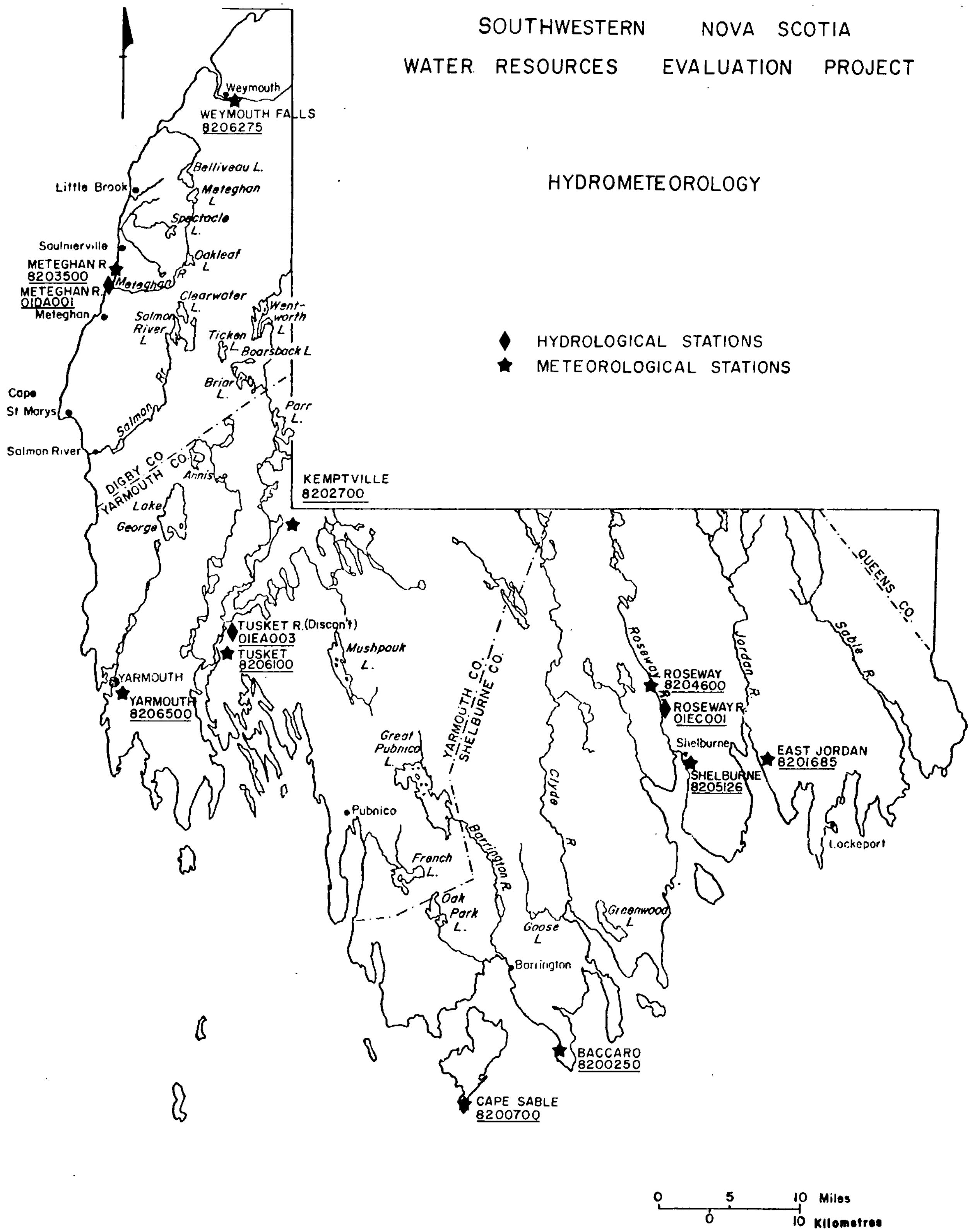


FIGURE 5-1 HYDROMETEOROLOGY

TABLE 5-1

Annual Mean Precipitation
(period 1941-70)

Station	Location Lat.	Long.	Years of Record	Approximate Elevation (m)	Precipitation (mm)
Baccaro	43 28	65 28	13	3.0	1286
Cape Sable	43 23	65 37	16	3.0	1232
Kemptville	44 06	65 37	17	61	1416
Lake Rossignol	44 13	65 14	25	85	1265
New Grafton	44 25	65 11	17		1325
Roseway	43 37	65 21	21	15	1411
Tusket	43 53	65 58	20	11	1283
Yarmouth"A"	43 50	66 05	30	41	1084

TABLE 5-2
Hydrometric Stations

Basin	Meteghan	Tusket (Wilson's)	Roseway
Number	01DA001	01EA003	01EC001
Drainage Area (km^2)	167	1070	496
Latitude	44-12-58	43-55-24	43-50-18
Longitude	66-07-02	65-52-12	65-22-12
Period of Record Used	1965-79	1930-79	1918-79
Annual Discharge			
Maximum ($m^3 x 10^6$)	210	1390	720
Maximum (mm) on Drainage Area	1258	1299	1452
Year of Occurrence	1977	1959	1959
Mean ($m^3 x 10^6$)	155	1030	509
Mean (mm) on Drainage Area	928	991	1026
Minimum ($m^3 x 10^6$)	98.7	604	293
Minimum (mm) on Drainage Area	591	565	596
Year of Occurrence	1965	1965	1965

discharge drops sharply and then rises again. It appears that this short decrease of flow could be neglected in the monthly mean discharges, and in annual yield.

The Roseway River has natural flow from a drainage area of 495 km^2 (191 $mi.^2$), with records from 1918 to the present. Although there is a hydroelectric dam on the river, it is approximately 3.5 miles downstream from the gauge site and is considered not to have affected those records.

Historical records are available for the Tusket River which is not controlled by hydroelectric plants. This stream gauging station was discontinued on April 1, 1979. Natural streamflow records were obtained for the period 1915-29, before the station was fully constructed. The long term data are noted as "regulated".

However, analysis of the records gives some evidence that the runoff is comparatively uniform over the entire study area, in terms of depth (mm) over a drainage area.

5.5.1 Mass Curves

Mass curves are an established and convenient method utilizing records of streamflows to estimate the reliable yield from storage in the basin. The curve plotted from the cumulative yield of the basin in units of m^3/km^2 on the vertical axis, against time in days on the horizontal axis. Critical periods of low summer flows and discharges which increase during the fall and the spring snowmelt appear clearly. From these critical periods, relations of storage/km^2 of watershed area, and firm yield from the basin in units of m^3 /day may be determined and plotted on a "Firm Flow Curve".

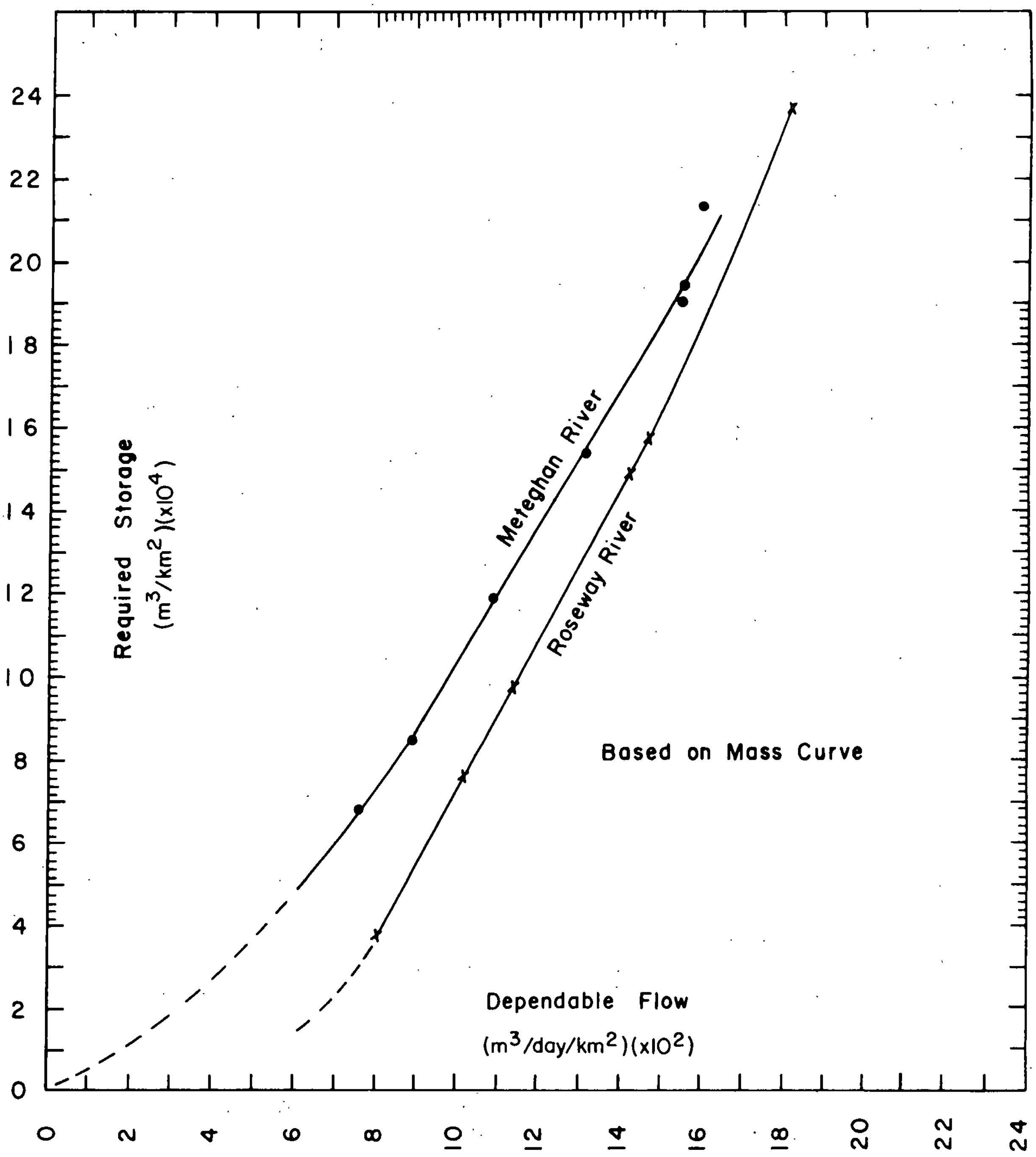
Calculations were made for the Meteghan and Roseway Rivers for the critical flow year of 1965-66. The unit storage required and the corresponding firm flows are shown on Figure 5-2. The curves rise steeply at high values of firm flow. Often these higher storages could only be obtained from a period of more than one year of inflow. The best accuracy of the curves falls approximately between the limits of about 5 to 20 x 10^4 m^3/km^2. They indicate a maximum firm flow in the order of about 17 m^3 /day-km^2.

If it were assumed that a dam is installed to raise the water level by about 0.9 m (3 ft.) above the normal water level the firm yield would be in the order of twice that shown in the table of lake yields. This estimate would assume nearly a linear relation between storage and firm flow over the central part of the curve.

5.5.2 Precipitation-Runoff Correlation

Gray (1968) states "Professor Ayers shows that a Linear Annual Precipitation-Runoff Relationship may be used. A form may be used in which watershed yield and evaporation on an annual basis are made to increase in a linear fashion with the precipitation. Because there may be distinct seasonal differences in the evaporation demands resulting in soil moisture storage depletion, there are frequently large inconsistencies in the partitioning of precipitation between runoff, evapotranspiration and soil moisture or groundwater recharge from season to season.

FIGURE 5-2 STORAGE vs DEPENDABLE FLOW



STATION #
METEGHAN RIVER 01DA001 167 km^2 Dry Years 1965-67

STATION #
ROSEWAY RIVER 01EC001 495 km^2 Dry Year 1965-66

"The method of multiple linear regressions for seasonal precipitation has been used. It has been shown that an improved correlation coefficient may be found by using water years at various starting dates, instead of using the regular calendar year".

Runoff may be expressed as:

$R = mP \pm b$

where:
R = runoff (mm over the drainage area)
P = precipitation
m = slope coefficient
b = intersection point

This method was applied to the precipitation and runoff for the Meteghan and Roseway Rivers for 13 years (modified water years). The results are:

Meteghan: R = 0.84 P-63 with a correlation coefficient of 0.88
Roseway: R = 0.82 P-110 with a correlation coefficient of 0.93.

These equations show a strong similarity in the two river basins as indicated by the closeness of correlation coefficients and slope coefficients.

5.6 Drought Frequency Curves

Drought frequency may be applied (a) to groundwater yield and (b) to total streamflow. If the minimum daily discharge for the summer months of June to September was selected, the resulting curve would approach the groundwater yield. During some of the months, the discharge would contain a component of surface flow and interflow.

A drought frequency curve could be made for any single summer month or for the average flow of the four months. During this study the lowest flows were in the summer months but it is possible the lowest flows may occur in winter, under ice.

Curves for the total summer yields from June to September inclusive for the Meteghan and Roseway Rivers are shown on Figures 5-3 and 5-4. The drought frequency curve precipitation is plotted on the same sheet.

A comparison between the drought frequency curves for the Roseway and two stations on the Tusket before the river became controlled by the hydro-electric plant shows that the natural flow of the Tusket River might be close to the averages for the Meteghan and Roseway.

5.7 Summer Runoff

Low summer streamflows are very important in a study of water supply. The minimum daily mean flow for the summer months may be used in the calculation of a drought frequency curve for the basin. This minimum flow may contain groundwater plus bank storage and overland flow.

5.7.1 Surface Water

Over the 14 year period for 1963-78 the total of 4 months summer minimum yield gave results shown in Table 5-3.

Comparisons between recession curves and actual data suggest:
1. Flows in May often plot above the curve.
2. Some minimum months also plot above the curve.

This indicates that groundwater yields will be less than those indicated by the monthly records.

