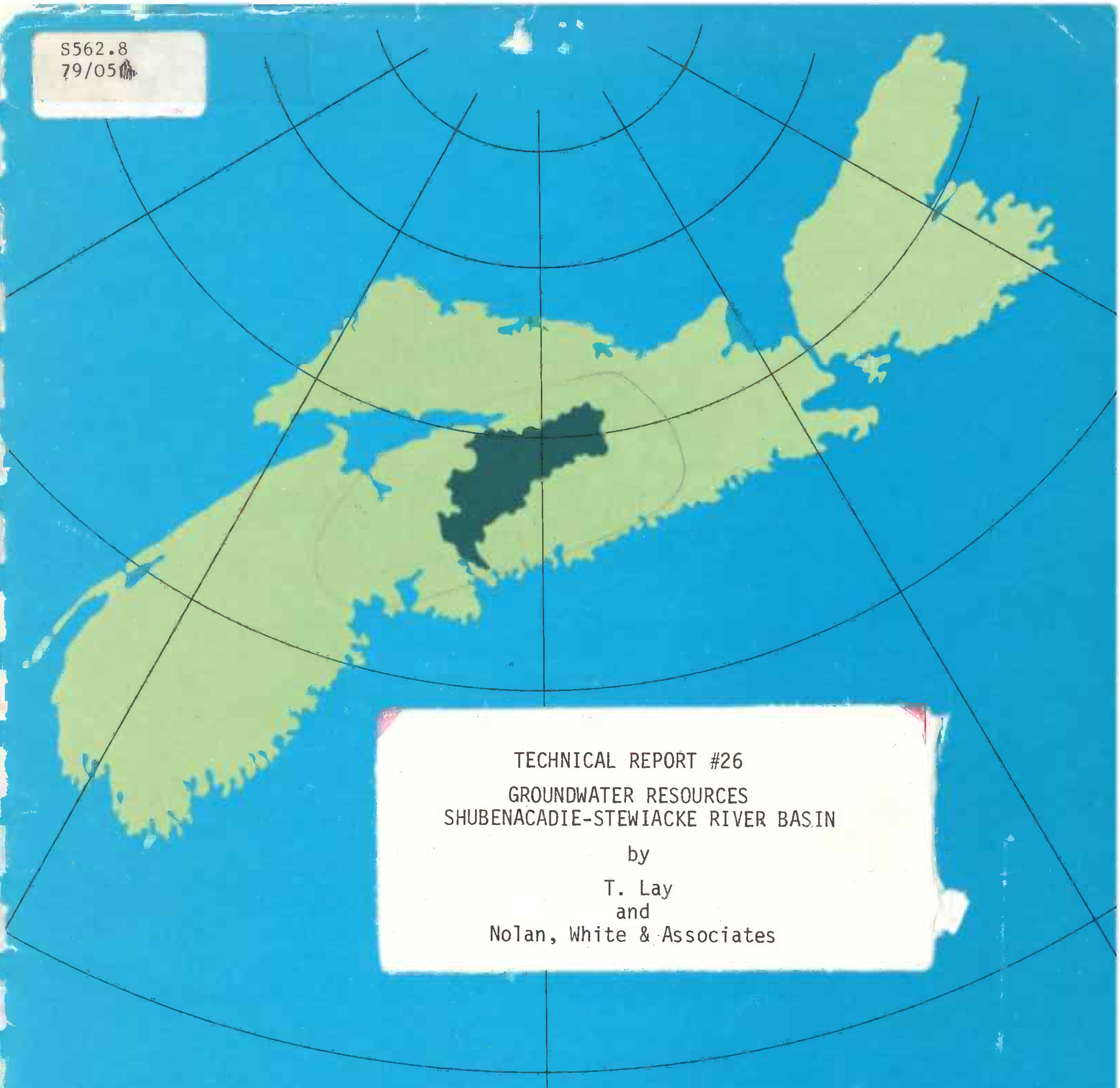

TECHNICAL REPORT #26

GROUNDWATER RESOURCES SHUBENACADIE-STEWIACKE RIVER BASIN

by

T. Lay
and
Nolan, White & Associates

SHUBENACADIE-STEWIACKE RIVER BASIN BOARD

a joint federal provincial project

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May, 1979

NOTICE

This is one of a series of technical documents based on studies undertaken by Consultants at the request of the Shubenacadie-Stewiacke River Basin Board. The Board is publishing this series of reports in order to make its findings available to government agencies and interested members of the public at the earliest possible date. The Board does not, however, assume any responsibility for the content of these reports nor is it bound by any recommendations or conclusions contained therein. The Board will consider the findings of these reports within the context of multiple purpose water management objectives.

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GROUNDWATER RESOURCES

SHUBENACADIE - STEWIACKE RIVER BASIN

INTRODUCTION

1.1 GENERAL

The purpose of this study has been to obtain facts pertaining to the groundwater resources within the Shubenacadie-Stewiacke River Basin System. The following report encompasses previously researched and compiled information along with data from recent studies. The terms of reference of the study were as follows:

1) to identify the major aquifers in the basin and to summarize their present water quality and quantity;
2) to identify existing pollution sources and identify potential encroachments on existing water supplies;
3) to review available data pertaining to the Windsor aquifer in particular, and to identify areas worthy of consideration for development;
4) to identify additional groundwater information which would assist water resource planners in managing and allocating groundwater resources in the basin;
5) to prepare a report, including a map at scale 1:50,000, which visually summarized the aforementioned information.

The following is comprised partially of an updated version of the Nova Scotia Water Resources Study from April 1967. This was prepared by the Groundwater Section, Nova Scotia Department of Mines. Other relevant information pertaining to the study area has been added to reinforce and supplement the basic facts. Ideas and suppositions put forth in the original relevant data obtained from groundwater observation wells within, or at a close proximity to, the study area may be employed in future hydrological evaluations. These data were derived from an ongoing program of water well level observations conducted by the Water Planning and Management Division, Nova Scotia Department of Environment. Other relevant well data, and specific studies relating to water quantity and quality was drawn from divisional files and projects done under the auspices of Nova Scotia Water Planning and Management.

A separate evaluation of groundwater reserves and description of existing types of supply systems was provided for individual communities and areas. This individual watershed delineation was a product of the Shubenacadie-Stewiacke Environmental Study completed in 1974 by Inland Waters Directorate and N.S. Dept. of Environment.

Summaries of pertinent meteorological data, based on records produced by the former Meteorological Branch of the Department of Transport and the present Atmospheric Environment Service of the federal Department of Fisheries and Environment, were employed as background information and are appended to this report.

1.2 PREPARATION PROCEDURE

The data employed for this report were drawn from the original Nova Scotia Water Resources Study, N.S. Department of Mines files,from files of the Water Planning and Management Division and from several special projects carried out by this division in conjunction with the Shubenacadie-Stewiacke River Basin Board. An extensive mapping programme provided surficial data, and a field programme during August 1976 has made available water quality and quantity information, all in addition to previously existing data. Data from the special task force on arsenic conducted by the provincial departments of Health and Environment,was also incorporated in this report. The communities chosen for extensive arsenic evaluation were those which lie in close proximity to previously-worked gold mines. Other special studies were conceived to gain knowledge about potential groundwater reservoirs. The water resources data which was employed as a basis for this report was mainly available for the more densely populated areas, since domestic and commercial wells provide much required information. Thus, the major focus was along the two main growth corridors from Sackville to Windsor and from Dartmouth to Shubenacadie, following the major highway routes.

A composite map has been prepared for the entire Shubenacadie-Stewiacke River Basin System, although data was available for only the major population areas and development zones. The basic mapwas produced from Mines and Technical Surveys topographic maps at a scale of 1:50,000. It depicts topographic features, transportation and water systems.

Two plastic overlay maps for the Sackville area are provided with the composite map. One gives the elevation of the bedrock surface as computed from 1:50,000 scale topographic values less the determined depth to bedrock in located drilled wells. The other overlay shows the elevation of the bedrock water table as deduced by subtracting the depth to water in drilled wells from the topographic values.

Throughout this study, and in the preparation of this report, it has been clearly evident that the basin really consists of two distinct areas, particularly in relation to the geology and hydrogeology. Consequently, the two are separated in this report as follows: a) The Headwaters, and b) The Corridor Region.

1.3 DESCRIPTION OF AREA

1.3.1. Shubenacadie Headwaters

1.3.1.1 General

The Headwaters includes all that area upstream from the outlet of Shubenacadie Lake and consists of 145 sq. miles of terrain which drains directly or indirectly into that lake. Unlike the Corridor region, the Headwaters contains a multitude of lakes and ponds which, by their very presence, have contributed to the rapid development which has taken place in recent years in this region.

Nearly the entire area of the Headwaters lies within the boundary of Halifax County. There are two minor exceptions to this - both of which are in Hants County. The larger of the two consists of an area which surrounds, and drains into, the north tip of Shubenacadie Lake. This is about 12 square miles in total area. The second area marks the north-western extremity of the Headwaters and is little more than 4 square miles in area. It contains three small lakes, Lewis, Savage and Nicholson, which form a significant part of this portion of the Headwaters lying within Hants County.

1.3.1.2 Climate

Halifax County has a humid temperate climate with few extremes in temperature during summer or winter. Slight temperature and precipitation variations may take place according to elevation and distance from the coastline. The mean annual temperature is 44.6° F with a mean range from 23° to 65°. Precipitation averages 54 inches per year with February usually experiencing the least amount and the late fall and early winter months the most.

1.3.1.3 Physiography and Drainage

The Shubenacadie Headwaters area forms part of an undulating plain rising from sea level up to approximately 500 feet in altitude. This plain is part of the Southern Upland extending from Yarmouth to Canso. The physiography of the area is somewhat complex, due in large part to the folding and faulting of the predominantly underlying slate and quartzite beds, with the slate being more susceptible to weathering and erosion.

The topography for most of the Grand Lake, Lake Fletcher and Lake Thomas areas is characterized by gently undulating to drumlin type terrain, with slopes ranging up to 15%. To the west of Grand Lake, the topography is undulating with rough, micro relief and small depressions. Soils in the area are of the Wolfville and Danesville Series usually derived from shale and sandstone rock formations.

From Lake Thomas, south, the topography is undulating to moderately rolling plain and uplands, characterized by the size and frequency of boulders strewn on the surface. The surficial deposits are of the Halifax Series soils derived from the quartzites.

Also significant are the areas having little or no surficial cover, locally boulder-strewn with structural ridges and hollow micro relief and peaty depressions. These areas are located west of Lake Fletcher and William, and in Miller, Soldier, Juniper and King Lakes areas.

There are sixteen drainage systems in the Shubenacadie Headwaters area, consisting of 68 lakes with a total surface area of 4,318 acres. Runoff is fairly rapid in terms of the somewhat youthful topography, but the numerous lakes create an overall high retention factor. Internal drainage throughout most of the soil types in the area is slow due to the relatively high content of fines, but groundwater storage is limited due to the thinness of overburden and absence of large basins.

1.3.2 Corridor Region

1.3.2.1 General

The remaining Corridor region river basin consists of all that area downstream from the outlet of Shubenacadie Lake and includes the tributary watershed of the Stewiacke River. This entire drainage area, exclusive of the headwaters, is approximately 850 square miles.

The Shubenacadie River forms the municipal boundary between the counties in which most of the watershed lies. The entire Stewiacke River basin is within Colchester County, and it is partly for this reason that Colchester claims the greatest area of the Corridor region. A small part of the remaining basin,Gays River Watershed,is within Halifax County.