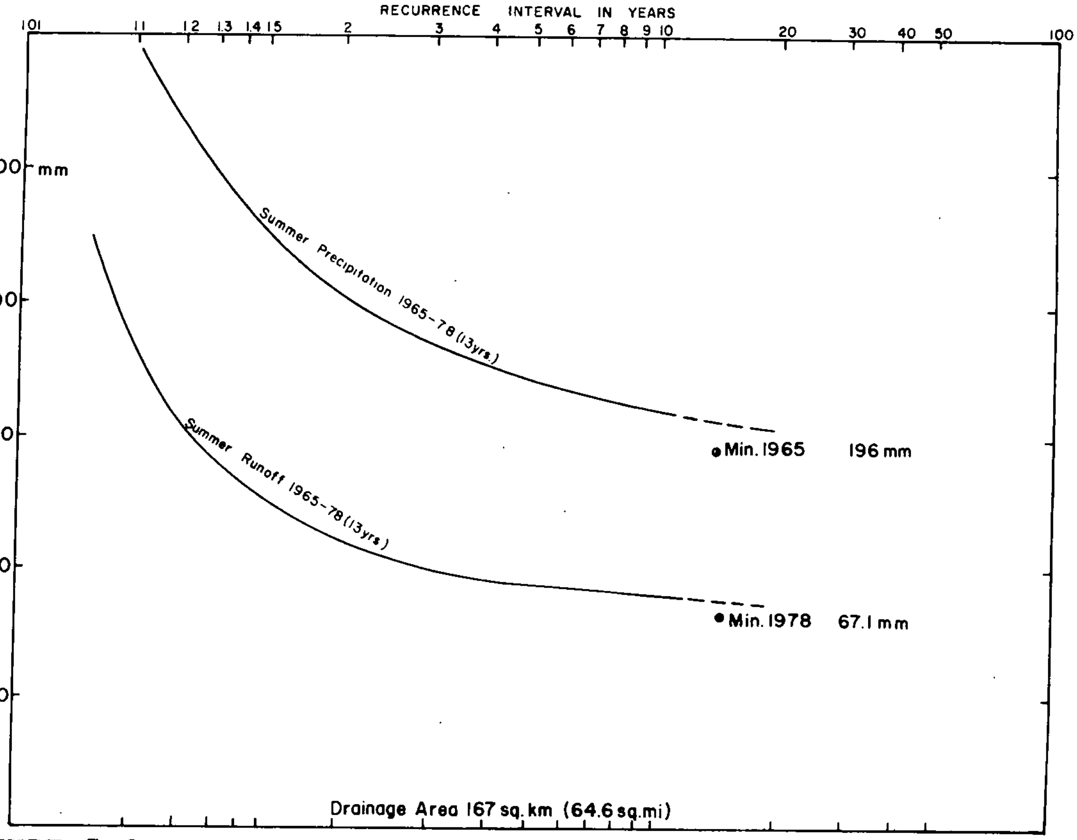


FIGURE 5-3 DROUGHT FREQUENCY CURVES - Meteghan River Sta. 01DA001 (June-Sept. inc.)

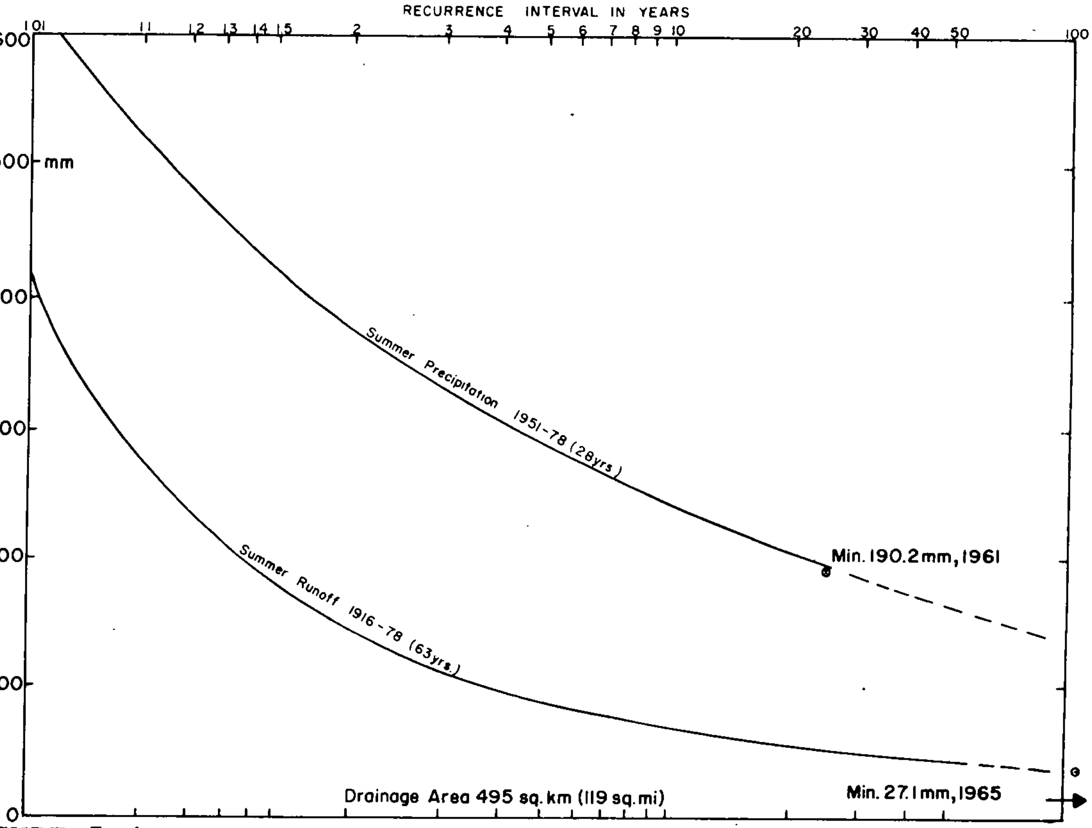


FIGURE 5-4 DROUGHT FREQUENCY CURVES - Roseway River, Sta. 01EC001 (June-Sept. inc.)

TABLE 5 - 3

Surface Water Recession (1963 - 1978)

	Meteghan	Roseway
Maximum 4-month Yield ($m^3 \times 10^6$)	33.8	86.5
Year of Occurrence	1973	1973
Mean 4-month Yield	14.9	33.5
Minimum 4-month Yield	7.3	10.5
Year of Occurrence	1978	1965
Ratio of (4 month total/annual total) Discharge	0.10	0.07

TABLE 5 - 4

Groundwater Recession
Meteghan (example)

	$m^3 \times 10^6$	mm over drainage area	Year of Occurrence
maximum	23.0	131	1969
mean	10.3	59	-
Minimum	2.5*	14	1968

* omitting 1979

The basic principle of the Kunkle (1962) method of finding the groundwater component of streamflow is to draw a recession curve touching several of the minimum monthly discharges. Usually at least one of the summer minimum discharges will plot above the curve. On semi-logarithmic paper, the recession curve plots as a straight line and has the equation:

$$Y = Y_0 e^{Kt}$$

Where: Y = groundwater yield (m^3/s)
Y_0 = minimum yield (m^3/s)
K is determined by trial and error
t = time

The area under the recession curve may be calculated for a time interval, after the constant "K" has been determined from the hydrograph curve which is established by trial and error.

On the hydrograph of the Meteghan River during 1971-2, (Figure 5-5), the recession curve might have been drawn at a steeper slope to approach the minimum streamflow at the end of April. Twelve summer recessions were calculated as an example and the results are given in Table 5-4.

The hydrograph curve of the Roseway River 1971-2, Figure 5-6, might have been drawn to the low streamflow on the first of May. The objection to this plot is the excessive interval from the curve to the low flows during June, July and August.

5.8 Annual Groundwater Yields

The annual groundwater yield is difficult to estimate due to the shortage of reliable data. Streamflows that may be accepted as groundwater are:

a) Minimum monthly discharge in October or November.
b) Minimum monthly discharge in January, February or March, when there is a seepage from the banks in the channel.
c) Minimum monthly discharges in June, July, August or September.

To obtain an estimate of the annual groundwater yield the hydrograph is divided into three separate portions as shown in Figures 5-7 and 5-8. In fact, sharp breaks as seen in Figures 5-6 and 5-7 are unlikely to occur. They were drawn to emphasize the use of the recession equation. A smooth curve would be more realistic.

The curves for other basins will vary in shape, but the general pattern of rising and falling limbs will be similar.

5.8.1 Modified Water Year

A "modified water year" extending from the lowest flow in one year to the lowest flow in the following year was used as an alternative to the previous method. Often this period was longer than the regular water year of October 1 to September 30. Under this condition, the effect on change of storage is minimal.

A statistical analysis was made of the annual groundwater yield using the Log Pearson III distribution method. Small values of skewness and approximately normal distribution resulted. The theoretic norm of best fit is a straight line through (x-s), 15.9%; (X), 50%; (x+s), 84.1%. These three coordinates are shown on Figure 5-9. The projection of the straight lines to ($x \pm 2s$) has little

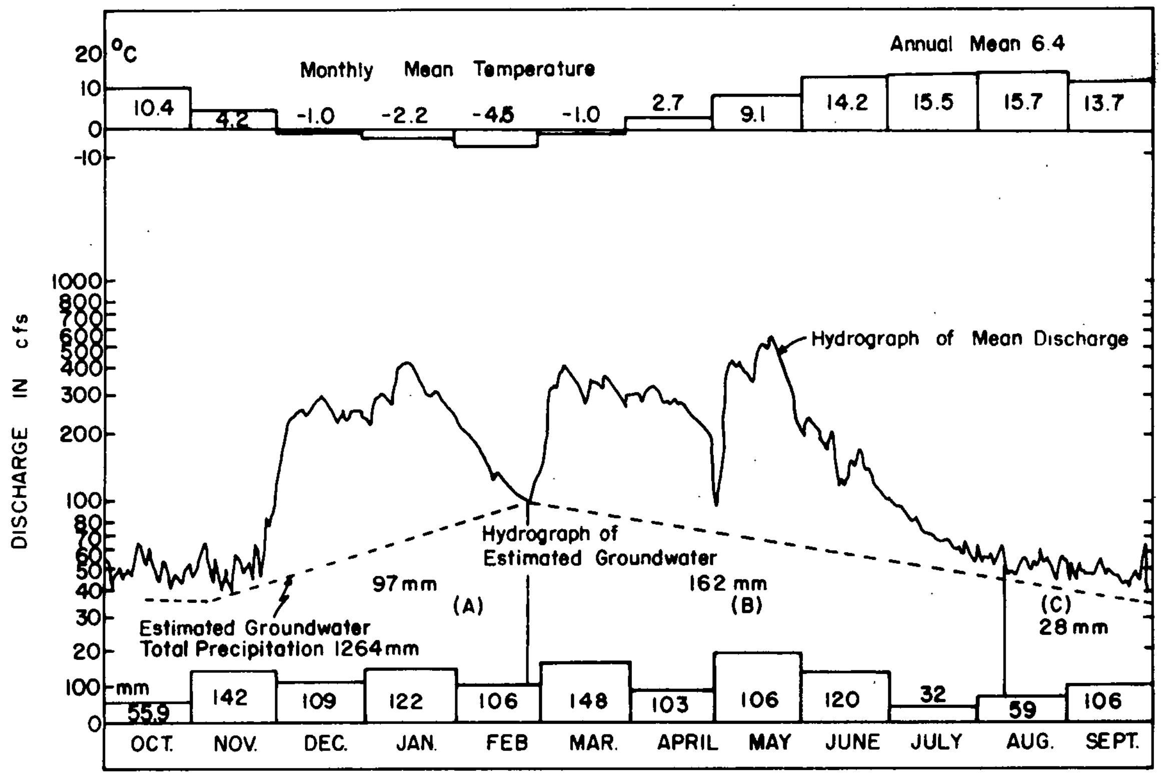


FIGURE 5.5 DISCHARGE HYDROGRAPH, METEGHAN RIVER NEAR METEGHAN, 1971 – 72

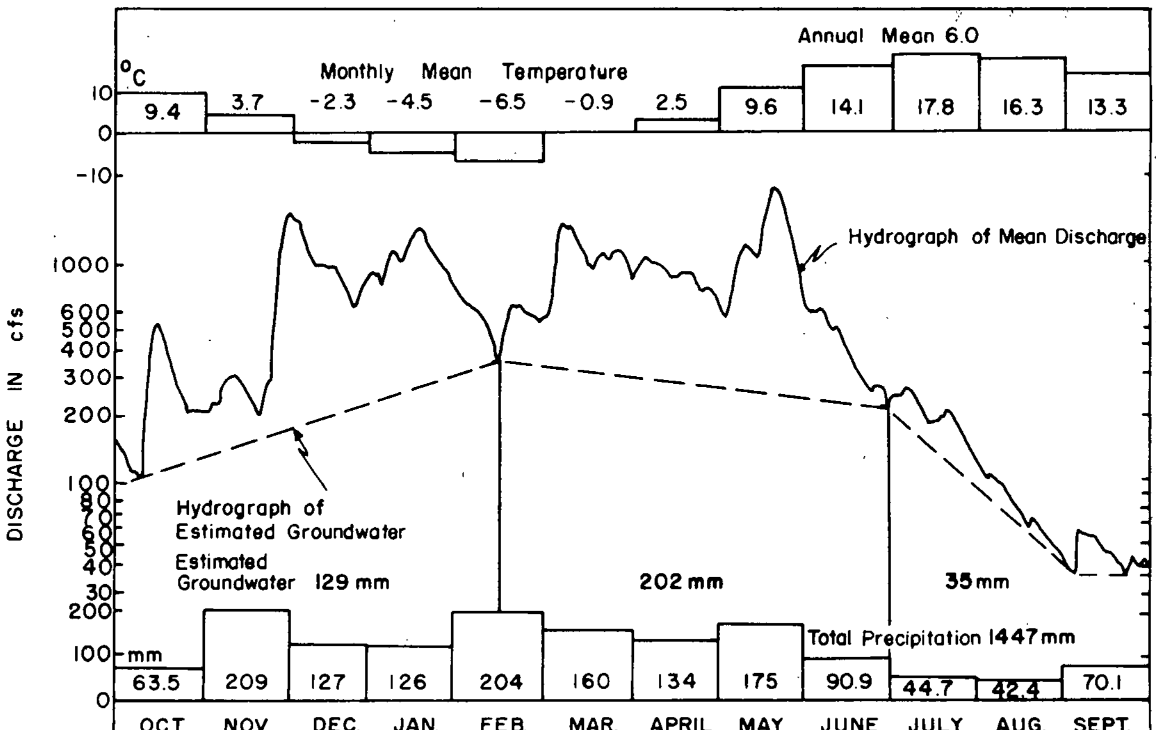


FIGURE 5–6 DISCHARGE HYDROGRAPH, ROSEWAY RIVER AT LOWER OHIO, 1971 – 72

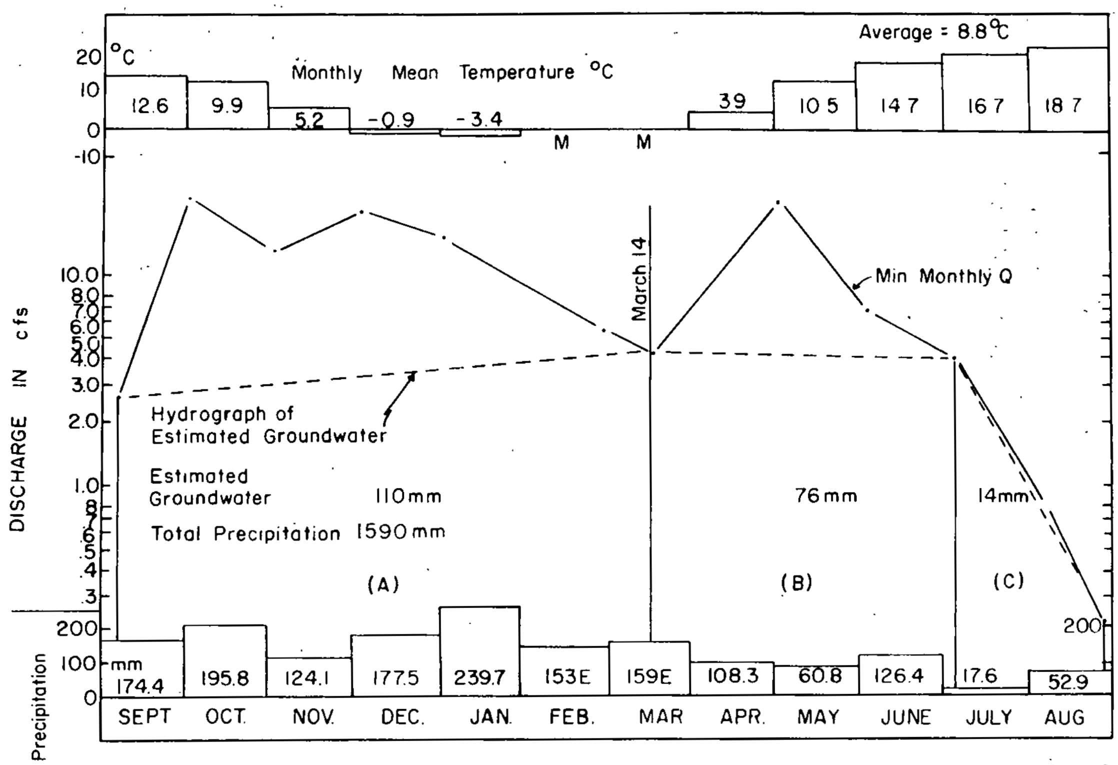


FIGURE 5-7 HYDROGRAPH OF MINIMUM MONTHLY DISCHARGE, ROSEWAY RIVER, 1977 - 78

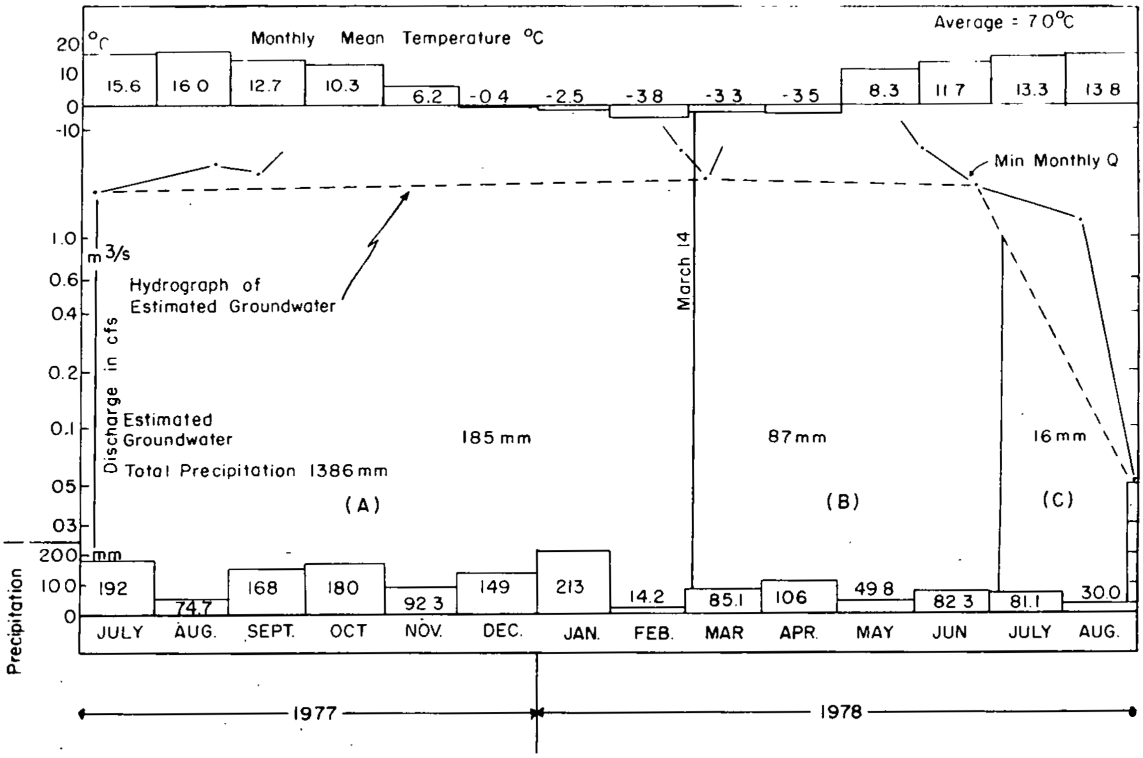


FIGURE 5-8 HYDROGRAPH OF MINIMUM MONTHLY DISCHARGE, METEGHAN RIVER, METEGHAN

significance in this case because of the few years of data. The length of period of records affects the coefficient of skew.

The curves for the Meteghan and Roseway Rivers fall near each other and are practically parallel indicating that the mean of the curves should provide a useful estimate of the groundwater yields between these basins.

5.9 Curve for Groundwater Hydrograph

The study of groundwater data indicates that the most reliable coordinates for a hydrograph during the water year occur in: (a) October, (b) the minimum streamflow during January or February or March, and (c) the minimum flow in June, July, August and September. Often only two points during the four summer months can be accepted as the other two fall above the best fitting recession curve.

The groundwater hydrograph may be divided into three parts: (a) autumn and early winter, (b) mid-winter to the end of May, and (c) early June to the lowest yield in September. For any individual year these logistic curves may not coincide with the curves plotted on semi-logarithmic paper; however, the average of a number of years of records gives an indication that this method may have possibilities worth further study.

5.9.1 Application: Roseway River, Dry Year, 1977-78

Several methods of calculating the yield of the groundwater hydrograph were used. The basic data are the summer flows in June to September. These were plotted on Figure 5-10 on arithmetic coordinates, and on Figure 5-11 using semi-logarithmic paper.

The first decision is the selection of the coordinates that will approximately fall on the recessional curve. The flows of July, August, and September were selected. The curve was projected backward to May 31 to give an estimated groundwater flow of 3.60 m^3/s, Figure 5-10. The following are three methods used to approximate groundwater:

A. First Method:

The areas under the curve were calculated by the equations

(1) $q = Q_o e^{Kt}$

(2) $K = \ln(q/Q_o)/t$

(3) Yield = $c\ Q_o e^{Kt}/K$

where:

(4) $c = 8.64/W$ (W = Drainage Area in Km^2)

B. Second Method:

If the value of K is small, equation (1) approaches :

(5) $y = a + bt$ (linear).

The area under the section of the curve approaches that of a trapezoid or

(6) Yield = $c\ (Q_o + Q_1)\ (t_1 - t_o)/2$

C. Third Method:

Assume that the hydrograph follows the logistic curves:

(7) $Q = Ae^{(-B_1 e^{k_1 t})}$

(8) $Q = Ae^{(-B_2 e^{k_2(t-t_2)})}$

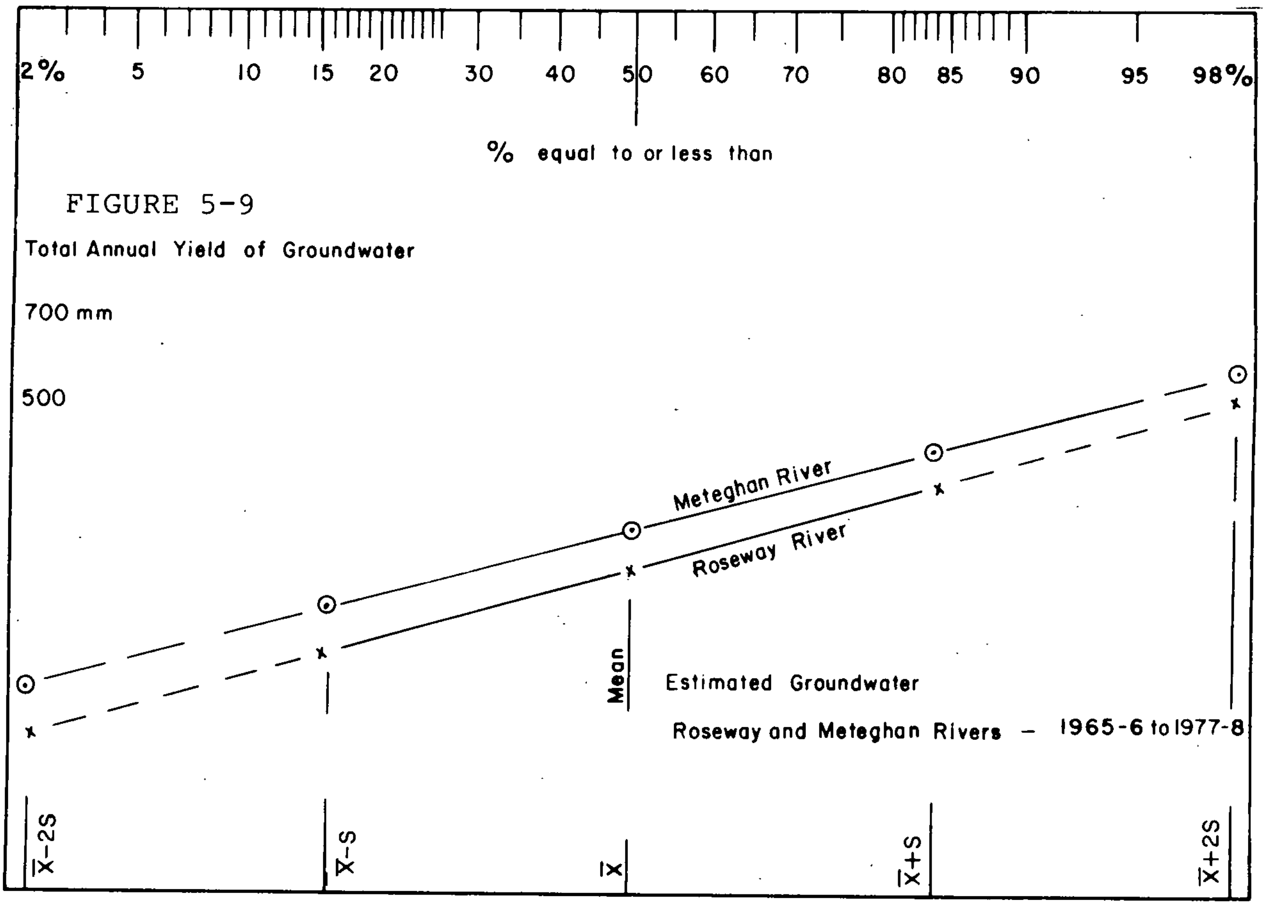


FIGURE 5-9

Total Annual Yield of Groundwater

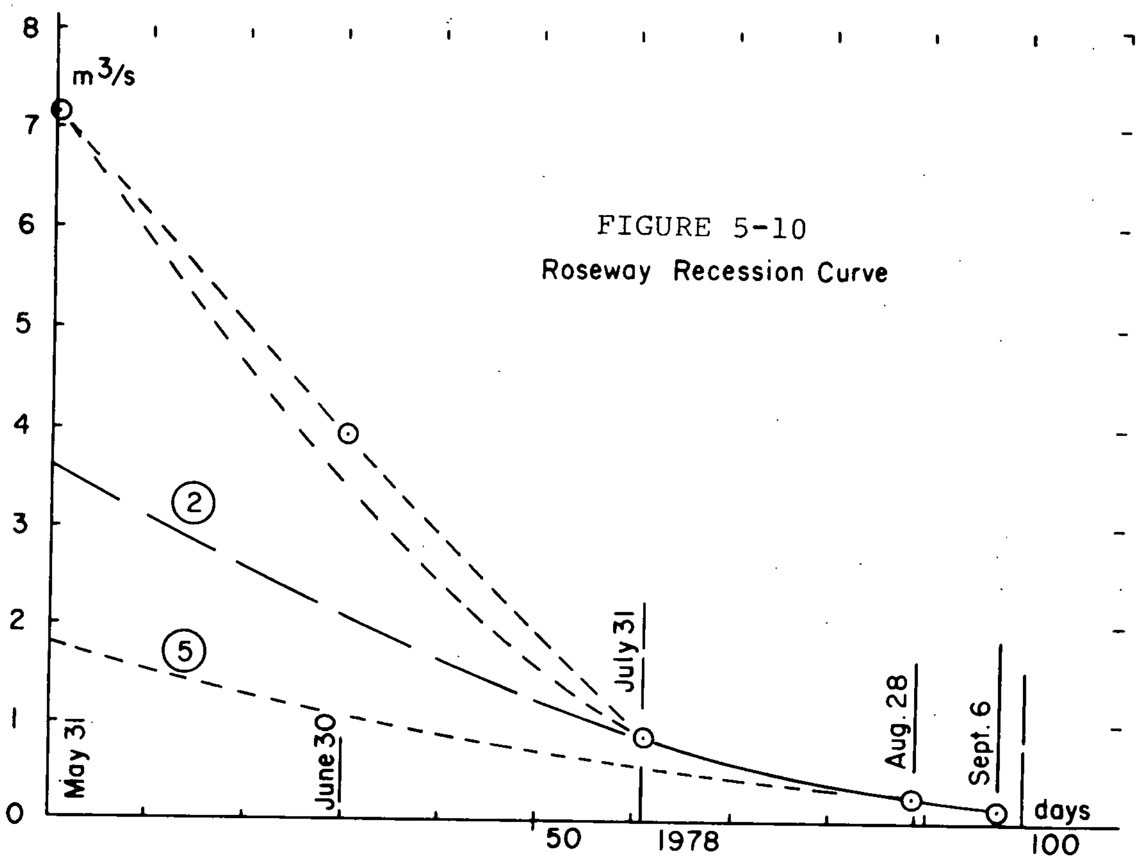
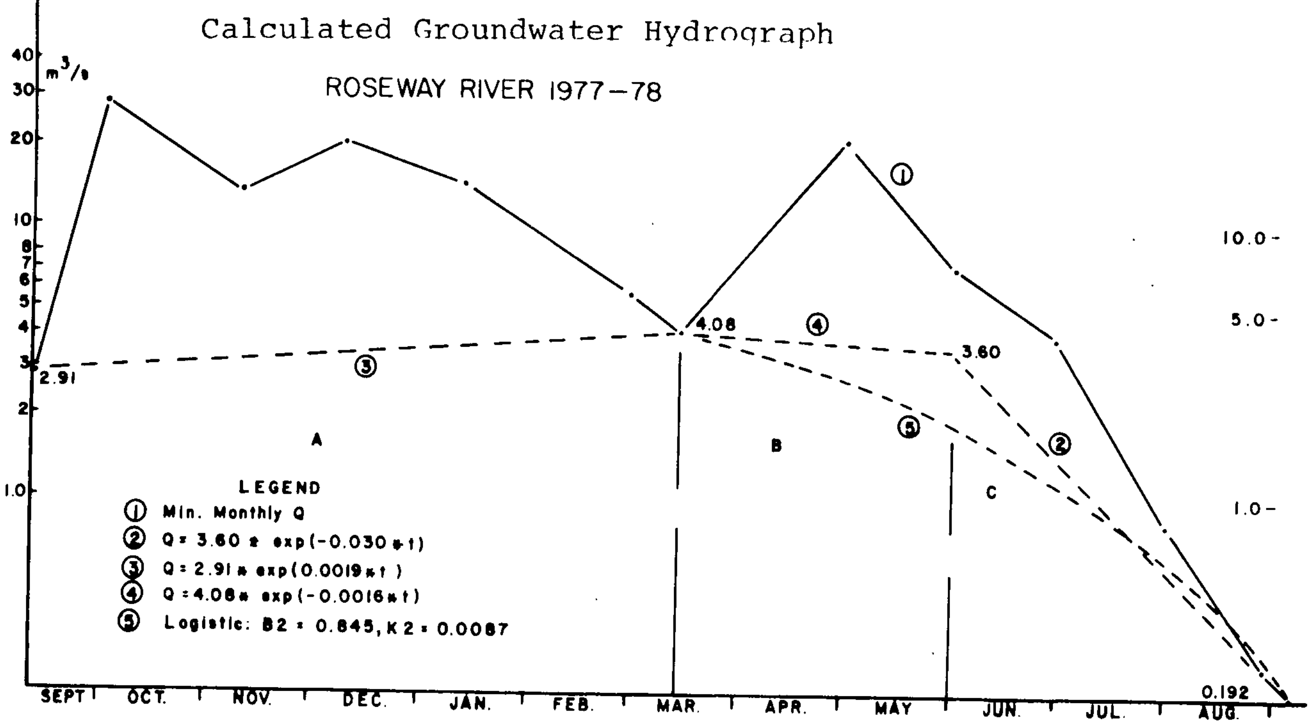