Unlike the Headwaters, lakes are few and the relief is gentle. Development has been more limited to the main corridor highway from Halifax to Truro, which has resulted in a ribbon type development. Minor development has taken place along the good secondary roads which follow the other major water courses such as the Stewiacke and Nine Mile Rivers.

Much of the land underlain by Windsor series bedrock is conducive to cultivation and,as a consequence, there are a large number of dairy farms in this area.

1.3.2.2 Climate

The climate of the corridor region is humid to temperate, with total annual precipitation being in the order of 45 inches. Evapotranspiration is considered to range between 15 and 18 inches per year as reported by Cann, Hilchey and Smith in the "Hants County Soil Survey Report". Temperatures can, in this region, show greater extremes than in Halifax County, due mainly to lower winter temperatures of 17 to 18 degrees Farenheit.

1.3.2.3 Physiography and Drainage

The physiography of the region has been described by Goldthwaite in the "Physiography of Nova Scotia", (1924) and in numerous geologic and soil reports since. The Corridor area comprises mainly the Carboniferous lowlands of the Shubenacadie River Valley, which seldom attain elevations of more than 150 feet above sea level. The soft sedimentary rocks underlying this area have been easily eroded to their present level and it is thought by Goldthwaite that most of this denudation took place during the Tertiary period. According to Stevenson, however, the presence of Cretaceous clays at Shubenacadie indicates a Mesozoic age for at least some of the valley.

In the lowland areas, bedrock has been covered almost entirely by glacial debris which in places is more than 250 feet thick. The upland areas are only thinly covered with drift and underlain by resistant rock such as the Meguma (e.g. height of land between the Stewiacke and Musquodoboit Rivers).

Numerous small streams have developed their channels upon the weak underlying Windsor series rock which is prevalent throughout the corridor.

The lowland areas are generally poorly drained with most rivers being slow moving with meanders. This low relief contributes to slow runoff and creates boggy terrain.

The Shubenacadie River is tidal for nearly half its length with salt water occasionally reported as far inland as Lantz bridge. At Shubenacadie, approximately 20 miles from Cobequid Bay, the tidal range is 12 feet. It is for this reason that much of the tidal portion of the river is characterized by the deep brown colour derived from the silt brought in from the Bay of Fundy.

Flooding occurs at a number of locations within the Corridor area along the main river channels and affects the communities of Shubenacadie and Stewiacke. It also occurs on other major tributaries of the Shubenacadie.

The Shubenacadie River Basin is described in greater detail in the "Maritime Provinces Water Resources Study", Volume 4, Book 4.

1.4 PREVIOUS WORK

The physical environment and water resources of the Headwaters area have been studied by the Water Planning and Management Branch Inland Waters Directorate and described in reports Sectors 2 and 4 in 1974. This study, although not directed toward groundwater, provided a considerable amount of data throughout a large area; but, because of the short duration of the study, detail was lacking in a number of aspects. Nevertheless, within the time frame allotted, a worthwhile assessment of environmental factors was made in a broad sense.

Unique to the Headwaters area is the abundance of lakes (more than twenty) which represent 11% of the entire area. The majority of these are a source of beauty and provide an attractive environment for aquatic sports and recreation. Unfortunately, the rate and amount of development in the Headwaters area has exposed many of the lakes to sources of pollution and contamination.

Sector 4 of the survey deals with the surface water resources of the area.

Sector 2, entitled "Physical Terrain", describes Soil Conditions, Septic Tank Suitability and Recreational Opportunities.

Associated with the study is a series of 25 maps which deal mainly with the physical terrain, development aspects and limiting features in relation to land use. A supplement is available which describes the purpose of each map and method of interpretation, where not obvious. Limitations are also described. In most cases, these relate to the broadness of coverage and general lack of detail. It is recommended that the map be used for regional comparisons and not, for example, apply to a particular building lot.

Much field data was acquired during the summer of 1974 through physical examination and by a public questionnaire. Numerous sources had to be combined in preparing, for example, soil thickness maps, requiring the use of soil series maps, air photo interpretation, well log records, etc. In spite of this, however, large information gaps still exist.

The study was done before the discovery of arsenic as a contaminant in well water. Hence, there is no reference to a problem which has subsequently become well known.

In early 1976, the arsenic contamination of well water was first discovered in the Waverley area. This followed the diagnosis of chronic arsenic intoxication in a patient from Waverley at the Victoria General Hospital in Halifax. As it has turned out, the concentration of arsenic in the patient's well was the highest amount observed in any well tested in subsequent years and to the present time.

Because of the obvious concern brought about by this event, a "task force" was formed to instigate and co-ordinate an investigation into the occurrence of arsenic in water wells in the province. This group consisted of members from Department of Health, Mines and Environment as well as the Pathology Institute. The results of the study were reported in October 1976, by Grantham and Jones in "Arsenic Contamination of Water Wells in Nova Scotia". The American Water Works Journal carried what was essentially the same article in December 1977.

The Department of Mines Water Resources Study describes the communities individually in respect to population, existing water and sewer services, water requirements and groundwater potential. This report also deals with the climatological data and presents various provincial maps relating to precipitation and temperature. The Montreal Engineering report, "Maritime Provinces Water Resources Study", has utilized much of the information from the Department of Mines report on community and individual groundwater supply in the Shubenacadie/Stewiacke river basins.

In addition, there have been studies commissioned by various municipalities in relation to community water and sewer services. Consulting engineering firms have done a number of these and have, in some instances, included hydrogeological studies through collaboration with provincial government hydrogeologists. Most significant among these are three studies carried out by T. Hennigar while he was with the Groundwater Division of N.S. Dept. Mines. His studies, in all cases, concentrated on the groundwater potential of the surficial deposits in the areas. The areas studied included Brookfield and an area comprising the communities of Elmsdale, Lantz and Enfield. As well, on behalf of the provincial Wildlife Services, a local groundwater study was carried out in the vicinity of the Shubenacadie Wildlife Park.

A brief field study and test drilling program was carried out at the site of the Wittenburg dump to determine the extent, thickness and groundwater potential of the sand and gravel deposits. The study was also directed toward determining leachate contamination, or migration, in the vicinity.

In the Hardwood Lands area, west of Milford and Shubenacadie, subsurface testing and investigating have been carried out in efforts to assess the potential of the sand and gravel aggregate deposits in the area. Information is available in the form of reports and bore hole logs from Nova Scotia Sand and Gravel Limited, the Department of Indian and Northern Affairs and the provincial Department of Environment.

2. GEOLOGY

2.1 BEDROCK

The Headwaters area is underlain nearly entirely by sedimentary or metasedimentary rock. By far, the greater proportion of this is the Meguma series of Ordovician Age consisting of two distinct formations which are conformable in their attitude or orientation. The older of these is the Goldenville formation which is made up of quartzite and slate, with the quartzite being over 90% by volume. It is light grey to greenish grey and breaks in concoidal fracture. Individual beds can appear massive and may be several tens of feet thick. This rock type can (according to Stevenson) be best described as subgreywacke. Numerous systems of joints cut these rocks in attitudes which vary considerably from place to place and do not follow a well-defined system. The younger Halifax formation has been described by Stevenson as forming a "monotonously uniform succession of rusty weathering, sericitized, banded slates and argillites, commonly interbedded with relatively narrow bands of siltstones and minor chloritic, dense quartzites".

The older rocks of the Goldenville formation occur in a northeast trending band between Enfield and Oldham. This band continues southwestward across Grand Lake through Middle Beaverbank. South of Oldham a series of the younger Halifax formation runs parallel to the Goldenville and includes the area of the Halifax airport. A four-mile-wide band of Halifax formation strikes north-eastward and continues approximately 30 miles. This tightly folded belt plunges beneath Windsor series in the Coldstream - Gays River area to the southwest.

The Goldenville formation is famous for the occurrence of numerous gold showings throughout the eastern and southeastern part of the province, discovered at the turn of the century. More recently, it has been considered as the host rock for arsenic in the Waverley area and other parts of the province.

2.1.1 Devonian Granite

Granite underlies a relatively small portion of the Headwaters area at two locations. One such area of about two square miles lies immediately east of Soldier Lake, while the other similar-sized area covers most of the area between Kinsac and Fletcher

Lakes. These areas cause local variation to the topography and soil cover, and to some degree the vegetation, as compared to the surrounding area of Meguma rocks. Elsewhere in the Shubenacadie-Stewiacke River Basin, there is no granite exposed.

2.1.2 Horton Group

Sedimentary bedrock belonging to this group is exposed in the northern part of the basin. Horton conglomerates and sandstones, outcropping north of Stewiacke River, form part of the eastern extension of the south limb of the so-called "Walton Anticline". Elsewhere conglomerates, sandstone, shales, and mudstones are prevalent. These are usually grey, brown or reddish brown in color and comparatively soft, being much less indurated than the Meguma. There are no Horton rocks exposed in the Headwaters or in the southern part of the Corridor area.

2.1.3 Windsor Group

At the north end of the Headwaters area, and surrounding Little Lake, rocks of the Windsor formation underlie the countryside. These Carboniferous sedimentary rocks, as with the Horton, are to a much lesser degree consolidated than the older Meguma. In this area, they are mainly sandstones and shales and contribute to different soil entirely from those previously mentioned. The higher erodibility of the Windsor rocks was a significant factor during Pleistocene time when glaciers scoured the countryside. These rocks are less exposed throughout the area because of their greater susceptibility to erosion and an accurate breakdown of this series has not been possible. The common rock types present are shale, limestone, gypsum and minor sandstone. According to Stevenson, the best sections of Windsor rocks are exposed along the Shubenacadie River, but the strata are so badly folded and faulted that true thickness measurements cannot be determined. The contortion of strata is often associated with underlying gypsum beds. Apart from the river channels, however, outcrop is lacking in the major portion of the Corridor area.

The limestone beds that outcrop along the Shubenacadie River, and southeast of Shortts Lake, are of marine origin and considered to be of late Windsor age.

Red shale beds are common and outcrop along the river. They usually occur at the base of a sequence which contains in order upwards gypsum and limestone.

Gypsum occurs at random throughout the area, but with the most extensive deposits being near Milford. Thickness varies considerably because of the contortions created during the conversion from anhydrite. The quarry at Dutch Settlement is at present 200 feet deep and comprises an area of 130 acres. It is the gypsum and limestone beds of the area that adversely affect groundwater chemistry throughout the Corridor region.

2.1.4 Riversdale Group

The Scotch Village formation of the Riversdale group is thought to conformably overlie the Windsor. It occupies an area of approximately 50 square miles in the Stewiacke Watershed. The rocks occur mostly as friable soft sandstone, with minor shale and siltstone. Rarely, thin beds of fossiliferous limestone occur within the formation. (Lay reported interesting limestone in a test drilling program at the Wittensburg dump). This limestone may be a productive aquifer but, it would have to be developed with caution since Stevenson reports that numerous salt springs occur in regions underlain by the Scotch Village formation. "These springs which have a typical brackish, gypsiferous taste, evidently originate in the underlying Windsor strata and reach the surface via fractures in the overlying Scotch Village rocks".

2.2 SURFICIAL GEOLOGY

The overburden throughout the Headwaters area consists mainly of glacial till with minor occurrences of alluvium and glaciofluvial sediments. These tills are heterogeneous accumulations of a wide range of particle sizes, from clay to boulders, but generally the finest material is silt size. The tills produced from granite and quartzite are quite stony and unsuited for cultivation. The softer Windsor rocks produce a finer-grained till with fewer boulders and the soil type "Wolfville" derived from this is better suited for agriculture. The Wolfville soils cover more than half the Headwaters area and are mainly present in the central and western regions. The parent till material is mainly a sandy clay loam.

It is this same till that makes up the numerous drumlin features in the west of the Headwaters area. These elliptically-shaped hills are roughly parallel - their long axis pointing in a southeasterly direction - this being considered the major direction of glacier movement in the area. Drumlins are frequently cultivated and usually indicative of tens of feet soil thickness, unlike the thinner mantle of overburden which covers most of the area. Unlike the Headwaters region, the Corridor is more extensively covered with overburden and to greater depths. The main mantle of drift is typically a red-brown, clayey, sand till which varies in thickness from several feet to over 200 feet.

In and adjacent to existing stream channels, there occur deposits of sand and gravel which originated as water-born sediment in ancient and recent stream valleys. This alluvium can be a good source of groundwater and screened wells properly developed in this material may produce good quality water which is less prone to quality changes, such as turbidity, than the river itself. The sand and gravel deposits derived from glacial meltwater action are referred to as "glaciofluvial" if the deposition process is river type, or "glaciolacustrine" if they are lake sediments formed from incoming meltwater laden with sand and silt during flood periods.

Hughes (1957) has described the Surficial Geology of the Shubenacadie area (Geological Survey of Canada Paper 56-3) and has classified the glaciofluvial deposits (sand and gravel) genetically as eskers, kames or outwash plains, the interesting aspect of such deposits being their high degree of sorting and high permeability and porosity. Hydrogeologically, the most important aspect of such deposits is their relative elevation to the groundwater table since it is only the saturated thickness which may be considered as a "pay zone".

The glaciofluvial deposits form a number of discontinuous chains that follow major valleys but locally pass over low divides. As Hughes points out, the best defined of these chains follows the valley of South Stewiacke River and McLean Brook, then turns at Pine Grove to enter the Shubenacadie Valley. The glaciofluvial deposits in the Hardwood Lands area appear as a continuation of this train which, when extended further to the west, joins up with deposits along the valley of Nine Mile River. It is within this chain of glaciofluvial deposits that the greatest groundwater potential probably exists within the entire Shubenacadie/Stewiacke Watersheds.

Three of the largest glaciofluvial deposits of the area are described in detail by Hughes, a high kame knoll, a low esker ridge and an outwash plain of sand. These were later singled out by Lay as potential exploration targets. The general northwest slope of the esker and distribution of outwash sand, north and west of the esker and kame, show clearly that the system was deposited by meltwater that was flowing northwest. It is unfortunate that a large portion of the outwash is within the influence of the estuarine flood plain of the Shubenacadie and St. Andrews Rivers.

The Cooks Brook deposit consists of a kame at its eastern end and an outwash plain at its western extremity, with a series of short esker ridges joining them. A broad channel occupied by Cooks Brook divides the outwash plain into two parts. The size of the channel and large volume of outwash suggest a volume of meltwater far greater than could be expected from the small drainage area of Cooks Brook. Hughes suggests, therefore, that, during an earlier stage in deglaciation, meltwater from Musquodoboit Valley spilled over the low pass into the valley of Cooks Brook.

The Coldstream deposits are made up of several small kame deposits at the eastern extremity, an esker 3 miles long in the middle part, and an outwash plain of sand at the southwest end. This deposit is approximately 4 miles east of the Shubenacadie-Milford area.

The alluvial deposits include sediment in modern flood plains, in outwash forms of tributary streams and in river terraces. Recent flood plain deposits are mostly silt and sand except in some tributaries where velocities are higher and capable of coarse sediment transport. Estuarine flood plain deposits of red-brown silt and fine-grained sand border parts of the Shubenacadie, Stewiacke and Gays Rivers.

3. HYDROGEOLOGY

3.1 INTRODUCTION

3.1.1 General

Included in this section is a summation of the water-bearing characteristics of the geologic rock units within the Shubenacadie-Stewiacke River Basin. The general nature of the overlying surficial material is also described. The numbering system used for bedrock units on the composite map corresponds to the numbers given to rock types on the Geological Map of Nova Scotia produced by the Department of Mines in 1965.

Water quantity values are calculated from short and long term pump test results of domestic and industrial wells within the study area. Data is presented for various communities and rural areas surrounding certain towns and villages. These values indicate at what rates the drillers pumped or bailed the wells to validate their acceptability as domestic, commercial or industrial supplies. It is possible that the pumping rates could have been set higher.

3.1.2 Hydrogeologic Units

A hydrogeologic unit consists of geological material which has unique water transmitting and storage properties (Trescott 1968). Only interconnected or continuous interstices, pores or pore space in earth materials can serve as conduits for groundwater movement. All such interstices fall into two main systems: primary and secondary. The primary (or original) interstices were formed by geological processes which governed the origin of the geological units and are found in sedimentary and igneous rocks. Secondary interstices, such as joints, fractures, foliation, solution channels, and openings formed by plants and animals were developed after the rock was formed.

In the Headwaters area, there is little or no significant amount of primary pore space within the bedrock underlying that area. The granite which occurs is a typically dense crystalline rock with no vugs or pores as might be created through escaping gas as in some volcanic rocks. The older sedimentary rock, especially the sandstones which formed the Goldenville formation, no doubt, at one time contained primary pore space typical of most sand formations. However, due to the considerable time and periods of deformation that these rocks have undergone during the evolution of the earth's crust, the pore space has long since become sealed due to pressure and recrystallization of the quartz grains. The Halifax slates, of course, were mostly deposited as mudstone which, in its original state was highly porous, but, due to the extremely fine-grained nature of the particles, the permeability would have been low. These rocks too have become metamorphosed and the increase in lithification has further reduced their porosity.

Since the Enfield-Shubenacadie Corridor is underlain by relatively young sedimentary rock, primary interstices in some rock types, no doubt, make a significant contribution to the storage of groundwater. Some of the sandstone, conglomerate and limestone beds within the Windsor, Horton and Riversdale rocks would be included. These rocks have not been metamorphosed and, by comparison to the Meguma, are only mildly lithified. This is not to say that all Windsor sandstone is highly porous, since, in most cases, the grains are cemented with fine-grained material such as clay; nor does it mean that good aquifers in such rock are necessarily the result of a high percentage of primary pore space. It may be that fracture porosity and permeability are the main contributing factors.

The Meguma slates and quartzites may eventually be classified as separate hydrogeologic units as more data becomes available. They are herein, however, together classified as one unit due to the similarities of their water-bearing potential and fracture-type permeability characteristics. The Devonian granite is also similar hydrogeologically, but, due to the other distinctive features of this rock, it is described separately in Section 3.3.

The surficial deposits are described relative to the rock types on which they rest and, hence, are not true hydrogeologic units.

In Sections 3.2 through 3.6, therefore, the descriptions are of geologic units and their water-bearing and transmitting capabilities. This is done in the absence of sufficient data to positively identify specific hydrogeologic units.

3.2 MEGUMA GROUP AQUIFERS AND OVERLYING SURFICIAL AQUIFERS

The Meguma Group, although divided into the Goldenville and Halifax formations, is not divided in terms of groundwater potential. The presence of fracture permeability accounts for low capacity wells found in this rock type (1-10 gpm), although occasionally wells capable of producing over 50 gpm have been documented. (Yields greater than 2 gpm are considered adequate for normal domestic purposes). Water quality is generally good except for instances of low pH and excessive iron and manganese, and the occurrence of arsenic in some areas.

The surficial material overlying the Meguma is mainly a sandy, gravelly till, derived from the underlying bedrock as a result of glacial movements. This material may range in depth from one foot to over thirty-five feet. Dug wells in sandy, gravelly till yield adequate supplies for domestic use, although they are subject to the same chemical limitations as the drilled wells in Meguma bedrock. In some areas within the basin and overlying the Meguma, a till type, having red clay as its main matrix constituent, and minor sand and gravel is present. This combination is usually found in the form of drumlins, although there are a few areas where these transported Wolfville soils have settled as relatively thick layers over the Halifax and Goldenville formations. This clay till may range from 10' to 120' in thickness, and is limited in its ability to yield adequate and reliable quantities of water by its low permeability. The water quality is usually acceptable, except for occurrences of high manganese values and excessive iron on a less frequent basis.

Wells drilled in the Grand Lake Station - Oakfield - Kings Station area are bottomed in slate and quartzite of the Meguma group. The yield characteristics are:

quartzite - 3.5 gpm (average) or 0.5 - 12 gpm (range) with one seemingly anomalous value of 125 gpm

slate - 5.7 gpm (average) or 0.5 - 10 gpm (range)

gravel - one well yielded 12 gpm

The wells in the Lake Charles to Montague mines area were drilled into the Meguma and the yields ranged from 0.5 to 20 gpm with an average yield of 3.8 gpm and a mode of 3.0. A further breakdown gives: wells in quartzite yielding an average of 3.5 gpm and a range of 0.5 to 12 gpm, and wells in slate yielding an average of 5.7 and a range of 0.5 to 10 gpm.

In the Lake William - Waverley - Silversides area, the average yield was 2.8, the mode was 0.5 and the range was 0.25 to 15 gpm from Meguma bedrock.

The Wrights Cove area yielded an average of 6.5 and a range of 1 to 14 gpm from the Meguma.

The Waverley Road to Lake Charles section average 3.9 gpm with a mode of 3 and a range of 0.5 to 20 gpm, while Fall River Village produced an average of 3.4, a mode of 1.5 and a range of 0.5 to 15 gpm, all from the Meguma.

Barrett Lake Subdivision yielded an average of 1.5, a mode of 0.5 and a range of 0.5 to 3 gpm. The Middle Beaverbank - Kinsac section exhibited an average value of 5.5, a mode of 10 and a range of 1.75 to 12 gpm, while Lucasville had an average of 3.6, a mode of 4 and a range from 1 to 5.5 gpm.

The community of Beaverbank displayed an average well water yield of 8 gpm in slate, with a mode of 4 and a range of 1.5 to 25 gpm. A representative 72-hour pump test conducted in the Upper Sackville Springfield Lake area in a Meguma bedrock well produced: 3 gpm yield with a drawdown of 91' and a recovery to 10' in one hour. The located wells in the area produced a range of yield values according to the type of bedrock unit encountered. A summary gives: for quartzite, an average of 3.2 and range of 1 to 20 gpm, for slate, an average of 9.1 and a range of 0.5 to 33 gpm and the overall average yield mode and range values were 5.8, 3.0 and from 0.5 to 33 gpm respectively.

Six wells were located from Gore to East Gore and all were drilled into slate of the Meguma group. The average well depth was 84' and the average yield was 3.5 gpm.

3.3 DEVONIAN GRANITE AQUIFERS AND OVERLYING SURFICIAL AQUIFERS

There is little granite exposed within the entire basin. Two areas do exist, however, within the Headwaters. One of these lies between Kinsac Lake and Lake Fletcher. The other is a slightly smaller area (2 to 3 sq. miles) just to the east of Soldier Lake.

The Devonian Granitic rocks consist of biotite granite, muscovite-biotite granite and minor pegmatite. Due to the development of fracture permeability in granite-type rocks, only small capacity wells can be expected. These may yield from 1 to 10 gpm, with some wells, on rare occasions, yielding as much as 50 gpm. The expected water quality is fair, except for some occurrences of high iron and manganese and a pH on the acidic side.