FIGURE 5-10

Roseway Recession Curve

FIGURE 5-11



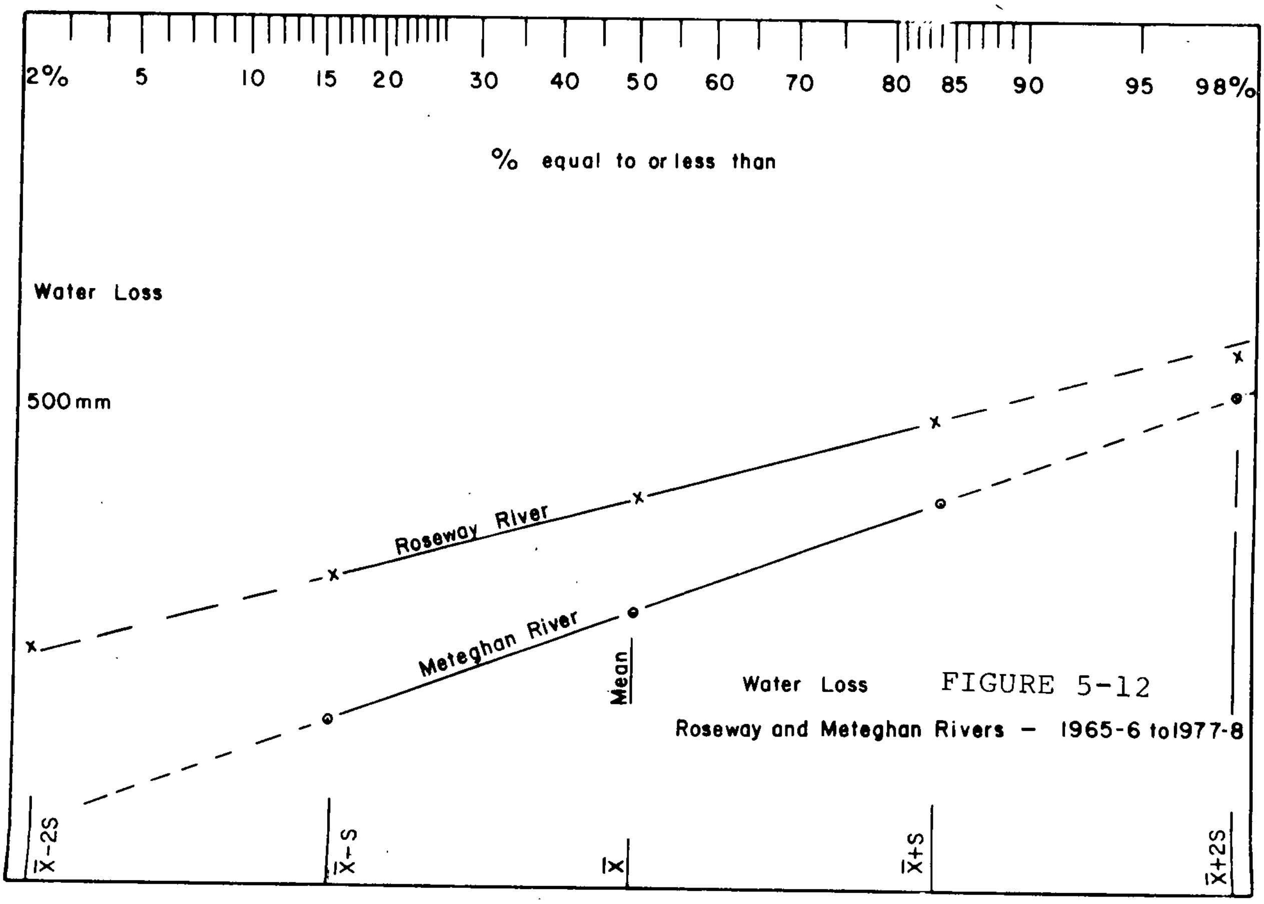


FIGURE 5-12

Water Loss

Roseway and Meteghan Rivers – 1965-6 to 1977-8

The input is initial t and Q; winter t and Q; and final t and Q.

In this method, the selection of early summer points is eliminated. It is assumed that these three coordinates will provide the necessary parameters for the rising and falling limbs of the logistic curve.

After the equations are completed, values of Q for any desired increment of time, and the area under the three sections of the hydrograph may be determined.

5.9.2 Results

The final curves are plotted on Figure 5-12. The calculated yields are shown in Table 5-5.

Comparison:
For the fall and early winter period (1) the results are within 1%. In the winter-spring period (2) method (A) and (B) give values within 1%. The greatest variation appears in the summer period. (3) The most acceptable result is method (A).

The sharp break at May 31 is very unlikely to take place, probably the correct hydrograph would be midway between curves (2), (4) and (5).

5.9.3 Suggested Approach

With varying ranges of Q and t, the following is a suggested approach:

(1) Use the modified water year, from the lowest monthly streamflow of one year to the lowest monthly streamflow in the following year.
(2) If the maximum, mean and minimum groundwater yields for 10 years of data, or more, are to be found, use the trapezoidal method to find these yields, and the nearest year of occurrence. For these three years, repeat with method (A) or (C).
(3) If the coordinates of the hydrograph are desired, as in searching for a correlation between groundwater flow and the elevation of water in wells, use the logistic method.

The arrangement of the equations suggests that a computer program would be desirable. They may be calculated by a programable hand calculator.
(4) For the summer months, use the first method, preferably making a quick plot of the minimum monthly yields, and sketching the recession curve on both arithmetic and semi-logarithmic paper.

5.10 Water Balance

The water balance equation may be rewritten: R = P - W.L.
where: R = annual runoff at the gauge,
P = annual precipitation
W.L. = Water Loss (Evapotranspiration ± Change of Storage).

The mean of 14 years of data on precipitation and runoff for both the Meteghan and Roseway Rivers are shown in Table 5-6 (A), and the means of 13 modified water years are shown in Table 5-6 (B).

Assuming no change of storage, and the water loss is evapotranspiration, using the data from Table 5-6 for both the calendar year and the modified water year, results were as follows:

The averages of methods (A) and

TABLE 5 - 5

Comparison of Annual Yields of Groundwater

Calculated by Logistic Curves and by Exponential Function

Yield (mm on drainage area)

	Meteghan						Roseway					
	Logistic Curves			$y = Y_0 \exp (K*t)$			Logistic Curves			$y = Y_0 \exp (K*t)$		
Year	Rise	Fall	Total	Rise	Fall	Total	Rise	Fall	Total	Rise	Fall	Total
1977-8	193	116	309	186	102	288	136	90	226	110	90	200
1971-2	108	216	324	97	201	298	212	265	477	155	237	392
1946-77 *	169	229	398	154	236	390	231	215	446	201	176	377
	Average Totals		344			325	Average Totals		383			323
	Ratio: 325/344 = 0.95						Ratio: 323/383 = 0.84					

* Synthetic hydrograph from the mean monthly minimim flow.

(B) give nearly the same results, suggesting that using the simpler calendar year may give a result with consistent accuracy.

For calculations involving mean yields the evapotranspiration is in the order of 250 mm for the Meteghan River and 370 mm for the Roseway River. Conservative estimates of yields may use estimated evaporation ranging from 450 to 500 mm, from Thornthwaite's method.

The water loss calculations were analyzed by the Log Pearson II distribution and the results are shown on Figure 5-12. The curves form a virtually straight line within the limits of ($x \pm s$); beyond these limits, the Roseway shows some curvature that is barely noticeable on the scale plot. As a check, the Roseway was recalculated using 23 years of records. In this case, the longer period showed higher coefficient of skew, and slightly more curvature.

The convergence of the straight lines suggests that, given longer periods of records on the Meteghan River, the two lines will meet, perhaps at ($x + 3s$).

The calculation of evapotranspiration using the Thornthwaite method gives an average of about 500 mm at Truro, and 540 mm at Yarmouth "A". These values occur approximately at a probability of 90% to 95% on the water loss curves. The figures suggest that a year may occur in which the change of storage is negligible, and the total water loss would be evapotranspiration.

5.11 Overall Tabulation of Well Data

Wells were selected from the records noted "Domestic", and these data were grouped according to Nova Scotia Department of Mines map code. The name of a town or village was added as a reference. The mean standard deviation of well depth and yield were calculated; the results are shown in Table 5-7 and Figure 5-14.

Because of the small number of wells in each group, the results have a low statistical value. However, they give general indication of yields in the study area.

The overall mean depth and mean yield of the 256 wells were 51.47 m (169 ft.) and 36 litres/min (8 igpm). For the depth, the coefficients of variation (Cv) were in the order of 0.33 to 0.67; for the yields, they were in the order of 0.76 to 1.71. Such values of Cv might be expected from wells drilled into granite bedrock.

Wells were selected from those plotted by the project team on maps of the Crown Land Forestry Series, Scale 1:15840 (1 inch = 1320 ft.). The well logs had been previously sorted into these grid blocks as TS10-1, TS10-2, ... As the logs had the entries "D, Domestic", and "I, Industrial", a grid block could contain data on well yields.

Three regions were selected for trial; Cape Sable Island, Shelburne and Meteghan. Cape Sable Island is an area with a large concentration of fish plants

TABLE 5 - 6

Water Loss Calculations

(A) Calendar Year

		Meteghan	Roseway
Precipitation	mm	1175	1436
Runoff	mm	912	1077
Water Loss	mm	267	359
Ratio: Runoff/Precipitation		0.78	0.75

(B) Modified Water Year 1965 - 6 to 1977 - 8

		Meteghan	Roseway
Precipitation	mm	1181	1443
Runoff	mm	933	1074
Ratio: Runoff/Precipitation		0.79	0.74
Water Loss	mm	248	369

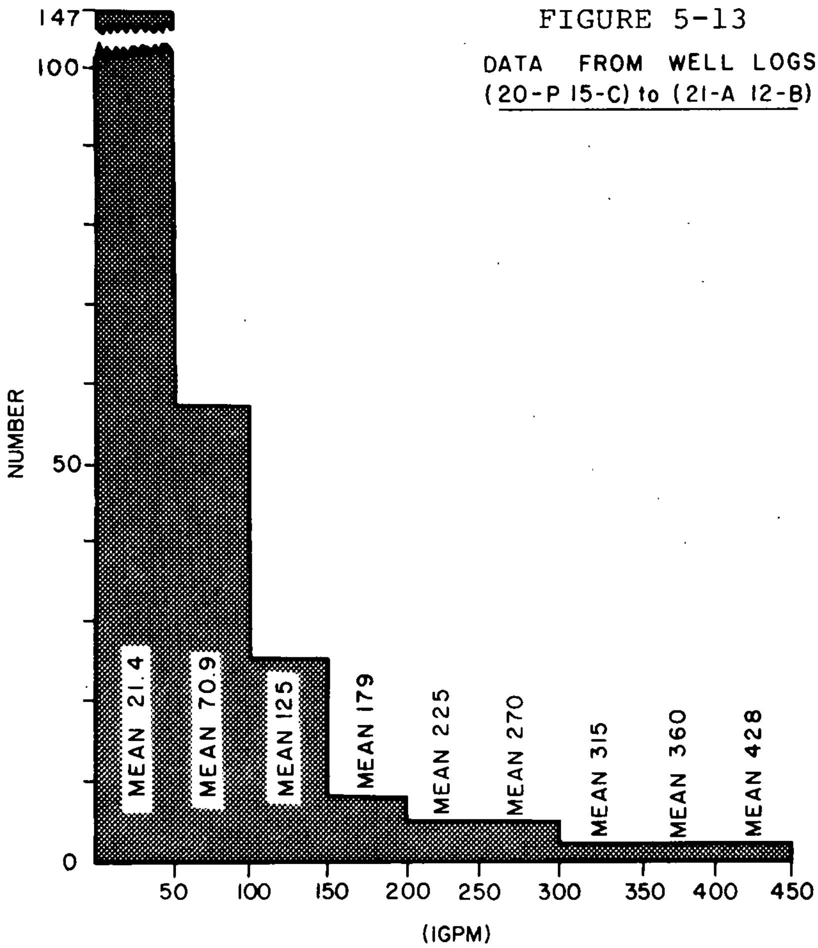
TABLE 5 - 7

Summary
Domestic Well Yields
Southwestern Nova Scotia

Location Mining Tracts	No.	Depth Mean (m)	Std. Dev.	Cv	Yield Litres/min. Mean	Std. Dev.	Cv	Reference
(20-P 15-C) and (20-P 15-B)	7	38.24	15.62	0.41	25	21	0.83	Port Joli
(20-P 11-D)	17	53.59	21.85	0.41	15	18	1.22	Lockeport
(20-P 14-A) and (20-P 14-D)	11	43.18	17.01	0.40	27	21	0.76	Sable River
(20-P 11-C)	21	47.40	21.55	0.45	17	17	1.00	Birchtown
(20-P 14-B)	16	53.42	21.43	0.40	73	79	1.08	Shelburne
(20-P 11-B) and (20-P 6-C)	11	66.33	44.64	0.67	13	13	1.00	Port Clyde
(20-P 5-D)	19	69.89	36.17	0.52	14	18	1.26	Cape Sable Is.
(20-P 12-A) and (20-P 12-B)	12	59.28	19.53	0.33	90	154	1.71	Barrington
(20-P 13-B) and (20-P 9-D)	15	57.22	22.51	0.39	28	35	1.26	Tusket
(20-P 12-C)	23	37.05	24.56	0.66	23	18	0.78	West Pubnico
(20-O 16-A)	26	58.41	39.12	0.67	32	35	1.11	Yarmouth
(20-O 16-D) and (20-P 13-C)	10	59.33	36.27	0.61	38	53	1.38	Port Maitland
(21-B 1-A)	10	43.45	16.61	0.38	33	33	1.00	Cape St. Mary
(21-B 1-D)	13	40.15	17.09	0.43	44	29	0.67	Meteghan
(21-B 8-A)	18	51.8	25.16	0.49	58	57	0.98	Church Point
(21-B 8-D)	20	53.42	25.80	0.48	49	44	0.89	Weymouth
(21-A 5-C) and (21-A 12-B)	7	42.81	15.31	0.36	36	29	0.79	Plympton
Mean Depth and Yield		51.47						
TOTAL	256							

FIGURE 5-13

DATA FROM WELL LOGS
(20-P 15-C) to (21-A 12-B)



HISTOGRAM OF YIELDS
FROM 256 DOMESTIC WELLS
SOUTHWESTERN NOVA SCOTIA

and shortage of water. The two others have shown some indications of groundwater potential.