Surficial deposits overlying the granitic rocks often consist of poorly stratified and poorly sorted sand, gravels and silts, which seldom attain any significant degree of thickness. In some locations, the thickness may be sufficient to enable the construction of shallow, screened wells to supply industries of modest water demand or residential complexes. Most frequent, the overburden over granite is a sandy-gravelly boulder till, which may range in thickness from 3 to 40 feet. Dug wells in this till will usually yield water of variable quantity and quality for domestic purposes.

3.4 HORTON GROUP AQUIFERS AND OVERLYING SURFICIAL AQUIFERS

The Horton rocks are of Mississippian age and consist of sandstone, shale, conglomerate and arkose. Horton Group aquifers exhibit a favourable degree of permeability and, assuming a good standard of well construction, yields up to 100 gpm may be expected from individual wells. There is considerable range in particle size in the Horton sediments, consisting mainly of sand-size particles set in kaolinitic cement. Water quality in bedrock aquifers is generally good. Pleistocene surficial deposits overlying the Horton are variable with respect to thickness, water-yielding ability and water quality. Excessive manganese values are encountered but all other parameters are usually within acceptable limits.

3.5 WINDSOR GROUP AQUIFERS AND OVERLYING SURFICIAL AQUIFERS

The Windsor Group rocks consist of limestone, gypsum, anhydrite, shale, sandstone, conglomerate and minor salt. The heterogeneity of the Windsor group accounts for the variance in permeability.

Drilled well yields are usually more than sufficient for domestic uses with yields ranging from 3 to 20 gpm. The quality of waters is fair except for frequent occurrences of excessive hardness and associated color, as well as lesser showing of high iron and manganese values. These unsuitably high values are due to the dissolution of evaporites in the formation, with the resultant production of chlorides and sulphates.

This bedrock unit underlies the majority of the basin area, being particularly prevalent in the lowlands. Pleistocene deposits consisting of sands and gravels, which are found overlying this bedrock unit,are usually less than 50 feet in depth, although there are several occurrences where depths are noticeably greater. This type of surficial aquifer may produce large quantities of good quality water from properly constructed wells.

Wells drilled into Windsor bedrock (#17) at Shortt's Lake yielded 3 gpm on the average. At Cloverdale, the average yield was 16 gpm, the range was 8 to 20 gpm and a one-hour pump test produced a drawdown of 45' followed by a recovery of 25' in 5 minutes.

Drilled wells in the Shubenacadie area are mainly into Windsor bedrock. The located wells are bottomed in gypsum, shale, limestone and sandstone and interbedding of all these rock types.

A number of wells are also drilled into surficial sands and gravels. In the Dewis area, wells mainly pass through interbedded limestone, shale and sandstone, with a limited amount of gypsum. A few are drilled into sands and gravels. Along the Hardwood Lands Road, the wells pass through the same interbedding, also with minor gypsum seams. In the Milford Station area, most drilled wells again pass through interbedded sandstone, limestone and shales. In the southern reaches of the village, towards the National Gypsum Quarry, gypsum becomes the predominant bedrock type.

Based on information provided in drillers records submitted to Department of Environment, the following statistics have been prepared. These relate to wells drilled into Windsor series bedrock or surficial deposits overlying Windsor rocks.

Rock Grouping	Yield Statistics (gpm)		
	Average	Range	Mode
Shale	7.6	4-20	5
Limestone + shale	4		
Limestone + gypsum	5		
Sandstone	13	5-20	10-20
Limestone	13	5-30	10
Gravel	9.5	4-20	5
Sand	10		

Wells located between Hardwood Lands and Nine Mile River (includes Indian Road and MacPhee Corner) were bottomed in varying bedrock types. The bedrock types and surficial materials are listed along with the reported yields in brackets. These values are averaged from a small number of wells and thus are to be considered as approximations. They are as follows: sandstone (8 gpm), shale (4gpm), limestone (12 gpm), limestone and gypsum (15 gpm), sandstone and gypsum (6gpm) and sands and gravels (4 gpm). These values indicate a noticeable range in yield (4-12 gpm), depending on the bedrock type penetrated.

3.6 UPPER MISSISSIPPIAN AND PENNSYLVANIAN AQUIFERS AND OVERLYING SURFICIAL AQUIFERS

Upper Mississippian and Pennsylvanian rocks include those of the Canso, Riversdale, Cumberland and Pictou groups. Rocks of the Canso group consist of conglomerate, sandstone, shale, limestone; those of the Riversdale, Cumberland and Pictou groups consist of conglomerate, sandstone, shale, coal and limestone. These rocks exhibit a considerable degree of heterogeneity with respect to type and, therefore, to permeability. Known yields of 10-400 gpm are quite sufficient to meet domestic demands and those of most minor industries.

Wells drilled in the Riversdale group (#19) at Middle Stewiacke, with shale as the major bedrock component, yielded an average of 7 gpm. In the same area, surficial wells drilled in sands and gravels averaged 7 gpm with a range of 3-12 gpm and an average drawdown of 45' in 3 hours followed by a recovery to 25' in 10 minutes. At Coldstream wells drilled in sand and gravel yielded an average of 9 gpm.

4. GROUNDWATER QUALITY WITHIN THE BASIN

4.1 GROUNDWATER QUALITY IN VARIOUS COMMUNITIES

The data summarized in Appendix E depicts the existing quality of groundwater in various communities and rural areas within the basin. The information relates to dug and drilled wells in a variety of bedrock and surficial materials. Average, median and mode values as quality indicators are presented where applicable, along with a few remarks. High values are underlined and are those which exceed the recommended limits as set under the Canadian Drinking Water Standards. Certain special study areas are assessed, the information being made available through the Water Planning and Management Division, N.S. Department of Environment and the Department of Health. Bedrock types are given numbers which correspond to the numbering system employed for the composite map.

The majority of water chemical sample results employed for this report are taken from data collected under the special arsenic study conducted by the N.S. Departments of Health and Environment and a special water quality analysis project sponsored by the basin study. For the arsenic study, practically all residences within certain towns, villages and rural areas were sampled. For the special basin assessment,sampling was at random with respect to the water quality results it would produce. The sampling policy was to attempt to obtain samples from drilled wells in various areas but,if these were not available, dug well samples were taken.

Of particular note is that the recommended limits for iron,manganese, hardness and arsenic are 0.3, 0.05, 180 and 0.05 mg/l. respectively. These prove to be the main chemical contaminants in groundwaters within the Shubenacadie-Stewiacke River Basin System. Other parameters which may be excessive are sometimes associated with these main contaminants, i.e. color, turbidity, total dissolved solids, and dissolved solids.

On the following pages, summaries are given for wells dug and drilled into various bedrock types and surficial materials. The averages of the chemical parameters are charted and the following letters and explanations apply.

A. This list includes towns, villages, and rural areas which rely mainly on dug wells into clay till over Windsor bedrock. Two wells were located in Lantz, which are dug into stream alluvium and underlain by Windsor bedrock.

Hardwood Lands, Milford Station, Elmsdale, Lantz, Carroll's Corner, Gays River, Lake Egmont, Cooks Brook, Chaswood, Enfield, Shubenacadie, Stewiacke, South Branch, Alton, Brentwood, Green Creek, Princeport, Maple Grove, Five Mile River, Upper Rawdon, MacPhee's Corner, Roulston Corner, Fort Ellis, West St. Andrews, Meadowvale, Southvale, Pleasant Valley, Upper Pleasant Valley, Brookfield (Sample results are available for these areas).

Upper Stewiacke, Smithfield, Eastville, Glenbervie, Chaplin, Dean, Newton Mills, Stewiacke Cross Roads (Samples were not taken from these areas, but values may be inferred from other similar areas).

In the Shubenacadie area 4/8 dug wells report high hardness, 3/8 have high iron and manganese and 5/8 have high manganese only. The maximum iron value is 1.8 mg/l, the mode is 0.1 and the average is 0.6 mg/l. The maximum manganese value is 8.7 mg/l and the mode is 0.05 mg/l. The mode turbidity value is 1.5, but the average is 12 JTU.

In the Stewiacke area 4/7 dug wells report high manganese, 2/7 have high iron and 4/7 have high hardness values. The maximum manganese value is 0.5 mg/l and the mode is 0.05, with the average value being 0.17 mg/l. The average iron value is acceptable at 0.2 ppm, although 2 wells have excessive values, which could be, in part, due to deteriorating plumbing fixtures.

Sample dug wells at Grand Lake Station have satisfactory quality. Two wells located at Dutch Settlement have reported high average manganese and color, with the mode value for manganese being 0.1 mg/l. The Enfield sampling involved three wells and high average hardness and manganese were reported. At Elmsdale, high average hardness and manganese were also found in three wells. Pleasant Valley posted high hardness in 1/3 wells, high manganese in 2/3 wells and high iron in 1/3.

The information from Lantz is inconclusive since only 2 wells were sampled. One had an iron, manganese and color problem, while the other was suffering only excessive manganese. Poor well construction may play a sizeable part in the causation of these values.

B. This list denotes dug wells over Meguma bedrock and into sand till. The specific areas are: Wittenburg, Oldham, Lucasville, Springfield Lake, Upper Sackville, and Mount Uniacke.

The manganese level is satisfactory in Upper and Middle Sackville and Lucasville. In Mt. Uniacke and Old Guysborough Road, 4/6 wells have high Mn values. The maximum value for iron and manganese is 0.6 and 1.7 respectively and the mode value is 0.1 and 0.05. The unacceptable values are probably more attributable to poor well construction than to the bedrock.

C. This list gives dug wells over Meguma (#5, 6), bedrock and into clay till. They are found at Devon, Grand Lake Station, Middle Beaverbank, Fall River Station and Windsor Junction.

Samples from Lower Sackville, Lucasville, Windsor Junction and Middle Beaverbank are satisfactory. Iron and manganese problems are probably due to bedrock along with poor well construction. At least 3/13 are believed to be due to surface water infiltration and 2/13 have associated hardness due to poor bedrock conditions. The maximum values for iron and manganese are 1.8 and 5.0 respectively, while the mode values are 0.1 and 0.05 mg/l.

D. This list indicates dug wells over Horton bedrock and into sand till. Georgefield is the only location sited, where just two wells were sampled with one of them being high in manganese and hardness.

E. This list refers to dug wells and springs in clay till which overlies Riversdale bedrock. They are located at Lanesville and Middle Stewiacke. Two of six wells sampled were high in iron and manganese and one of the six had excessive hardness.

F. This list denoted bedrock wells drilled into Meguma (5,6) bedrock. Sample wells are located at Piggot Lake, East Gore, Hillsvale, Lewis Lake, Grand Lake Station, North Beaverbank, Wellington, Upper Sackville, Springfield Lake, Lake Charles, Fall River and Windsor Junction.

One of the two wells sampled in East Gore had high manganese and one had a low pH. One well sampled in Enfield was high in manganese (due to the low number of specimens there is no real statistical value). Samples taken from the Grand Lake area were satisfactory. In the Lake Charles area 1/2 wells had both low pH and excessive manganese. In Hillsview 1/1 sample displayed high arsenic. In Wellington 2/2 were high in manganese. Of six wells sampled in Fall River, two showed excessive iron and manganese. Also within the same group 2/6 had high iron only. Of the total,5/6 were affected by iron or manganese.

North Beaverbank indicates slightly high manganese values. Four of five samples in Middle to Upper Sackville have high manganese values, while 2/5 have high iron (which could be due to the plumbing system). Oldham Road displays high manganese and hardness, although this is inconclusive. Average values for Meguma bedrock for this study area is 13/21 with high manganese and 4/21 with high iron.

G. This list depicts bedrock wells drilled into Riversdale bedrock. The sample wells are found at Stewiacke East and Middle Stewiacke. One of the two samples was high in iron, manganese, hardness and TDS.

H. These wells have been drilled into Windsor bedrock. The communities where sample wells are located are: Gays River, Carroll's Corner, Chaswood, Milford Station, Shubenacadie, Stewiacke, Lantz, Elmsdale, Hardwood Lands, Admiral Rock Brookfield, and Alton. Parameters listed under H reveal the chemical quality from seven wells throughout this particular region. All of these were high in average hardness and color, although the sample well from the Shubenacadie area was only slightly above the recommended level of 180 mg/l. The sample well at Hardwood Lands exhibited a poor hardness rating of 355 mg/l.

I. The six wells comprising this list are located in Milford Station, Dutch Settlement, and Carroll's Corner areas, where population density and use of drilled wells are higher. Groundwater in the Windsor bedrock in these areas displays very high hardness, total dissolved solids and total solids values, as well as high associated color, iron and manganese levels. The average value is

1,004 mg/l for hardness. (Waters exhibiting a value greater than 500 mg/l for hardness are considered unsuitable for most domestic and industrial uses.)

4.2 RESULTS FROM ARSENIC SURVEY

The arsenic study conducted by the N.S. Departments of Health and Environment was mainly aimed at analysing dug and drilled well waters within communities and rural areas which border lands that were formerly worked as gold mines. It is a well-followed contention that slag and tailings dumpings in these mining areas, as well as the pyrite-rich bedrock underlying them, are a possible source of the high arsenic levels prevalent in numerous wells. A number of locations throughout the province were sampled extensively. The table in Appendix E, as well as the following notes, summarize the findings of this task force.

Elmsdale, West Gore, Tanglewood Drive (Lewis Lake) - the wells in these areas all produced values within the acceptable limit of 0.05 mg/litre.

Rawdon Gold Mines - Ten wells were sampled for arsenic only, with 10% of the total having an average value of 0.05 mg/l, although 25% of the drilled wells were contaminated.

Collins Park - All the wells in this subdivision were sampled for arsenic only, as of August 1976. The average value was high at 0.17 mg/l, the mode was 0.005 and the range was from 0.005 to 0.55 mg/l. The percentage of drilled wells contaminated was 63%.

Wellington - All the wells sampled had values within the acceptable limits.

Four locations were sampled for the full range of chemical parameters as well as arsenic, with the water quality of these special study areas being as follows:

Silversides - Virtually, all the wells in this subdivision were tested as of August 1976. The average manganese value was high at 0.2 mg/l, with a range of 0.5 to 1.7 and a mode of 0.05 mg/l. For the drilled wells, the average value was 0.02, the range was 0.005 to 0.08 and the mode was 0.005 mg/l. Sixteen percent of the drilled wells and 0% of the dug wells were contaminated by arsenic. The average arsenic value was 0.02, the mode was 0.005 and the range was 0.05 to 0.08 mg/l.

Oldham - For the Oldham to Enfield area, the general water quality is within recommended limits. Iron and manganesevalues are generally high in drilled wells and manganese is high in dug wells. The average iron value is 1.0 mg/l, the mode is 0.1 and the range is 0.1 to 3.5, for drilled wells. For dug wells, the average iron count is 0.1 and the range is 0.01 to 0.5 mg/l. The average value for manganese in drilled wells is 2.3, the mode is

0.05 and the range is from 0.03 to 21.0 mg/l. For dug wells, the average manganese value is 0.2, the mode is 0.05 and the range is from 0.05 to 0.3 mg/l. Only 1/16 drilled wells remits a high value of 0.05 mg/l for arsenic and 0/12 dug wells portray a high value. One may conclude that this area is at or beyond the border line of arsenic contamination, but the wells are still situated over and in the Meguma, thus are subject to high iron and manganese values.

In Oldham Village, iron and manganese are again high. For drilled wells, the average iron value was 0.3, the mode was 0.1 and the range was 0.08 to 0.6 mg/l. For dug wells, the average iron count was 0.3, the mode was 0.1 and the range was 0.08 to 0.6 mg/l. For dug wells, the average iron count was 0.3, the mode was 0.1 and the range was 0.1 to 2.8 mg/l. The average manganese count for drilled wells was 0.6, the mode was 0.05 and the range was 0.05 to 3.8 mg/l. For dug wells, the average manganese value is 0.3, the mode is 0.05 and the range is 0.05 to 1.6 mg/l. These high values are again felt to be associated with the underlying Meguma bedrock.

Of major concern in this village is that 1/8 drilled and 10/27 dug wells have arsenic counts above the acceptable limit of 0.05 mg/l. Also, 1/1 stream and 3/3 spring samples register as high values. For drilled wells, the average arsenic count is 0.02, the mode is 0.005 and the range is 0.005 to 0.06 mg/l. For dug wells, the average value for arsenic is 0.05, the mode is 0.05 and the range is 0.005 to 0.23 mg/l. For springs, the average arsenic value is 0.3 and the range is 0.22 to 0.33 mg/l. The one stream count for arsenic is 0.10 mg/l. Definite conclusions have yet to be drawn, but data seems to indicate that waters washing near surface or exposed bedrock and mine tailings could be absorbing natural arsenic. Also noteworthy is that the Oldham community well has a value of 0.24 mg/l arsenic. The individual sample wells are too numerous to be placed on the composite map.

Waverley - For this area, the drilled sample wells employed are marked on the composite map, but, due to space limitations, dug wells are not. The dug well locations are found interspersed within the same overall area as the drilled wells and statistical quantity and quality values are available for both well types.

For this study, 24 drilled wells and 21 dug wells were picked at random from the available chemical samplings. Of the drilled wells, all parameters were within the acceptable limits except the manganese and arsenic values. The average manganese value was 0.34, the mode was 0.05 and the range was 0.05 to 2.4 mg/l. The average arsenic value was 0.08 mg/l, the mode was 0.05 and the range was 0.005 to 0.98 mg/l. For dug wells, only manganese values were high with an average count of 0.21, a mode of 0.05 and a range of 0.05 to 1.6 mg/l.

Montague Mines - All parameters were below the standard limits except iron, manganese and arsenic. Most of the wells in the community were sampled. For iron, the average value was 0.3, the mode was 0.1 and the maximum 1.5 mg/l. For manganese, the average value was 0.4 mg/l. For arsenic, the average was 0.03 and the range was from 0.005 to 0.08 mg/l. Of the 19 wells sampled, 20% of the drilled wells and 11% of the dug wells had arsenic levels above the recommended limits.

5. CONCENSUS OF PUBLIC OPINION REGARDING WATER QUALITY AND QUANTITY

A personal survey was conducted within the study area to gain knowledge about the water quality and quantity of existing individual water sources. This data is presented in Appendix E in terms of community water sources. Information was taken from individual homeowners and pertains to their own systems as well as their neighbours. Thus, the results may not be totally accurate, but they provide an insight into the overall domestic water supply situation.

6. SPECIAL STUDY AREAS WITHIN SHUBENACADIE/STEWIACKE RIVER BASIN

There are two areas within the basin which had been singled out for special study. Both involved subsurface investigation of surficial deposits. The first is on lands owned by Nova Scotia Sand and Gravel Company in the Hardwood Lands area and the second is a land fill site known as the Wittenburg Dump.

6.1 HARDWOOD LANDS DEPOSIT

6.1.1 General

The lands of Nova Scotia Sand and Gravel are located at 11E3B - 11E4A on the Mining tract grid system. This company had subsurface data gathered through borehole drilling programs. The purpose of this program was to outline the extent and thickness of granular deposits and to approximate groundwater quantity and quality and to note any potential threats to,then existing,sources of water supply. The data obtained was recorded and summarized in report form and is in possession of the company at the present time. In addition to this work, the Nova Scotia Department of Environment drilled two test wells on the property.

6.1.2 Geology

The area is underlain by Windsor group rocks consisting of limestone, gypsum, anhydrite, shale, sandstone conglomerate and salt. The two test holes by Nova Scotia Department of Environment revealed gypsum as the main bedrock in the two locations.

The quarry operation of Nova Scotia Sand and Gravel is located within an area of ice contact stratified drift in the form of an esker, which winds its way throughout the area in an east west direction. There is also outwash material lying adjacent to the esker at certain locations. Most of the remaining area is covered in a red clay till. West of Blois Road, most of the material is a clay,sand till which continues to the west and northwest. Recent stream alluvium is found along major stream beds and embankments within the area. The distribution of the materials described is displayed on map number 3 and on land and forest map I-24, I-25 for Hardwood Lands area (in the Shubenacadie-Stewiacke River Basin Study File).

Nova Scotia Department of Environment test hole numbers 1 and 2 were drilled to determine the depth and extent of surficial materials in the area (specifically along the esker). A summary of these test holes reveals the following:

Hole # 1	0' - 20'	bog and sand
	20' - 49'	red clay and silt
	49' - 110'	soft grey gypsum
Hole # 2	0' - 30'	fine grained sand
	30' - 39'	sub angular gravel
	39' - 54'	red clay and silt
	54' - 67'	limestone and gypsum

6.1.3 Hydrogeology

The test holes of N.S.D.O.E. did not appear to intersect good aquifers as there was no noticeable amount of water detected.

Test hole # 1 did reveal that, the esker at the eastern end, is about 40 feet thick and consists of fine grained sand over subangular gravel, with the bedrock type being gypsum. Test hole # 2 was drilled to determine the lateral thickness of the surficial deposit and as an attempt to strike any potential underground stream channels. It showed, with 0 to 20 feet of bog and sand, that the major part of the deposit is in the above ground part of the esker with little material being under the surface level of the swampy area adjacent the bog, which represents the lowest elevation in the immediate area. This seems to indicate that, any water falling in the vicinity and particularly on esker material, passes laterally into the swampy area and drains off via a stream which runs out from the bog and into the Shubenacadie River at Milford Station.

The western part of the company land contains the new wash plant. This consists of a pit dug beneath the existing water table into sands and gravels, from which water is drawn and circulated through the washing process. Also, there is a sediment settling pond connected to the wash area and then to a line back to the pit. It is believed that this pit is capable of producing several hundred gallons of water per minute, but due to the recycling of the extracted water, the long term safe yield is uncertain.

In the east central part of the esker deposit there are two wells located near the field office of Nova Scotia Sand and

Gravel's field operation. One of these is a shallow dug well (No. 50) and the other (80B) is drilled. Apart from a chemical analysis from the drilled well there is no other information available for either of the two.

Indian Reservation No. 14 lies just ¼ mile to the north of wells Nos. 80 and 80B. An extensive drilling program was carried out at the south edge of the reserve to determine the volumes and quality of the sand and gravel deposits within the reserve. The results indicate thickness of granular materials up to 80 feet. It is known that lateral flow from this area acts as a feeder supply for the Indian Reserve water supply about 200' to the north. A test well with subsequent pump test would reveal some indication of the water yielding potential of this site. This testing was not conducted during the spring of 1977 test program since it was felt that it could possibly interfere with the existing water useage. Further testing on this site, at a future date, may produce reliable information about the volume of potential reserves, preferably when there is no danger of interference pumping.