5.11.1 Well Yields

The whole of the Southwestern Nova Scotia study area may be expected to produce yields of 50 litres/min. (11 igpm) or less with few exceptions as shown in Table 5-7. The higher yields are probably the result of groundwater released from the more permeable surficial material, flowing through fractures in bedrock.

CHAPTER 6
SPECIAL PROJECTS

6.1 Introduction

During the course of this project a total of 22 test holes were drilled and several test pits were dug for the primary purpose of groundwater investigation. They also served to confirm surficial deposits.

6.2 Phase I Drilling Program

Test holes were drilled during this phase, 3 near Great Pubnico Lake, 6 near Salmon Lake and 6 in the Saulnierville area.

A. Great Pubnico Lake Area

These holes were drilled along the access road to the lake, in the area of a contact between granite and the Goldenville Formation. This area was chosen because it was suspected that an increase in the size and number of fractures would occur here. This zone of intensified fractures would allow for more storage and increased fracture permeability.

Pump tests were performed and it was concluded that the wells had yields ranging from 36 to 250 L/min (8 to 55 igpm).

B. Salmon Lake Area

Test holes in this area were drilled in sands and gravels. Indication from blow tests indicated yields of approximately 10 L/min (2 igpm). No pump tests were performed.

C. Saulnierville

Test holes here were drilled in an area of glacial outwash having an average thickness of approximately 5.5 metres. Results from one pump test performed indicate a yield of approximately 590 L/min (130 igpm).

6.3 Phase II Drilling and Test Pit Program

During this phase, three major sites were explored. Several test pits were dug, but 3 are of particular interest in the Saulnierville area. A total of 7 test holes were drilled, 3 near the Cape Sable Island causeway, in consideration of the shortage of water being experienced on the Island, and 4 test holes at the end of Popes Road near Lower East Pubnico.

A. Saulnierville

This area, explored by digging test pits is located between the Amirault Road (#542) and the Saulnierville Road (#544) about 200 metres east of Highway #1. The digging showed the water level to be very near the surface and bail tests again indicated yields in excess of 455 L/min (100 igpm). On higher ground at the periphery of the site, only small amounts of water were found.

B. Cape Sable Island

A series of three test holes were drilled in granite at one site near both Barrington Passage and Cape Sable Island. The reason for choosing this site was that it appeared to be at the lower end of a fracture zone. It is located immediately behind an abandoned rock quarry. While yields of 14 to 23 L/min (3 to 5 igpm) were found, this quantity was insufficient to be considered a reasonable supply for Cape Sable Island which is in dire need for a fresh water supply.

C. Lower East Pubnico

An urgent request for a fresh water supply for fish plants in the area, experiencing shortages, resulted in the the investigation of local groundwater potential.

Previous work at Great Pubnico Lake, French Lake and Popes Road, near Upper Woods Harbour verified a contact between migmatite and granite, and indicated an extensive fracture zone with good transmissivity and storage. This along with ready access to a pipeline, lead to the decision to explore the area near an existing good production well at Popes Road.

Four test holes were drilled as shown in Figure 6-1, with the following results:

TH #	Yield (L/min) from blow test
1	7
2	64
3	273
4	273

From this information it was decided to carry out pump tests on the two higher producing wells to assess the potential of the site as a well field.

A series of 4 pump tests were carried out during the period from January 28, 1982 to February 14, 1982 by L. Baird Well Drilling Ltd. and Nova Scotia Department of the Environment staff. Three of the tests (#1, #2 and #4) were performed by pumping individual wells alone and monitoring the remaining wells, whereas test #3 was performed by pumping all three wells together. Pertinent test data and well specifications are shown in Figure 6-6 with the well location indicated on the site plan (Figure 6-1).

Pump tests data were plotted (Figures 6-2, 3, 4 and 5) and calculations carried out to determine the 20-year safe yield (Q_{20}) of the wells. It has been determined that this yield, strictly on the basis of pumping individual wells by themselves, is as follows:

Well PW	Q_{20}	=	385 L/min (85 igpm)
Well TH#3	Q_{20}	=	320 L/min (70 igpm)
Well TH#4	Q_{20}	=	320 L/min (70 igpm)

Calculations for Q_{20} on the basais of simultaneous pumping of wells PW, TH#3 and TH#4 using:

$$Q_{20} = \frac{0.7\,HT}{1848}$$

Where:

H = The total available drawdown, from the average water level to the pump intake.
T = transmissivity

These calculations allow a 30% margin of safety, and assume that the simultaneous pumping will continue uninterrupted for a period of 20 years.

The Jacobs plots were extrapolated to cover a 20-year period. This extrapolation did not allow for the recharge, which became evident during the latter portions of the tests, thus giving a more conservative estimate of the drawdown which would be experienced by 20 years of continuous simultaneous pumping of the wells.

FIGURE 6-1

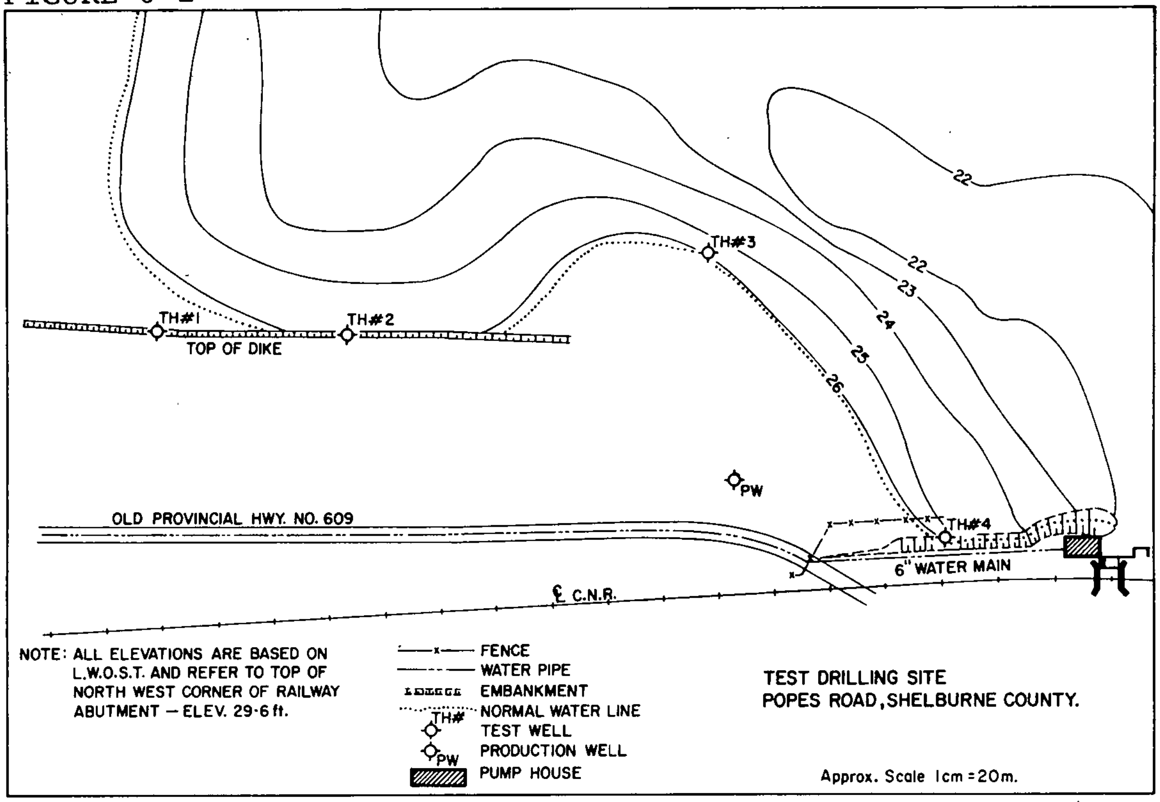
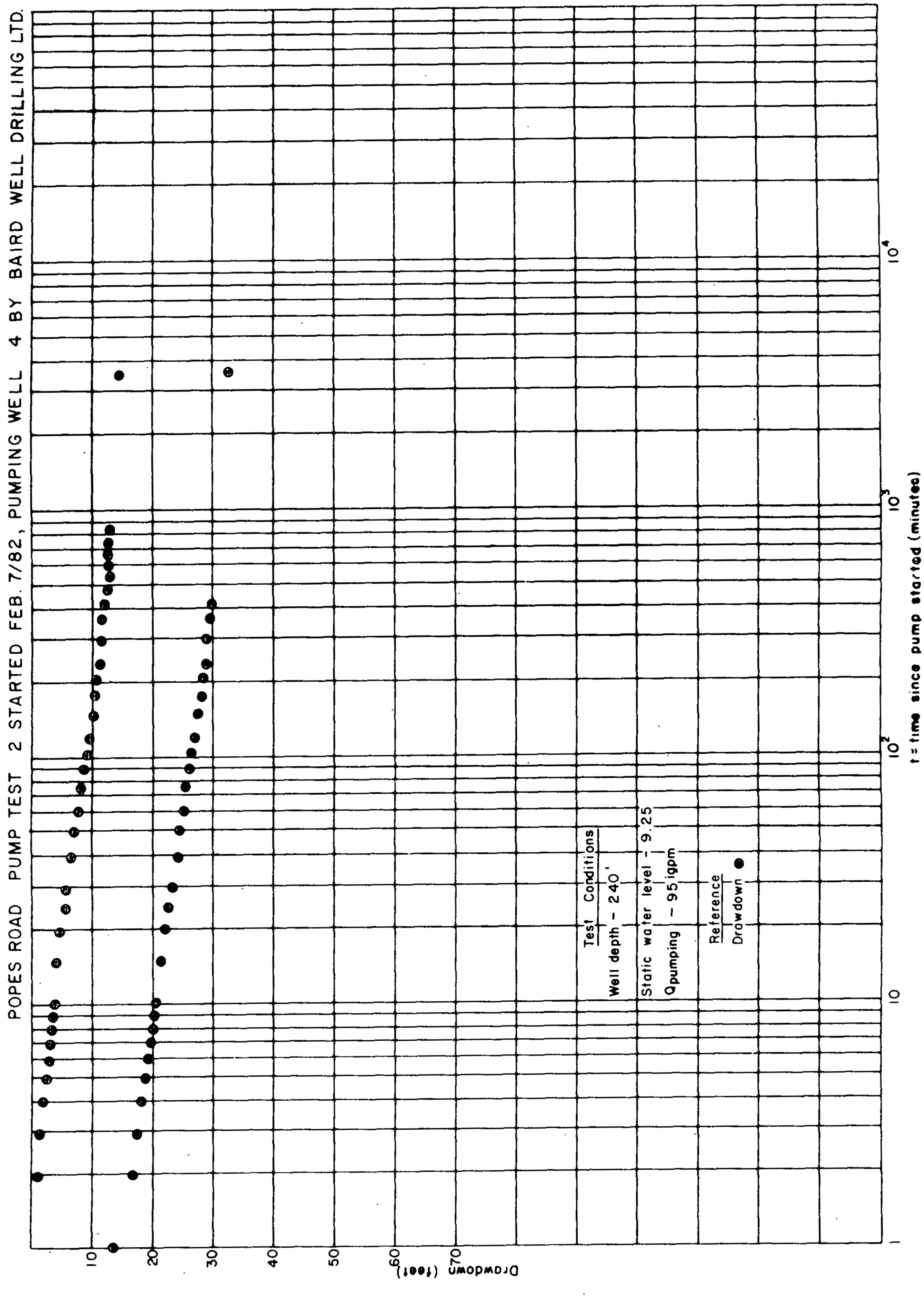

TH#1
TH#2
TOP OF DIKE
TH#3
22
22
23
24
25
26
PW
TH#4
OLD PROVINCIAL HWY. NO. 609
6" WATER MAIN
℄ C.N.R.
NOTE: ALL ELEVATIONS ARE BASED ON L.W.O.S.T. AND REFER TO TOP OF NORTH WEST CORNER OF RAILWAY ABUTMENT — ELEV. 29·6 ft.
FENCE
WATER PIPE
EMBANKMENT
NORMAL WATER LINE
TH#
TEST WELL
PW
PRODUCTION WELL
PUMP HOUSE
TEST DRILLING SITE
POPES ROAD, SHELBURNE COUNTY.
Approx. Scale 1cm = 20m.

FIGURE 6-2



POPES ROAD PUMP TEST 2 STARTED FEB. 7/82, PUMPING WELL 4 BY BAIRD WELL DRILLING LTD.
Test Conditions
Well depth - 240'
Static water level - 9.25
Qpumping - 95 igpm
Reference
Drowdown
t = time since pump started (minutes)
1
10
10²
10³
10⁴
Drawdown (feet)
10
20
30
40
50
60
70

FIGURE 6-3

POPES ROAD PUMP TEST STARTED JANUARY 28/82, PUMPING PRODUCTION WELL BY N.S.D.O.E.