Test holes were not drilled in the middle portion of the main deposit due to lack of accessibility and relative distance from populated area (Refer to Map #2). This area is currently being worked by N.S. Sand and Gravel, and potential sites for setting up and drilling test holes reveal that surficial materials range in thickness from

18' to 58',and are comprised mainly of sand with minor gravel and stones (Map #3). There is no valid information on the potential for water yield from this section of the deposit other than the fact that N.S. Sand and Gravel pump water from a dug pit at about 2400 gpm for their washing operation. The water is recycled, thus no accurate assessment can be made of the total volume available. It would be possible to pump the pit without recycling and this would give an indication of water volume to the bottom of the pit (20') at least. This would utilize about 20' of the estimated 50' of saturated material at this site. Since N.S. Sand and Gravel use the water continuously, a long term pump test could temporarily deplete their source. A properly conducted pump test in a well drilled into these surficial materials, would be necessary to determine the true water bearing capacity of this section of the deposit. As the site is presently in use, it is recommended that testing be delayed until greater access and manoeuverability is possible.

The extreme westerly part of the esker extends across Blois Road and borders a swampy area. No doubt the swamp is due to poor drainage of water which runs in from surrounding clear hills and from the esker abutting it. This would indicate a lack of water in the surficial materials of this section of the esker. Drill hole information is available

for this section as provided by Nova Scotia Sand and Gravel Limited Map #2. It indicates that materials depth ranges from 82' near Blois Road to 10' where the esker ends and clay till begins. This also marks the Nova Scotia Sand and Gravel property boundary.
Again, no pump test data is available for this section of the deposit. The elevation of the swamp is about 50' below the crest of the esker, which indicates that the materials may reach a depth of 20' - 30' below the swamp elevation on one side and 30' - 40' below the clay till surface which borders the other side.

A new municipal dump has been conveniently located above the cut-away esker ridge and west of Blois Road (Map #2), abutting and encroaching upon the swamp. If leachate moves from the dump, it will move into the swamp either by surface runoff or through seepage in esker materials. The Blois Road cuts the swamp off from the surficial materials to the east, thus these features are not directly linked at the surface. This does not eliminate the possibility that the esker materials to the west and east of Blois Road and the swampy area which contains sand also, are linked below surface level. Topography in the area indicates that flow may move east or west (Map #2). Any evidence that the dump poses a direct threat to existing water reserves is inconclusive at present. It is recommended that further study be initiated to gain greater appreciation of this potential threat to the existing natural resource.

6.2 WATER QUALITY AND QUANTITY STUDY WITTENBURG, COLCHESTER COUNTY

6.2.1 General

A study of short duration was done around the site of the Wittenburg Dump to determine various characteristics for the granular materials present and to assess the hydrogeology of the deposits. A secondary reason was to determine if leachates were moving through the surficial materials toward the St. Andrews River.

The major surficial deposit is located at 11E3B.98 to 99 and 11E3C.2 to 3 on the mining grid system. Two test drill holes were sunk, one about 200 feet north of the existing dump area,and a second approximately 200 feet east of the first. They are noted on location Map #3. The land area is divided into: lands owned by the N.S. Department of Highways and used as a source of sand and gravel, lands owned by Colchester County and used for a municipal dump and privately owned lands. The St. Andrews River borders the surficial deposit to the north and a swampy area lies to the west.

6.2.2 Geology and Hydrogeology

The area is underlain by the Riversdale group of rocks which consists mainly of sandstone, shale and limestone in this part of the province.

The areal extent of the surficial materials, consisting of various grades of sand and gravel, is displayed on the following Map #3.

The stratigraphy of test hole No. 1 is as follows:

0-30'	sand, fine grained
30-32'	clay and gravel
32-106'	sandstone, reddish fine-grained and shale, grey
106-135'	limestone, greenish
135-152'	sandstone, reddish, fine-grained

This test hole was bailed at a discharge rate of 60 gpm for a period of 1.5 hours. This is obviously quite significant and it is felt that the yield could be as high as 150 gpm for extended periods. The main water bearing zone is thought to be the 30-foot-thick limestone sequence.

Test Hole No. 2 was discontinued before water was encountered since the main object of the program was to assess the surficial deposits. The log of hole no. 2 is as follows:

0 - 20'	-	gravel, fine, sand, coarse
20 - 30'	-	sandstone, green and red, fine grained

The above subsurface information is the only such information available for this entire area and, consequently, it is not possible to make any meaningful correlation with other similar materials.

The quality of water tested from hole no. 1, with the exception of iron and manganese (5.7 and 0.2 mg/l respectively), is considered to be good. Turbidity is high at 210 JTU, but this is felt due to the drilling activity. It is possible that the elevated iron content might be related to the drilling activity.

6.2.3 Conclusions

There was found to be approximately 20-30 feet of sands and gravels overlying bedrock in this deposit. The predominant material from 10-30 feet was tight, fine-grained sand which contained no noticeable amounts of water. On the other hand, the porous underlying limestone,at about 100-140 feet,contained large quantities of water. There is a 2-foot clay and gravel layer lying just on top of the bedrock. This could act as a retaining barrier for water to be captured in the sands, but there is no evidence to support this hypothesis.

It appears that any water entering the bounds of the surficial deposits, either directly or from surrounding topographic highs, is passing through the sands and moving vertically into the bedrock, or is moving laterally into the swampy area and ultimately into the St. Andrews River. This conclusion seems to apply to the whole western side of the deposit. The eastern side seems, at least at surface level, to contain a greater percentage of gravel. It is bordered by a large clay hill to the far east and by the St. Andrew's River on the north. One cannot be sure without testing whether or not these materials contain noticeable water, or whether the water moves directly into the river or into bedrock.

The water quality from well No. 1 is good, except for high iron and manganese counts, which are considered anomalous. This helps to confirm assumptions that Riversdale Group limestone is capable of producing good quality water. Since there were no noticeable amounts of water encountered in the surficial materials, the possibility of leachate contamination of the sands and gravels is not a major concern. What is particularly disconcerting is that leachates may be moving with the water either vertically downward into the bedrock or, most probably, laterally into the swampy area and then ultimately into the St. Andrews River. It should be noted that the Saint Andrews River is the only source of water for the Stewiacke town water system and the intake is located approximately two and one half miles from the dumpsite. What quantity of leachates entering the river, if any, is not known and thus the assimilative ability of the river water is not calculable. This situation merits future attention.

7. CHEMICAL AND PHYSICAL ENCROACHMENT ON GROUNDWATER SUPPLIES

Groundwater contamination within the Shubenacadie-Stewiacke River Basin is not as yet a serious problem. Where it does occur, it is as a result of natural or human influences.

A number of occurrences of salt contamination of wells has been attributed to highway salting practices,with the injured parties being provided with new potable supplies at government expense. Also, hydrocarbon contamination has occurred in several private wells due to gasoline truck or storage tank spills or leaks.

A few cases of wells being contaminated by human or animal waste have been studied. This problem may arise through any of several factors related to terrain and soil conditions such as impervious soil, high water table, steep slope or thinness of overburden. Carelessness in choosing a well site (e.g. near a barn or livestock pen) can be an obvious cause.

Another less noticeable but highly prevalent problem is that of poor dug well construction and the need for cleansing of dug wells. Within the basin, 64% of the dug wells tested for total coliform bacteria (an indicator of the potential presence of pathogens in water) displayed values above the recommended limit of 10 per 100 ml. of sample. This problem could be reduced through some type of educational program oriented in that direction. It would be most effective, however, if started with new home owners who would be more receptive to the type of advice and instruction required.

Chemical contamination of groundwater springs and streams is a well known and highly visible problem. Certain bedrock types are felt to be mainly responsible for poor water quality in many groundwater supplies. The Meguma group is known to impart high iron and manganese values to waters and the Windsor group (due particularly to gypsum) has proven to cause very high values of hardness and dissolved solids.

Within the basin, there are several cases in which facilities have been poorly located with respect to their impact on the water resource. In particular, one may cite the construction of sanitary landfill operations and open dumping near or on known or potential water reserves. Further study of such a situation could be considered in the future, at Hardwood Lands - Nine Mile River dump site.

It must also be borne in mind that runoff from farmlands carries chemical remnants of fertilizer into surface and groundwater systems. There are as yet no specific problems of this nature reported in the basin, but as time goes on, they may occur. Hence it is in our interest to assure that surveillance related to this potential problem is not relaxed.

Surprisingly, there are to date only a few proven reported cases of groundwater supplies being contaminated by faulty septic tank construction. One might expect this to increase as land occupancy density escalates and development pressures force the use of less desirable sites for human habitation. Further to this, we must consider the large number of homes constructed in the Headwaters and Corridor areas in recent years. It will take several years or more before many of the problems due to poor disposal field construction become evident. It is probable that the potential for this is high as indicated from the Headwaters Study by Inland Waters Directorate.

Finally, the problem of well interference must be considered. However, to date there is no clear evidence of any residential area suffering a shortage of water due to population density and overpumping, although numerous individuals have made claims to this effect. Of particular concern is the location of large residential complexes (for example, trailer courts) adjacent to existing single family dwellings.

8. PROPOSED REQUIREMENTS FOR FUTURE DATA COLLECTION

The information requirements noted here pertain to voids in the existing data base which may be addressed in the future. To more thoroughly assess water quality within the basin, several areas require further sampling. The number of samples required are indicated as per sheet of Series D, Lands and Forests Maps at scale 1:1,320. They are among the unsampled well locations noted on the composite map.

SERIES D MAP NO.	FURTHER NO. OF WATER QUALITY SAMPLES REQUIRED (MATERIAL TYPE)
H-26	3 = 3 (ss.)
H-27	3 = 1 (ss.), 1 (ls.), 1 (grav.)
I-23	1 = 1 (ls)
I-24	3 = (gyp., ss.), 1 (ls.) 1 (grav.)
I-25	17 = 3 (ss.), 3 (ls.) 2 (ls., gyp), 4 (sh.) 1 (sd.), 2 (grav.) 1 (gyp.), 1 (qtzite.)
	TOTAL = 27 samples

Further study is required in the Hardwood Lands area to properly assess the actual underground water quantity available and to assess the potential threat that the municipal dump may impose. Also, the removal of granular materials should be considered with a view toward compatibility with maintenance of a possibly useful groundwater resource.

Streamflow measurements and precipitation norms are required for the remainder of the study area (beyond the scope of 1974 survey).

Data from continuous water level recording stations will be needed to analyse the groundwater budget within the basin. This will require the establishment of a number of recording stations within the basin. Test drilling and possible pump testing is required at various sites throughout the basin, so as to determine the character and extent of materials and their water-bearing potential. The Enfield to Shubenacadie Corridor is of particular concern, bearing in mind existing and future development pressures. A number of other sites which exhibit groundwater resource potential are found throughout the basin area. Evaluation of these sites will provide relevant base data upon which to make a regional groundwater assessment.

9. GENERAL CONCLUSIONS AND RECOMMENDATIONS REGARDING THE DEVELOPMENT OF FUTURE GROUNDWATER SUPPLIES WITHIN THE SHUBENACADIE-STEWIACKE RIVER BASIN

Several areas within the basin warrant future attention due to their individual potential and to increased development pressures. The Hardwood Lands area has been studied on an initial basis and additional data is required. Extensive exploratory drilling and possible pump testing is required to accurately determine the extent of water reserves in this surficial aquifer. It is a problem, however, to determine the best means of serving the interests of all parties involved with this natural resource, these being: Nova Scotia Sand and Gravel, government and municipal agencies.