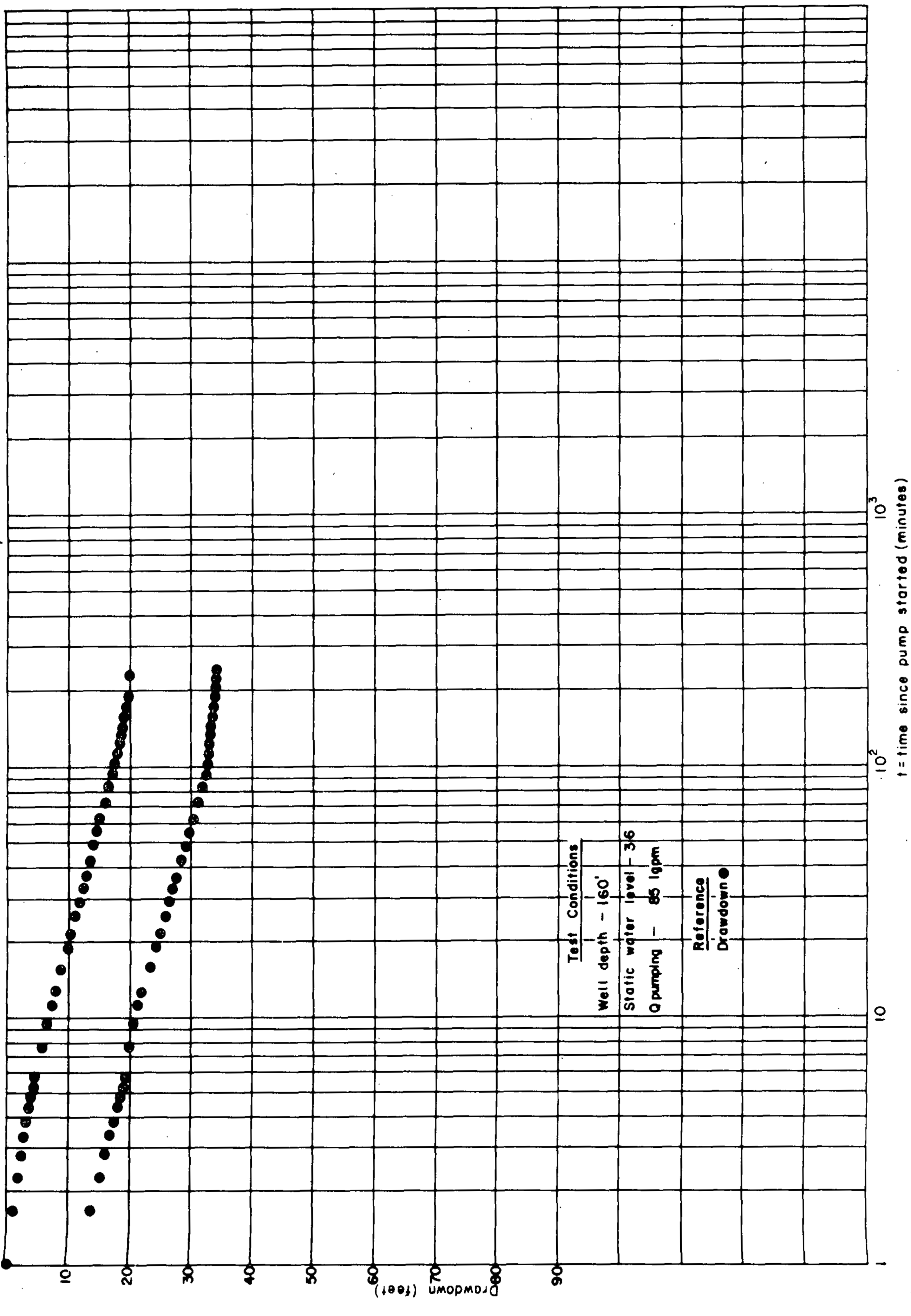
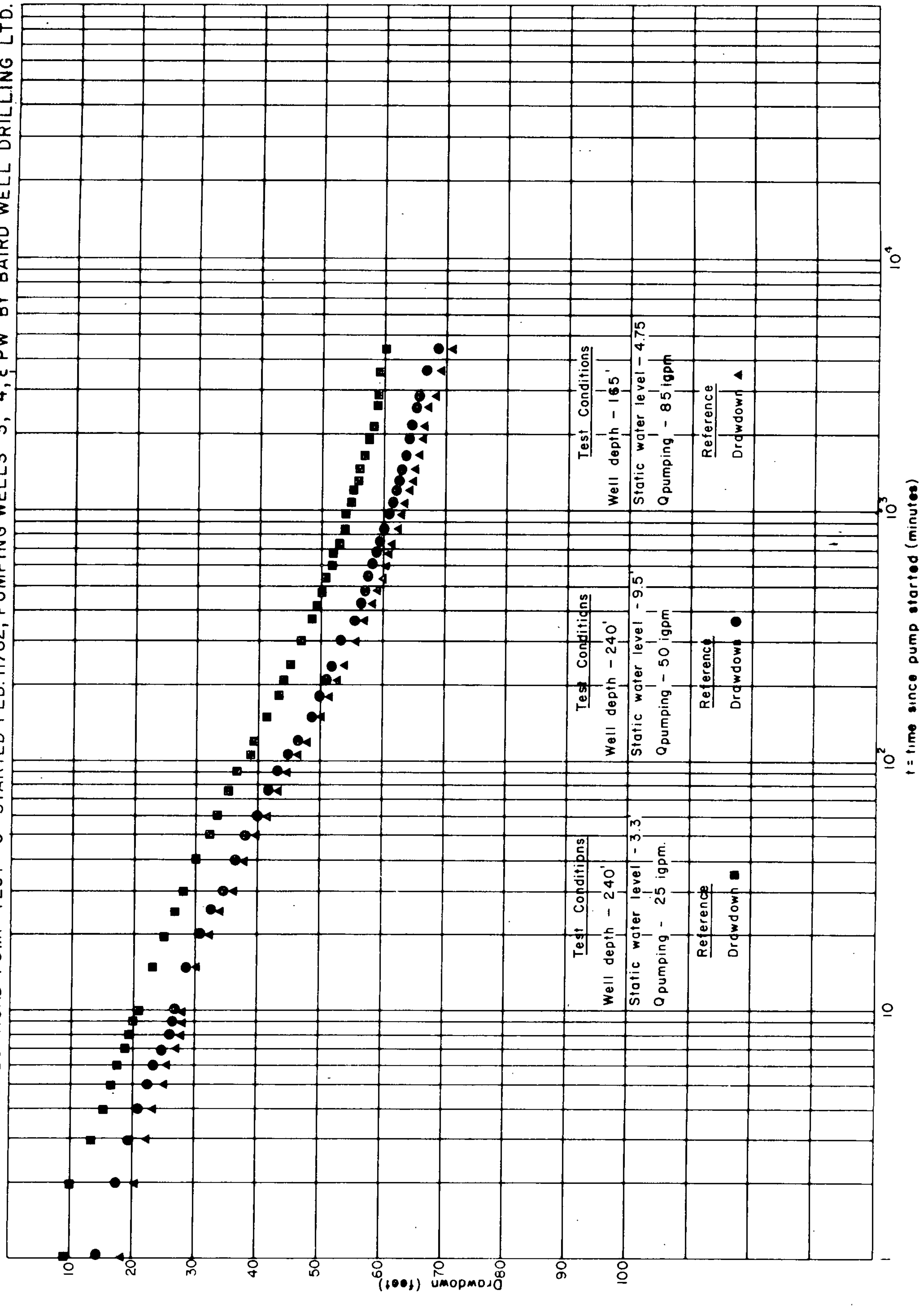


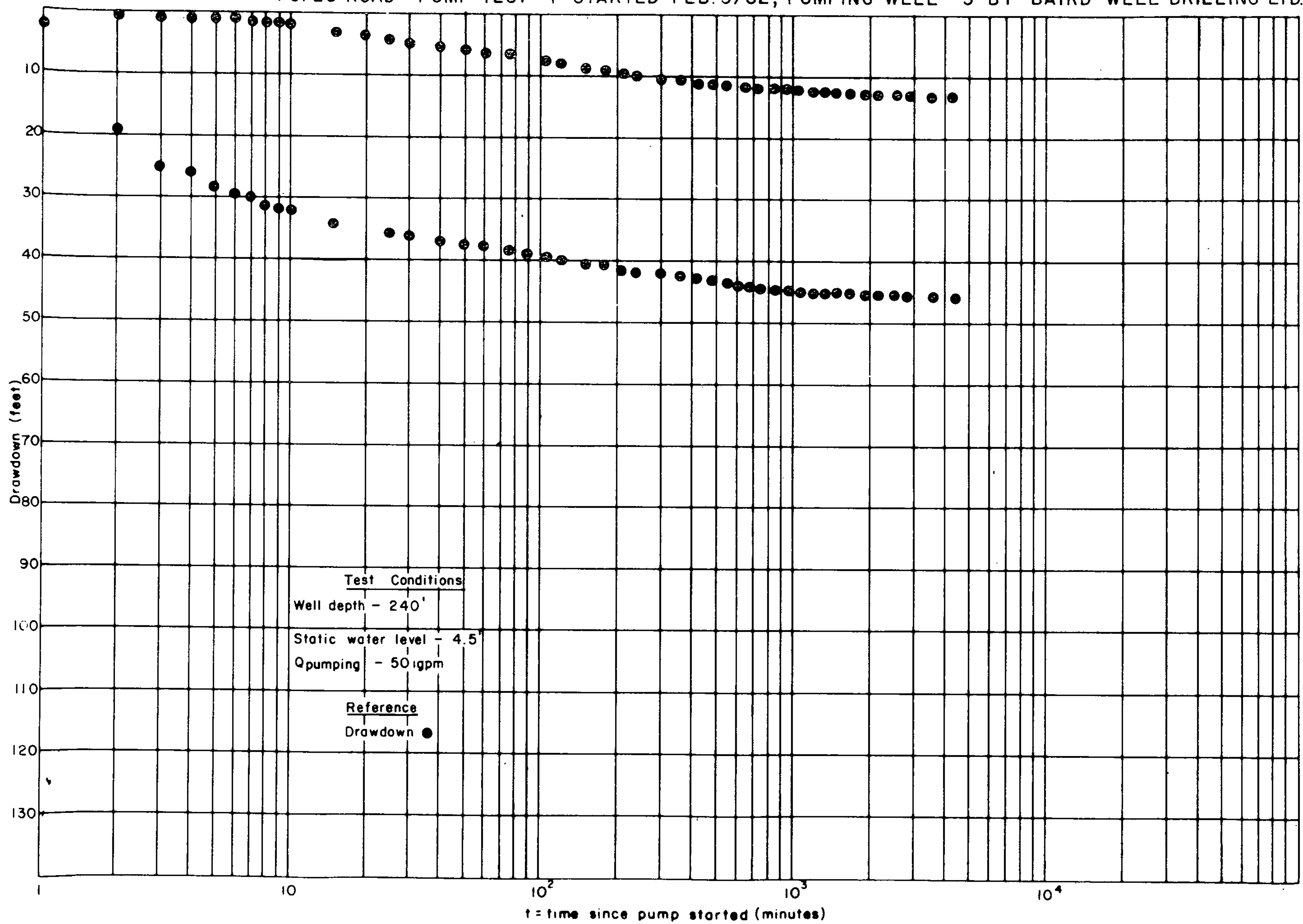
FIGURE 6-4



POPES ROAD PUMP TEST #3 STARTED FEB. 11/82, PUMPING WELLS #3, #4, & PW BY BAIRD WELL DRILLING LTD.

FIGURE 6-5

POPES ROAD PUMP TEST #1 STARTED FEB. 3/82, PUMPING WELL #3 BY BAIRD WELL DRILLING LTD.



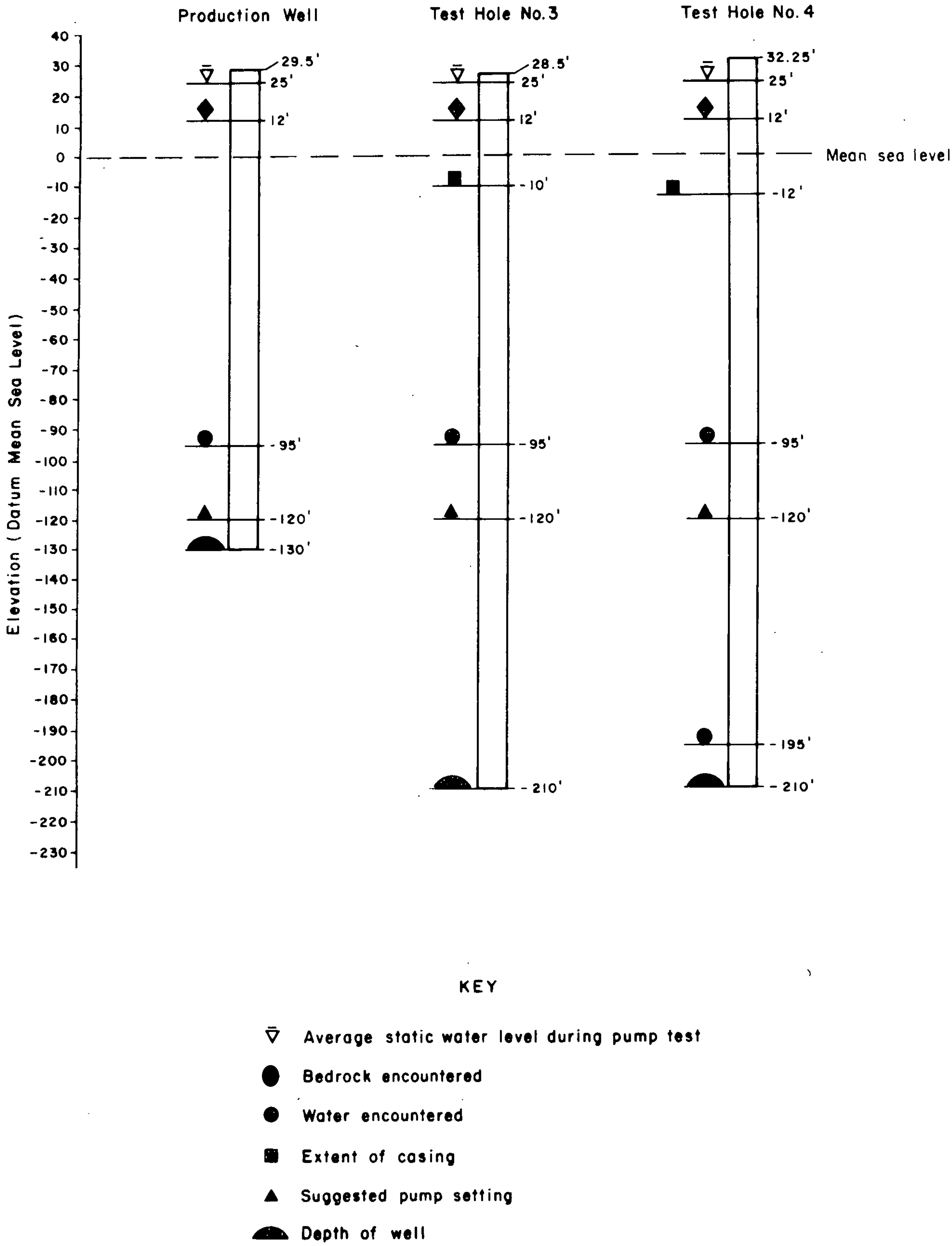


Figure 6-6 Well and Pump Test Data - Popes Road Site, Upper Woods Harbour, Shelburne County

In the assessment of potential well yields, the following facts were considered:

1) Recharge in the latter stages of pump test #3 was evident in all the wells.

2) 80% recovery to the static water level in all the wells was achieved within 5 hours after completion of the 72-hour simultaneous pump test.

3) Production use of the wells will not be continuous but intermittent, thus allowing periods for some recovery.

With these considerations, these wells should produce a combined total of 750 L/min (165 igpm) at the following individual maximum rates:

Well#	Q (L/min)	Q (igpm)
PW	385	85
TH#3	182	40
TH#4	182	40

with the pumps set at 45 metres (150 ft).