Shubenacadie Village now relies on Snide's Lake as the source for their central water distribution system. It should be considered that the close proximity of this source to development and agricultural activities, combined with its limited capacity and degree of stagnation, may jeopardize its usefulness as a satisfactory source in the future. It is known that drilled wells in the vicinity of the village can yield over 100 gpm. (in rare occurrences),although past testing reveals that the water has displayed a high degree of hardness. It is suggested that a satisfactory supply both in terms of quality and quantity may be found in limestone, shale or sandstone beds along the Shubenacadie River and the old highway 102. This cannot be confirmed without future test drilling, since the information to date is scant and is based mainly on communications with well drillers.

Testing was carried out in the Shubenacadie-Hardwood Lands area in an attempt to cite the possible existence of old buried river channels, with little success. The location of such channels may only be determined after a lengthy drilling program and expansion of the data contained in the Hardwood Lands special study in section 6.1 of this report. Lands assigned to the Shubenacadie Indian Reserve have been studied by the Water Planning and Management Division and Bird and Hale Consultants of Toronto. These studies were aimed at outlining alternative water supplies to the existing system originating near Nova Scotia Sand and Gravel holdings. The resulting data indicates that exploratory drilling on Indian lands may detect potential water supplies in the surficial materials, which Bird and Hale have outlined. Whether such supplies would be great enough to satisfy the demands of the Reserve,as well as outlying parts of Hants County,is uncertain. Equally important is the question of whether the authorities involved could negotiate an amicable arrangement. This group would include the Band Council, municipal,provincial and federal authorities.

The major development zone which merits concern from a water resources point of view is the Enfield to Shubenacadie Corridor. This section of Hants County has experienced a five-year growth rate of 25% between tabulation years 1966 and 1971 and,since 1971, the annual growth rate is estimated to be 7 percent. A previous study revealed that around Elmsdale, surficial sediments are unconfined and appear to contain water of acceptable quality, while in the Lantz area, the sediments are confined and water quality is adversely affected by the underlying Windsor bedrock.

A testing program is necessary to evaluate the potential of these surficial materials. It would involve the drilling of a number of small-diameter exploratory holes around Elmsdale to determine the depth of saturation of the sediments, and provide soil samples throughout the depth to determine the grain size (particle) distribution. At the most favorable site, a well would be properly constructed, developed, and pump tested with concurrent water level observations being taken in the adjacent exploratory holes. The results of the pump test would enable prediction of the perennial yield of the aquifer, and permit decisions as to the location of production wells. The testing method employed could involve geophysical,seismic testing through the most promising areas of surficial sediments. These areas would be basically along the river enbankment and flood plain below the 50-foot contour elevation. The most likely test sites are located on the north side of the Shubenacadie River and close to the demand area.

A similar test drilling program would be necessary to determine the character, extent and water bearing capacity of alluvial and lacustrine deposits of silt, sand and gravel along the Shubenacadie River where it passes through Lantz and Enfield. Due to the lack of drilled wells or other types of exploratory drilling around these communities, little information exists, particularly for Enfield. What is known is that the quality of the Shubenacadie River waters is in jeopardy and the ability of this source to provide an adequate primary supply for the communities of Enfield, Elmsdale and Lantz may be seriously impeded. Thus, investigations of the type mentioned should be seriously considered.

At the present time, Milford residents rely mainly on dug wells for their water requirements, since history has shown that drilled wells are highly prone to producing water contaminated by gypsum. It is suggested that further water well sampling be done in the Milford area to gain a more accurate assessment of the groundwater quality. Preliminary indications reveal that at various locations around Milford, good quality groundwater may be obtained. Considering the growth rate of this community, municipal authorities will be forced to investigate the prospects for a central water system, in the not too distant future.

A number of other areas within the basin are underlain by bedrock and surficial materials, about which there is little or no existing information. To determine the character, extent and water bearing potential of these materials, a test drilling and pumping program is required. A proper evaluation of these areas will enable one to develop a more accurate regional groundwater picture. The possible exploration sites have been identified in descending order of interest,on the basis that certain areas offer more potential for investigation than others, due to the presence of possible water bearing materials and the fact that all have a certain present or future demand potential, depending on their geographic locations. The areas are: Nine Mile River, Pine Grove (Shubenacadie area), Middle Stewiacke, Stewiacke, Upper Rawdon, Middle Beaverbank, Oakfield-Horne's Settlement, Brookfield, Cooks Brook, South Maitland, Latties Brook and Coldstream.

In summary, several locations along the Enfield to Shubenacadie corridor have the potential for groundwater resource development. The physical and chemical deterioration of existing supply sources in several communities, combined with a high growth rate, and accelerating demand for new or supplementary water sources, point to the need for immediate consideration. As well as offsetting demands due to a high growth rate, communities must offer services that will aid in realignment of present development trends. The major factor involved is a viable alternative to strip development along the major transportation systems within the corridor.

The Enfield-Elmsdale-Lantz area now relies solely on the Shubenacadie River as the source for central water services. The feasibility of this source is now in doubt. Thus, in light of ensuing development pressures, these areas require immediate attention with the development of potential groundwater reserves seemingly the most viable approach. The areas of investigation will be in close proximity to the existing communities and thus, if potable supplies are located, costs of central servicing from the source site will be kept to a minimum.

The Milford area now relies on individual wells to meet its water requirements. Due to its distance from potential surface water sources and the dubious quality of the Shubenacadie River waters, it is felt that Milford should explore the possibility of groundwater supplies to meet its future water needs. Previous investigations reveal that bedrock wells of production capacity may be possible within the confines of the existing community.

The third area requiring consideration on this basis is Shubenacadie Village and surrounding lands. The town now relies on Snide's Lake as the source for its water distribution system. It is felt that growth pressures and future potential encroachment on the quality of this supply dictates that alternative or supplementary sources should not be investigated. Again, development of groundwater sources could prove to be the most viable approach.

The final consideration should entail an evaluation of the groundwater resources of a number of smaller areas throughout the basin. Data resulting from this effort may be employed to create a more accurate regional groundwater picture. Such data could provide a sound basis upon which to make future water resource policy decisions and would enhance the effectiveness of attendant economic considerations.

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A P P E N D I X " A "

METEOROLOGICAL DATA

<u>Meteorological Stations in Nova Scotia</u> - Those pertinent to this study are: Truro (N.S.A.C.), Noel, Fraser Brook (I.H.D.), Upper Stewiacke, Middle Musquodoboit, Rawdon, Mount Uniacke, Halifax International, Lower Sackville, Westphal, Shearwater, Bedford and Halifax.

<u>Daily Maximum Precipitation</u> - Maximum precipitation values reported on any one observation day from 1931 - 1958 are explained as follows:

a) This data provides the maximum precipitation observed on a "precipitation day" at each official meteorological station relevant to the study area.

b) The observation day at synoptic observing stations consists of 24 hours ending at 1200 G.M.T. on the morning of the following day. Similarly, at most climatological stations the "observation" or "precipitation" day ends at the time of the next day's morning observation. This is usually about 8 a.m. local time, but varies from 6 a.m. to 10 a.m. It should be noted that the maximum precipitation for any consecutive 24 hours may well be appreciably higher than the amounts given here, which are tied to a specific 24 hour period.

c) The period of record is shown for each station. When the period is broken and not complete, the letter "B" has been inserted following the figures for the last year of record. In a number of cases, the observation site has not been at

c) (Cont'd)

the same location for the whole period of record, but the data have been considered homogeneous if the same station name has been used for the period.

d) The units used are inches of water expressed to the hundredth part. The month and year are indicated for each maximum value. The precise date of occurrence can be found by examining the "Monthly Record of Meteorological Observations in Canada" for the month in question. A separate listing with dates is given for the two largest amounts reported, within the study area.

Tables I and II give maximum precipitation values for the period 1931 - 1958.

Sunshine Hours

Mean, annual number of hours of bright sunshine are given as follows:

Halifax - 1,873 hours

Evaporation

The following evaporation data for Truro, Nova Scotia, are observed values of lake evaporation computed from a Class A Pan:

May	- 3.5"	August	- 3.5"
June	- 3.9"	September	- 2.4"
July	- 4.1"	October	- 1.4"

Annual estimated evaporation - 22"

These evaporation values are true for ponds and small lakes and reservoirs with negligible heat storage. In large lakes with significant heat storages, evaporation losses will tend to lag behind the seasonal changes indicated by these data.

Transpiration

Evapotranspiration charted information is taken from the Nova Scotia Survey Reports for Halifax, Hants and Colchester Counties.

Rainfall Intensity Data

Rainfall intensity frequency data is available from the Department of Transport in Moncton. This meteorological data can be employed for the determination of values pertaining to a water budget analysis and yield analysis for the entire basin or any subwatershed. The regional groundwater flow picture will be most easily understood and determined if it is treated on a subwatershed basis. Also, most available data comes from the 1974 Shubenacadie Environmental Survey, which broke the study area down into individual lake systems and presented it with this bias.

TABLE I

Two Maximum Precipitation Values Reported on Single Observation Days in Nova Scotia from 1931 - 1958.

Station	Amount in Inches	Date
Halifax	9.40	Sept. 21, 1942
Mount Uniacke	7.25	Sept. 21, 1942

Maximum Precipitation in 24 Hours - Shubenacadie-Stewiacke River Basin Area

Station	Period	Maximum Amount	Date
Beaverbank	1956-58	3.13	Jan. 1958
Bedford	1957-58	3.92	Jan. 1958
Halifax	1948-51	2.54	July 1948
Halifax-Dartmouth	1941-58	5.18	July 1954
Halifax R.C.A.F.	1940-50	9.40	Sept. 1942
Halifax DWPO	1951-58	2.92	July 1954
Harmony	1950-58	3.92	Aug. 1950
Kelly Lake	1953-54	2.87	Jan. 1954
Lucasville	1951-54	2.73	Jan. 1954
Md. Musquodoboit	1931-33	1.71	Sept. 1932
Mount Uniacke	1931-58	7.25	Sept. 1942
Noel	1934-58	3.95	Jan. 1956
Noel Shore	1956	2.08	Apr. 1956
Rawdon	1956-58	2.15	Jan. 1956
South Alton	1931-33	2.35	Oct. 1933
Truro	1931-58	4.60	Sept. 1942
Upper Stewiacke	1931-58	3.24	Sept. 1936
Westphal	1957-58	3.19	Feb. 1958

Locations of Observation Network Stations

HYDROMETRIC AND CLIMATOLOGICAL STATIONS

Hydrometric Station	Station Number	Drainage Area (mi.^{2})	Period of Record
Beaver River near Kinsac	01DG003	37.4	1921 - date
East River at St. Margaret's Bay	01EH003	10.4	1925 - date
Musquodoboit River at Crawford Falls	01EK001	251	1915 - date

Climatalogical Station	Period of Record
Mount Uniacke	1920 - date
Middle Musquodoboit	1963 - date*
Halifax International Airport	1961 - date
St. Margaret's Bay	1922 - date

*Partial Record available for 1961-1962.