Samples were taken during the tests from TH#3 and TH#4. The chemical analysis revealed that all parameters were within the accepted limits of the Guidelines for Canadian Drinking Water Quality with the exception of iron (highest level 0.85 mg/l) and manganese (highest level 0.23 mg/l). These levels were reduced as pumping continued and should present no problems where the water is being used for processing. If deemed necessary, they can be brought within the acceptable limits with minimal treatment.

CHAPTER 7
INDUSTRIAL AND MUNICIPAL WATER SUPPLY REQUIREMENTS

7.1 Introduction

A water supply development feasibility study was done for this project during the summer of 1981 by Montreal Engineering Company. The findings of that study have been incorporated in this chapter and in Chapter 8. The locations of fish plants and the statisical districts of fisheries are shown in Figure 7-1.

The major water supply requirements in Southwestern Nova Scotia are associated with the fish processing industry. Water requirements for fire protection can be a major water demand of fish plants. In many cases seawater can be used to reduce the demand for freshwater. Ice production is another major water demand but ice-making machines are available for seawater (Orlic, 1980). Most fish plants currently rely on individual dug or drilled wells for processing water. In many areas, water supplies limit peak production capacities. In areas where plants are concentrated, problems can result from both contamination of seawater by fish plant and domestic waste and limited groundwater supply.

Quality of seawater is frequently a problem in areas where population and fish plants are concentrated. The recent increase in installation of sewage treatment facilities should reduce the problem of seawater contamination. The Woods Harbour area currently appears to be the major problem area in relation to seawater contamination (L. Daneault, personal communication).

The status of water supply and demand is sorted according to the Fisheries Regions and District, in the following deliberation.

7.2 District 30:

Principal Town - Lockeport
Principal River - Lockeport
Principal Water Demand - fish plants

LOCKEPORT

Hayden Lake, situated 12 km northwest of Lockeport is the source of an industrial supply operated by the Province. Hayden Lake has an estimated yield of 6940 L/min (Montreal Engineering Company Ltd., 1969). The water supply was constructed to provide process water for the large National Sea Products fish plant at Lockeport. A treatment plant was required to provide water of sufficient quality for process use. The current freshwater system has a supply capacity of 1578 L/min, well below the reliable yield of the lake. A saltwater supply with chlorination also supplies an additional 2300 L/min of saltwater for the plant. Pierce Fisheries nearby, also uses the saltwater supply and may begin using the freshwater supply as well.

The large National Sea Products Limited fish plant was dstroyed by fire in 1980, and is currently being reconstructed. Water demands of the new plant are uncertain but adequate fresh and saltwater supply is likely to be available.

Domestic water supplies rely on individual dug or drilled wells. Groundwater supplies in the area appear adequate for domestic use

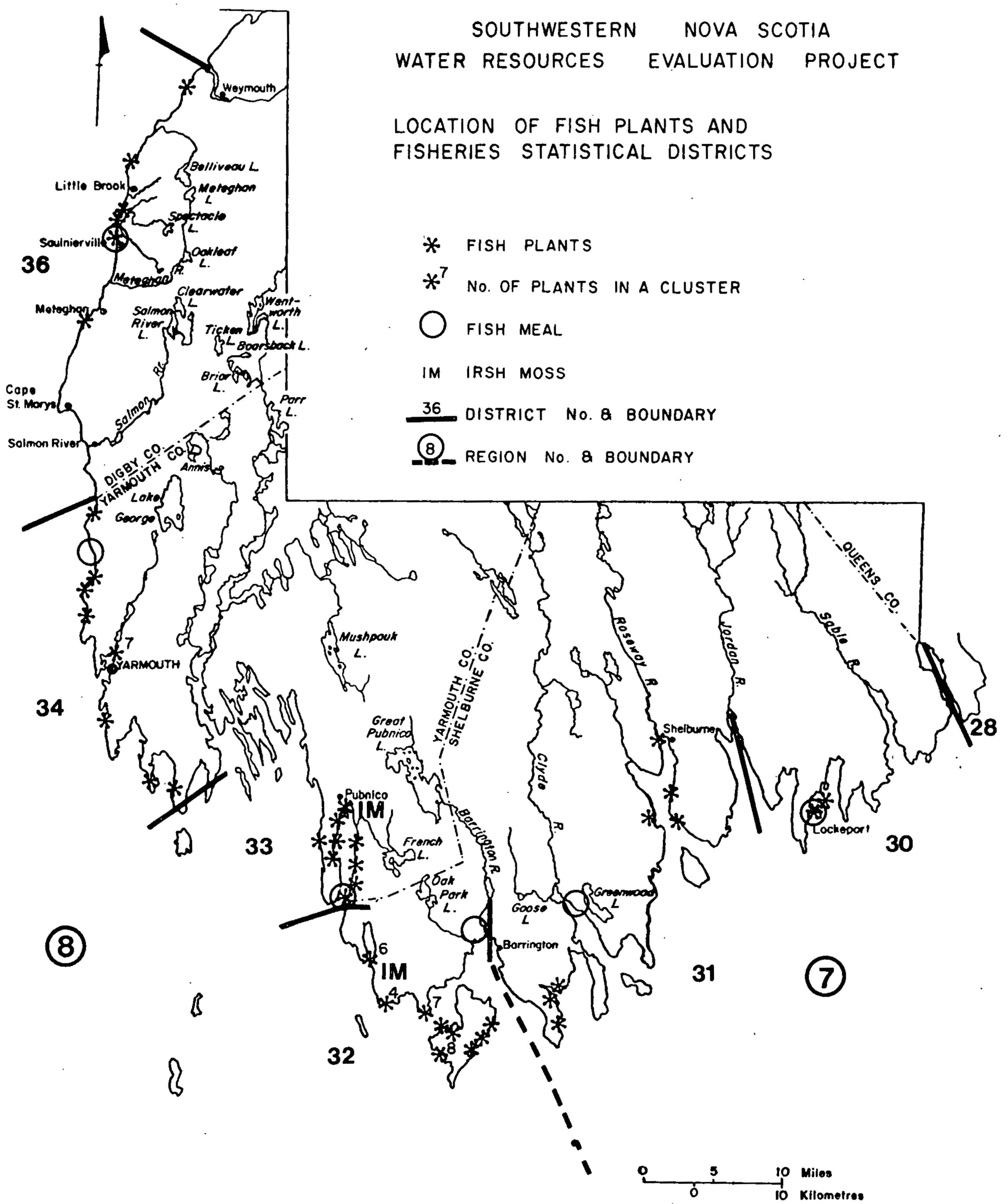


FIGURE 7-1 LOCATION OF FISH PLANTS AND FISHERIES STATISTICAL DISTRICTS

although bacterial contamination has often been reported.

7.3 District 31:
Principal Town - Shelburne
Principal River - Roseway
Principal Demand - Town

SHELBURNE

Rodney Lake, situated 5 km southeast of Shelburne, is the source of the municipal water supply. Rodney Lake has an estimated reliable yield of 5370 L/min (Montreal Engineering Company Ltd., 1969). The municipal water supply services part of the town and an industrial park. Of the three fish plants at Shelburne, only one is currently serviced by the municipal water supply. The other fish plants rely on drilled wells for processing water. The current pumping and treatment facilities supplies 1105 L/min, which is well below the reliable yield of the lake.

Currently, water supply does not appear to be a problem in Shelburne. The existing water supply adequately services the major water users in the area and individual wells appear sufficient to meet other demands.

7.4 District 32
Principal Village - Barrington
Principal River - Barrington
Principal Demand - fish plants on Sable Island

The water supply comes essentially from wells, both dug and drilled. In many cases the dug wells allow surface water to enter. The yield of the drilled wells is usually low.

Cape Sable Island has the most concentrated water demand, and the most limited supply. On the adjoining mainland the conditions are similar.

Barrington River may have possibilities for a dam and storage. A detailed investigation would be needed to find a site for the dam, access road, and a pipe line.

In this district drilled wells supply fishery plants at Lower East Pubnico (see Chapter 6).

7.5 District 33
Principal Villages - Pubnico, Argyle, Wedgeport
Principal River - Tusket
Principal Demand - scattered fish plants, housing, small commercial.

The Tusket River is regulated by a hydroelectric plant. The water for fish plants and other requirements comes from dug and drilled wells. There have been cases of salt water intrusion.

7.6 District 34
Principal Town - Yarmouth
Principal River - Chebogue, Chegoggin
Principal Demand - town and fish plants

YARMOUTH

Lake George, situated 13.5 km north of Yarmouth, is the source of the town water supply. The lake is estimated to have a reliable yield of almost 38,000 L/min (Montreal Engineering Company Ltd., 1969), but the distribution system is currently limited to 445 L/min. Because of inadequate distribution, the system is being increased in capacity and will reach 10970 L/min in 1983.

The town water utility currently supplies 5 fish plants as well as other industrial water users. Fish plants make up the majority of the industrial water demand with the textile industry being the next largest single water user. Contamination of the harbour and cost of an alternate salt water supply system force fish plants to rely on the municipal water supply for processing water. Inadequate water supply restricted fish processing to some degree during 1980-81. Once the new distribution system is completed, there should be adequate supply for both domestic and industrial demand.

Surface water supplies in the area generally require treatment to reduce levels of iron, manganese, colour and bacterial contamination to acceptable levels.

Although some arsenic was reported for Lake George sediment, water quality data for the supply indicate arsenic below detectable levels. The sediment quality data also indicate that metal concentrations, other than iron and manganese, do not appear to be a significant water quality problem in the region.

7.7 District 36
Principal Towns - Meteghan, Saulnierville
Principal Rivers - Meteghan
Principal Demand - domestic, fish plants

The principal fish plant demand is at Meteghan and Saulnierville. The potential water yields of surficial deposits in these areas are significant as indicated in Chapter 6. Interprovincial Engineering Limited and H. J. Porter and Associates (1977) notes, for example, that some sand and gravel deposits in the District of Clare might be capable of supplying water at the rate of 230 to 460 L/min or more.

CHAPTER 8
WATER SUPPLY FOR FISH PROCESSING

8.1 Introduction

The amounts of water required by the fish industry in southwestern Nova Scotia, Fishery Regions 7 and 8, have been estimated by Montreal Engineering Ltd. (1980). The study area is shown in Figure 7-1 and is made up of Statistical Districts 30, 31 and 32 in Region 7 and Statistical Districts 33, 34 and 36 in Region 8, according to Fisheries and Oceans Canada. Region 7 extends over the entire coastline of Shelburne County and Region 8 covers all of the Yarmouth and part of the Digby County coastlines.

The Nova Scotia Department of Fisheries has provided projections of fish landings, these are given in Table 8-1. Shellfish are not included, but the Department has provided figures for the shellfish landings in 1980.

Data on individual factories including the species processed, the type of process, number of employees and months of operation, the kinds and amounts of fish landed in each District were provided. Data on the amounts of fish processed at each factory were not given for reasons of confidentiality. The lack of data places severe limitations on the Montreal Engineering Company study (1980) as the present water requirements cannot be estimated accurately without such data.

Possible exploitation of under-utilized species, for example, squid and silver hake, could alter the picture somewhat. However, the values in Table 8-1 have been used to estimate future water requirements, in the A. Orlic and Associates (1980) study.

According to the projections in Table 8-1, there will be substantial increase in the landings of groundfish, especial in Region 7. The landings of pelagic fish do not show a marked increase. The shellfish landings consist mainly of scallop and lobster in Region 8. With these projections it is possible to estimate the water requirements of the fish industry, both the annual consumption and the peak demands. It has been assumed that the present emphasis on the processing of fish in local factories near the point of landing will continue. There are, however, a few other special factors which will have some effect and which should be taken into account.

A) In region 8, unlike all the other regions in Nova Scotia, there will be more pelagic fish landed than groundfish. It is reckoned, therefore, that the seasonal variations in supply will be greatest in Region 8.

B) It would be prudent to assume that much of the pelagic fish will be canned, whereas most of the groundfish will be processed in other ways including filleting, chilling, freezing, salting and drying. The water requirements for canning are high and the amounts of waste fish generated are relatively high.

C) There is a new fish processing plant which has increased water demands, at Lockeport in Region 7 on the site of a factory which was destroyed by fire.

TABLE 8-1

Annual Water Requirements, Cubic Metres (Thousands)

Fisheries Region	Water	Year	Groundfish	Pelagicfish	Shellfish	Fishmeal	Total
Fisheries Region 7							
	Fresh	1981	530	70	13	20	633
		1990	1030	80	13	38	1161
		1995	1320	80	13	49	1462
	Sea	1981	1590	560	113	600	2863
		1990	3090	640	113	1140	4983
		1995	3960	640	113	1470	6823
Fisheries Region 8							
	Fresh	1981	50	145	156	6	307
		1990	100	165	156	9	460
		1995	130	170	156	10	496
	Sea	1981	150	1160	1340	180	2860
		1990	300	1320	1340	270	3260
		1995	390	1360	1340	300	3420

TABLE 8-1

8.2 Water Usage for Fish Processing

The rate at which water will be used is dependent on the processes employed. The rate also varies from day to day and season to season, since weather and other factors make landings irregular and a number of fisheries are seasonal.

Figures for water usage are given in Table 8-1. They have been taken from the report "Water Requirements for Fish Processing Industry" by A. Orlic and Associates Limited (1980), except for higher values used for fish meal manufacture. The fish meal figures have been obtained from "The Production of Fish Meal and Oil", FAO Fisheries Technical Paper No. 142. All the values given in Table 8-1 are considered to be maximum 'safe' levels which could be reduced somewhat depending on the type of process and the need for conservation. The amounts of water required for shellfish processing vary considerably according to species. Thus, there are substantial margins, for both freshwater and seawater, for increased supplies of shellfish, some of which require large amounts of water for holding and processing.

Given the appropriate production figures, the demand for water during any given period, daily, monthly or seasonally could be estimated accordingto factory and municipality: this information not being available, two other methods have been examined. One is based on the number of employees, with a view to the types of processes employed; and the other is based on the landings of fish. Both are rough and there is not good agreement between the two.

It is known that some of the landed fish is transported from one district to another, but no figures are available. The 1981 requirements have been divided by 200 in order to arrive at the normal daily requirements for Region 7 where mostly groundfish is processed. A factor of 150 has been used for Region 8, because there is emphasis on pelagic fish and shellfish, and the landings are more seasonal.

8.3 Commercial and Industrial Water Usage Other Than Fish Processing

Water usage in commercial and industrial establishment is usually a unique situation. All of these types of situations are responsive to cost of the service. Most commercial and industrial users are sensitive to costs and economic incentives are likely to produce substantial water savings. Therefore, pricing of their commodity can be used to encourage conservation. Where these users are equipped with meters, and rate structures can be set up to encourage water conservation similar to that used by residential users. In addition to this, the use of water conservation devices and consideration of alternate uses of water within a particular industry can be considered. Usually the commercial and industrial users can examine their particular processes to effect changes resulting in conservation of water and thereby cause a reduction in overall operation cost.

8.4 Systems Maintenance and Operation

Any water supply systems can be more efficiently run provided they are properly maintained and operated. A maintenance program should involve both leak detection and repairs to the system. A basic leak detection program should be set up in conjunction with metering of the system in order to detect losses through the system for unusual consumptive uses. Any benefits of a leak detection and repair program must be weighed against the cost of the program. F. S. Brainard Jr. (1979) has provided a summary of some of these benefits as follows:

A. Water Saved: At some stage, now or later, water conservation will have a dollar impact on water rates and future supply, in addition to present operating costs.

B. Energy Saved: Most utilities at one time or another use energy to treat and distribute our water supply. Therefore, every utility should look seriously into this aspect of a leak detection program.

C. Dollars Saved: It costs money to locate and repair leaks but it would be a unique utility indeed that will not, in the long run, save money for its ratepayers by controlling waste on a disciplined basis.

D. Capacity Saved: Depending on the nature of the supply, capacity saved at each utility will vary. This potential saving should be further investigated.

E. Capital Expense Saved or Deferred: Installing a greater capacity or perhaps deferring facility construction can provide improved control and capital expense.

F. Knowledge and Confidence Gained: Utilities that have pursued a well organized leak detection and repair program acquire information that can give the management and directors of the enterprise greater confidence in their business judgments are subject to public scrutiny.

G. Metering Reviewed and Improved: A leak detection and repair program nearly always forces a utility engineering staff or consultant to review individual meter and master meter accuracy. This review could provide an opportunity to change metering policies.

H. Rate Setting Improved: Should rate setting procedures for a utility involve the cost of pipeline maintenance or replacement, a portion of that rate may be set so that these costs are not a surprise at a later date.

I. Improved Control and Distribution System: The fact that one person will be responsible for careful review of the pipelines provides an opportunity for review of the entire distribution system.

To assist in setting up a proper leak detection program, there is considerable service technology and equipment now available to determine leakage amounts, peak water demand loads and other usage information. There are companies which specialize in providing a special service to municipalities for leak detection as well as consultant services that are now available to examine records of metered usage or to make recommendations to systems that are unmetered.

8.5 Reduction of Freshwater Requirements at Fish Plants

The following suggestions for methods of minimizing freshwater requirements at fish plants have been primarily taken from Orlic (1980) and Interprovincial and Porter (1978).

A. Fire Protection

Water demand for fire protection should utilize seawater wherever possible to reduce the volume of pumping and storage in the freshwater system. Fire protection water systems require larger pipelines than those generally needed to meet normal daily demands.

B. Fish Handling

Fish handling operations have the largest water consumption. Recirculation of treated water or use of vacuum unloaders with mechanical seals can reduce water consumption. The use of spray nozzles for washing fish minimizes water use. Belt conveyance or pans for transporting fish require less water than flumes. Where fish are held before processing, use of a refrigerated seawater system rather than use of ice would reduce freshwater requirements. Reuse of water for fluming offal can conserve water.

Optimal handling of fish can also reduce water requirements for processing. If fish are kept chilled and processed as soon as possible, process water requirements are minimized.

C. Processing

Increasing the output of a plant can reduce water requirements per pound of fish since equipment and plant cleanup is required after each run. The use of spring-loaded valves and high-pressure jets would reduce water requirements for filleting. For salting processes, water consumption can be reduced by enrobing, dry salting recycling of brine solutions or spraying of brine. Water requirements for thawing of frozen fish could be reduced by air thawing, spraying and recycling of thawing water. Most processes using immersion of fish could be replaced by spraying to reduce water consumption.

D. Plant Cleanup

The use of high-pressure, low-volume water spray systems and spring-loaded valves would tend to reduce the quantities of water used in plant cleanup. Temperature and concentration of the cleaning solutions and contact time are factors in cleanup efficiency and can be varied to decrease water consumption.

8.6 Existing Water Supply and Demand

The fish processing industry is the major industrial water user within the study area. The water requirements of the fish processing industry have been extimated for each Fisheries Statistical District. The potential water supplies in terms of estimated demand within each of these districts are summarized as follows.

8.6.1 District 30

The water demand of fish plants within District 30 are concentrated in the Lockeport area. The Lockeport area is supplied with both freshwater and saltwater through a provincially operated utility. Although not all fish plants are currently serviced by the existing facility, services could be extended to other Lockeport plants.

A comparison of estimated supply and demand figures for District 30 indicates an average freshwater demand of 0.5 x 10^6 L/day and a supply of 2.3 x 10^6 L/day for fish processing. Saltwater supply also exceeds the average estimated demand. Seasonal peaks in demand would tend to equalize the supply and demand figures but in general there appears to be a sufficient supply of suitable quality fresh and saltwater for fish processing in District 30.

8.6.2 District 31

The Shelburne municipal water supply only services one of the three fish plants located near Shelburne. The other two plants rely on drilled wells for processing water requirements. Three other fish plants are located near the western boundary of District 31 around Baccaro. The fish reduction plant located in the center of the District draws its water from Greenwood Lake. Fish plants in District 31 are generally situated where adquate quality seawater is available. The lack of concentration of fish plants in any one area suggests groundwater supplies coupled with seawater should provide adequate water supplies to the fish processing industry in this District. Development of an additional surface water supply in District 31 does not appear to be required.

8.6.3 District 32

District 32 has the highest concentration of fish plants and has the highest water demand for both fresh and saltwater within the study area.

Apart from a supply for alginate processing, there are no surface water supplies developed in the District. On Cape Sable Island or within 8 km of the island, the prospect of finding high yielding wells in the thin surficial deposits is poor. Saltwater supply is generally satisfactory in the Cape Sable Island area. Installation of sewage treatment facilities at Clarks Harbour should minimize contaminaton problems in both well water and seawater used for processing. However, recent bacterial contamination of seawater of Woods Harbour has resulted in a demand for alternate water supplies at a number of fish plants. Installation of a saltwater intake outside of the harbour and a pipeline to the plants would improve conditions in this area and lessen the demand on freshwater supplies.

Three potential freshwater supply developments could be considered to supply the concentration of fish plants in the District. The Barrington River, Oak Park Lake or French Lake could provide reeliable yields to supply the area. French Lake would tend to be the favoured source of surface water because a pumping station, dam and spillway are already in existence.

8.6.4 District 33

The majority of fish plants in District 33 are concentrated in the Pubnico area. French Lake was formerly used as a freshwater supply for a number of fish plants in this area. Recently, lack of a treatment facility forced abandonment of the French Lake supply and sufficient groundwater supplies were located to meet the demand. Groundwater and seawater supplies in this District appear to be sufficient to meet the existing fish processing demands.

8.6.5 District 34

The only concentration of fish plants in this District is in Yarmouth. These plants are serviced by town water from Lake George. At present, the entire Yarmouth area distribution system is being upgraded. The completion of this system, in 1983, will ensure adequate future supplies. Outside of Yarmouth, fish plants rely on groundwater to meet freshwater processing requirements. Seawater makes up the majority of the demand in this area and adequate supplies of sufficient quality exist in the area. Groundwater supplies are generally of low yield in this District but the lack of concentration of fish plants would not justify development of an additional surface water supply.

8.6.6 District 36

Fish plants in this District are widely scattered along the coast. In general adequate groundwater supplies are obtainable from outwash deposits to meet the freshwater requirements of the fish plants. Clearwater Lake offers the best potential for development of a surface water supply. However, for the time being it does not appear necessary. Saltwater quality has not been identified as a problem in this District.

8.6.7 Summary

The major problems associated with water supply to the fish processing industry are concentrated in District 32. Saltwater supply currently is a problem in Woods Harbour area because of bacterial contamination and available data suggest the problem will continue until a new saltwater intake is constructed to service a number of plants. Freshwater supply is a problem in much of the District but is probably most severe on Cape Sable Island. French Lake is a potential freshwater supply for this area. Relocation of fish plants to other areas where adequate harbour and fresh and saltwater supplies are available may be the most economic long term solution to water supply in this District.

The management of water resources is becoming increasingly important as development costs escalate and options become more scarce. It is necessary, therefore, to make the most efficient use of this resource.

A water conservation program can be developed to cover residential consumption, commercial and industrial usage, systems maintenance and operations.

As in other industries, the fish processing plants can examine their own water consumption and very probably effect water conversation practices.
Industries and municipalites with centralized water supply systems can carry out leak detection, an organized maintemance program and metering of supply to aid in water conservation. At the residential level, a good public relations program to produce public awareness of the value of conserving water coupled with pricing policies and the availability of water conservation devices has the potential of changing water consumption on a permanent basis.

CONCLUSIONS

The Southwestern Nova Scotia Water Resources Evaluation Project undertook the investigation and evaluation of surface water and groundwater in Shelburne and Yarmouth Counties and in the Municipality of Claire, Digby County. This was a two phase operation; Phase I, April 1979 to September, 1980, to identify and ivestigate potential water supply sources; Phase II, September 1980 to March, 1982, to continue investigations started in Phase I and carry out the recommendations of the Phase I report. The purpose of these studies was to delineatre potential sources of water supply to help rectify current shortage and future expansion requirements for fish plants, industry and municipal usuages.

The major conclusions of this study are as follows:

Surface Water

(1) Lakes

Most of the lakes studied, receive water from the swamplands. This is particularly noticed in their pH and colour, and has some effect on the chemistry of the water. Two exceptions to this are Clearwater Lake and Lake George (Town of Yarmouth water supply). Lake water in the study area could be used, as sources of supply, in conjunction with the use of treatment facilities.

Basic lake data collected are as follows:

Number of lakes studied - 16

Volumes
- 0.5 to 68.8 (x $10^6 m^3$) with 12 less than 10 x $10^6 m^3$

Mean Depths
- 1 to 5 m

Residence Time
- 0.5 to 16 months
- mean 3.5 months

pH
- 4.3 to 6.0
- mean 5.2

Colour
- 12 to 500 TCU
- mean 50 TCU

(2) Rivers:

Eight rivers were studied. Sample results showed pH ranging from 4.1 to 6.0 with a mean of 4.7, and colour ranged from 350 to 700 TCU with a mean of 525 TCU.

Information from hydrometric records for stations at the Roseway, Tusket and Meteghan Rivers, indicate annual surface runoff as follows:

	Range (x $10^6 m^3$)	Mean
Roseway	98 - 210	155
Tusket	604 - 1390	1030
Meteghan	293 - 720	509

This correlates to averages over the study area as follows: range 580 to 1300 mm on the drainage area, mean 1000 mm on the drainage area. Similarly to the lake water, river water is effected by the swamps and can be used if treatment methods are applied.

Groundwater:

A study of 256 drilled wells indicated yields in the study area range from 2 to 590 L/min. and may be expected to be less than 20 L/min.

Groundwater is found in sands and gravels, and in the extensive bedrock fractures found in the southwestern area of the province. Rates of yield are dependent on the sizing, sorting and types of other materials mixed with sand and gravels, and size and number of fractures. In most cases, water coming from these sources does not require treatment.

Test drilling results indicate the areas with highest yields are those lying along contacts between differing bedrock types. These areas have accentuated fractures creating greater storage and permeability. Areas which demonstrate this feature are;

(1) Great Pubnico Lake where three test holes were drilled with pump test yields ranging from 4 to 409 L/min (8 to 90 igpm); and

(2) Popes Road near Upper Woods Harbour and Lower East Pubnico where four test holes were drilled and pump test yields range from 320 to 385 L/min (70 to 85 igpm).

A high yielding gravel aquifer was located near Salunierville between routes #542 and #544 withpump test yields of 590 L/min (130 igpm).

Data Base Inventory

The data base inventory for the Southwestern Nova Scotia area developed in conjunction with this project will provide information allowing rational industrial development. It will assist in reaching decisions regarding municipal and domestic water supply and waste disposal services. Most importantly, it will help to define water resource areas requiring protection.

Fish Plants

Approximately 70% of the fish processing plants in the province are located in the Southwestern area of the province. These have a high demand for water in both the processing and clean-up operations. The water used for processing must meet the standards set by Fisheries and Oceans Canada. They cannot be coloured to a degree which will affect the visual quality of the fish. In some cases, when water levels are low, plants must either transport water needed for processing or close down until water levels recuperate.

Conservation and Alternate Sources

In areas of poor supply, such as Cape Sable Island and Woods Harbour, water use and rates of consumption could be closely monitored and when necessary, conservation measures could be taken, or supplies augmented from alternate source (i.e. the use of seawater for clean-up operation).

Cape Sable Island

A heavy concentrations of fish plants exists on Cape Sable Island, where they, along with the residents, experience water shortage on a regular basis, due to the small surface area available for groundwater recharge. A program to locate a source of water supply for the island could be initiated to overcome these shortages. An investigation could be carried out on the mainland in the area near the end of the Cape Sable Island Causeway, to resolve this problem by locating a water supply source and piping the water to the island.

TABLE (A - 1)

ABBREVIATIONS USED IN TEXT

cm	=	centimetre
m^3	=	cubic metre
Kg	=	Kilogram
Km	=	Kilometre
L/day	=	litres per day
L/s	=	litres per second
m	=	metre
mm	=	millimetre
m^2/day	=	square metres per day
m^3/s	=	cubic metres per second
mg/l	=	Milligram per litre
Mw	=	Megawatt
TCU	=	True Colour Units
NTU	=	Nephelometric turbidity units
sq. Km	=	square Kilometre
^oc	=	Degrees Celsius
JTU	=	Jackson Turbidity Units
	=	NTU

Table A-2

MIG	= million Imperial gallon	1 MIG	= $4546.09m^3$
MIGD	= million Imperial gallon per day	1 MIGD	= $0.0526m^3/s$ = 1.858 cfs
cfs	= cubic foot per second	1 cfs	= $0.0283m^3/s$
igpm	= Imperial gallon per minute	1 igpm	= 0.0758 litre/s
ppm	= parts per million	1 ppm	= 1 mg/dm^3 = 1mg/litre
mile	= statute mile	1 mile	= 1609.344 m
sq. mi.	= square mile	1 sq. mi.	= 2.59 km^2
in.	= inch	1 in.	= 25.4 mm
ft.	= foot	1 ft.	= 0.3048 m
ac.	= acre	1 ac.	= $4046.9m^2$
$mm\text{-}km^2$	= millimeter on square kilometer	1 $mm\text{-}km^2$	= $1000m^3$
ac-ft	= feet on acre	1 ac-ft	= $1233.5m^3$
1 $mm\text{-}km^2$/year	= $2.74m^3$/day = $0.114m^3$/hour = 0.0317 litre/sec 602.2 igpd = 0.4182 igpm = 0.0152 in.-sq. mi/year		
igpm/ft	= Imperial gallon per minute per foot (specific capacity-transmissivity-transmissisibility)	1 igpm/ft.	= $0.2486 \times 10^{-3} m^2/s$
igpd/sq. ft.	= Imperial gallon per day per square feet of cross-section (Specific discharge - conductivity-permeability)	1 igpd/sq.ft	= 0.5663×10^{-6} m/s = 0.04893 m/day

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