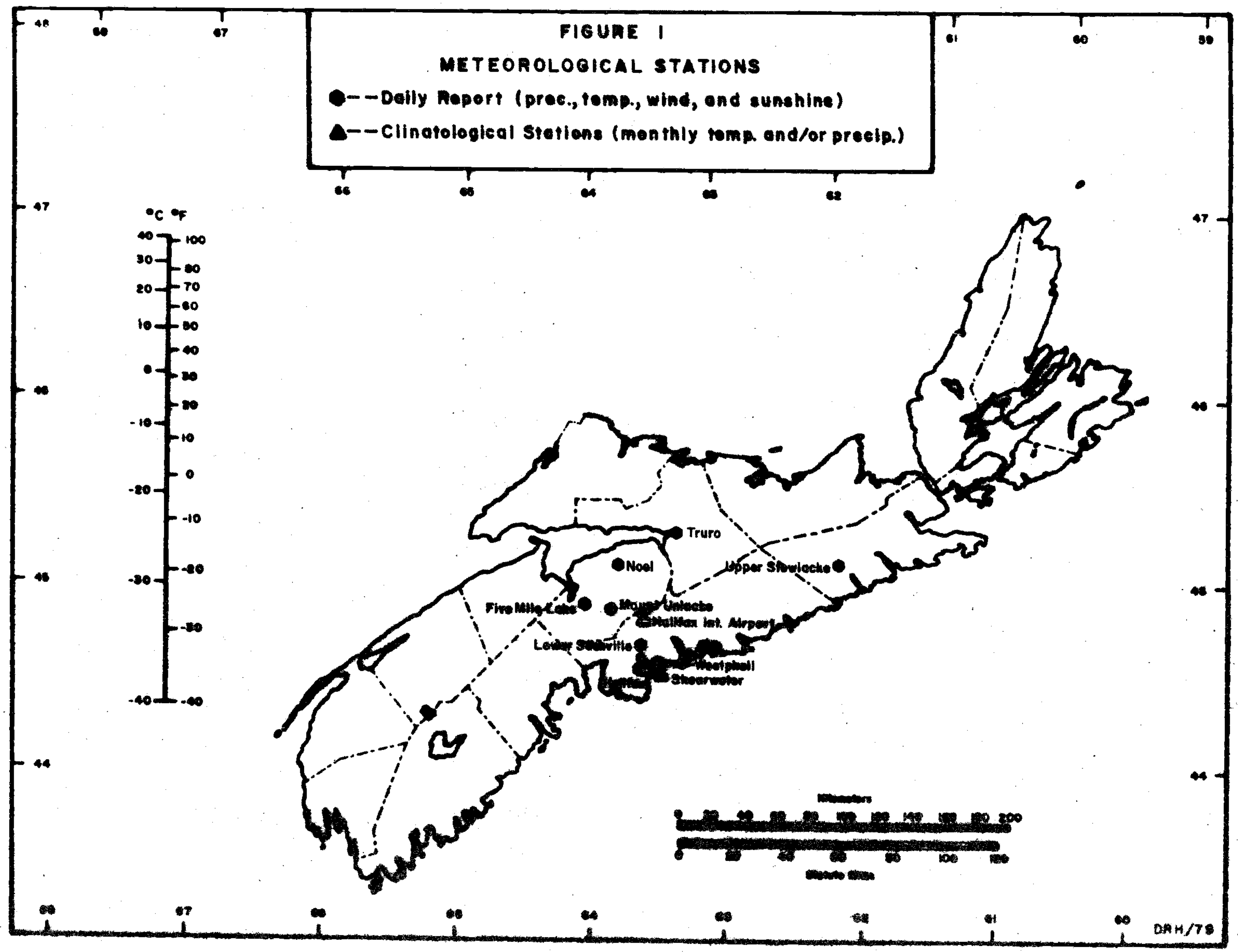


FIGURE I
METEOROLOGICAL STATIONS

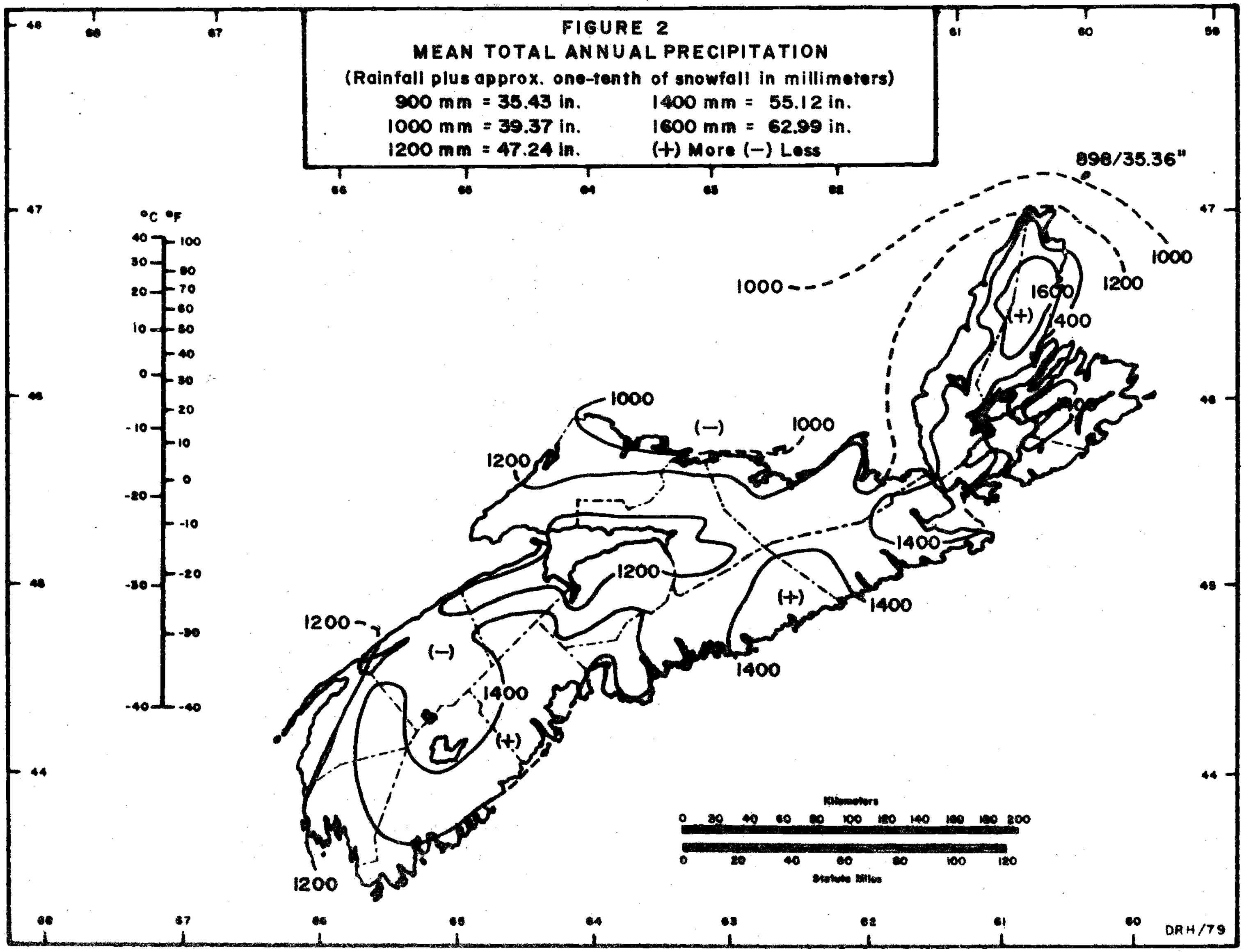


FIGURE 2

MEAN TOTAL ANNUAL PRECIPITATION

(Rainfall plus approx. one-tenth of snowfall in millimeters)

900 mm = 35.43 in.	1400 mm = 55.12 in.
1000 mm = 39.37 in.	1600 mm = 62.99 in.
1200 mm = 47.24 in.	(+) More (–) Less

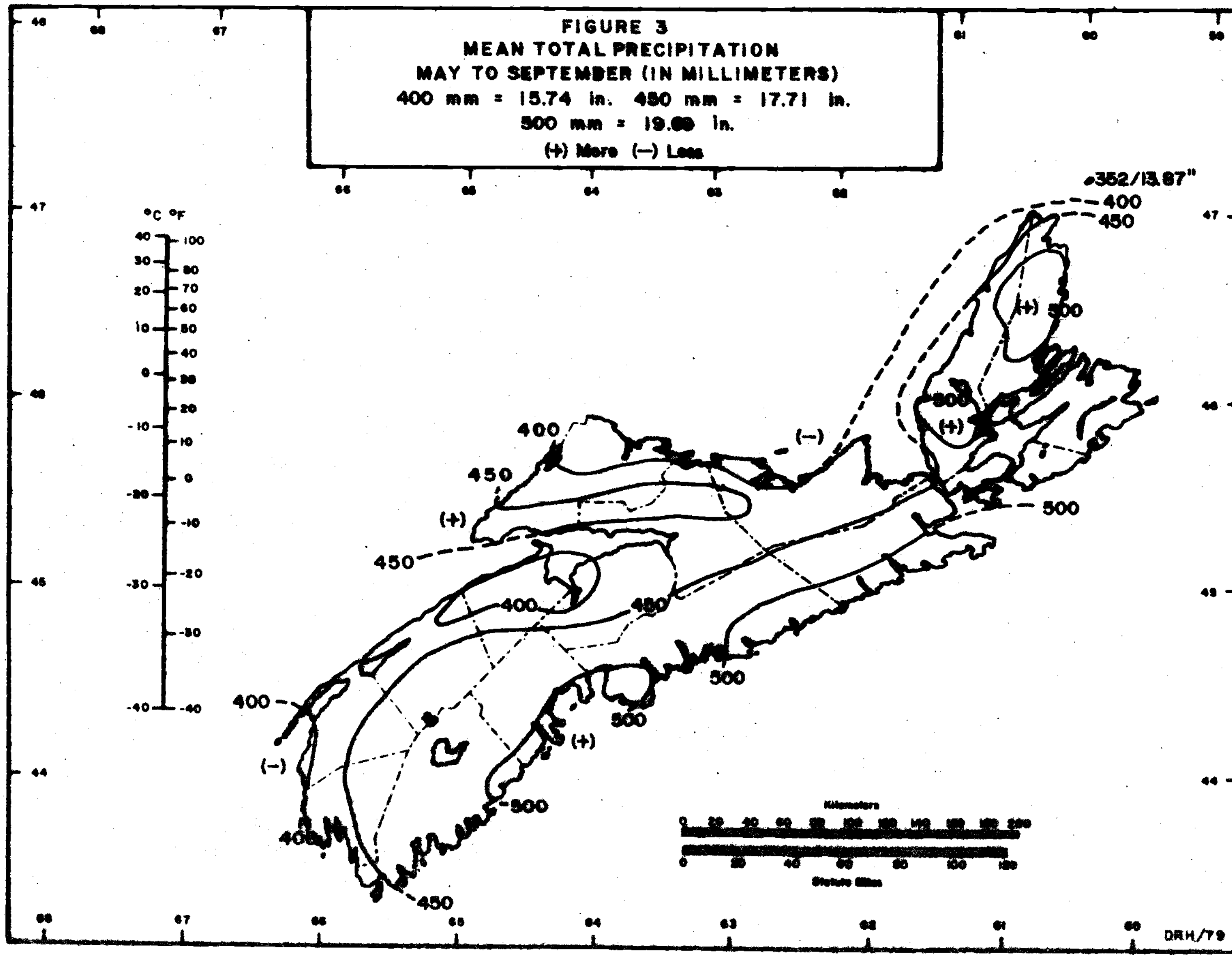


FIGURE 3
MEAN TOTAL PRECIPITATION
MAY TO SEPTEMBER (IN MILLIMETERS)
400 mm = 15.74 in. 450 mm = 17.71 in.
500 mm = 19.69 in.
(+) More (−) Less

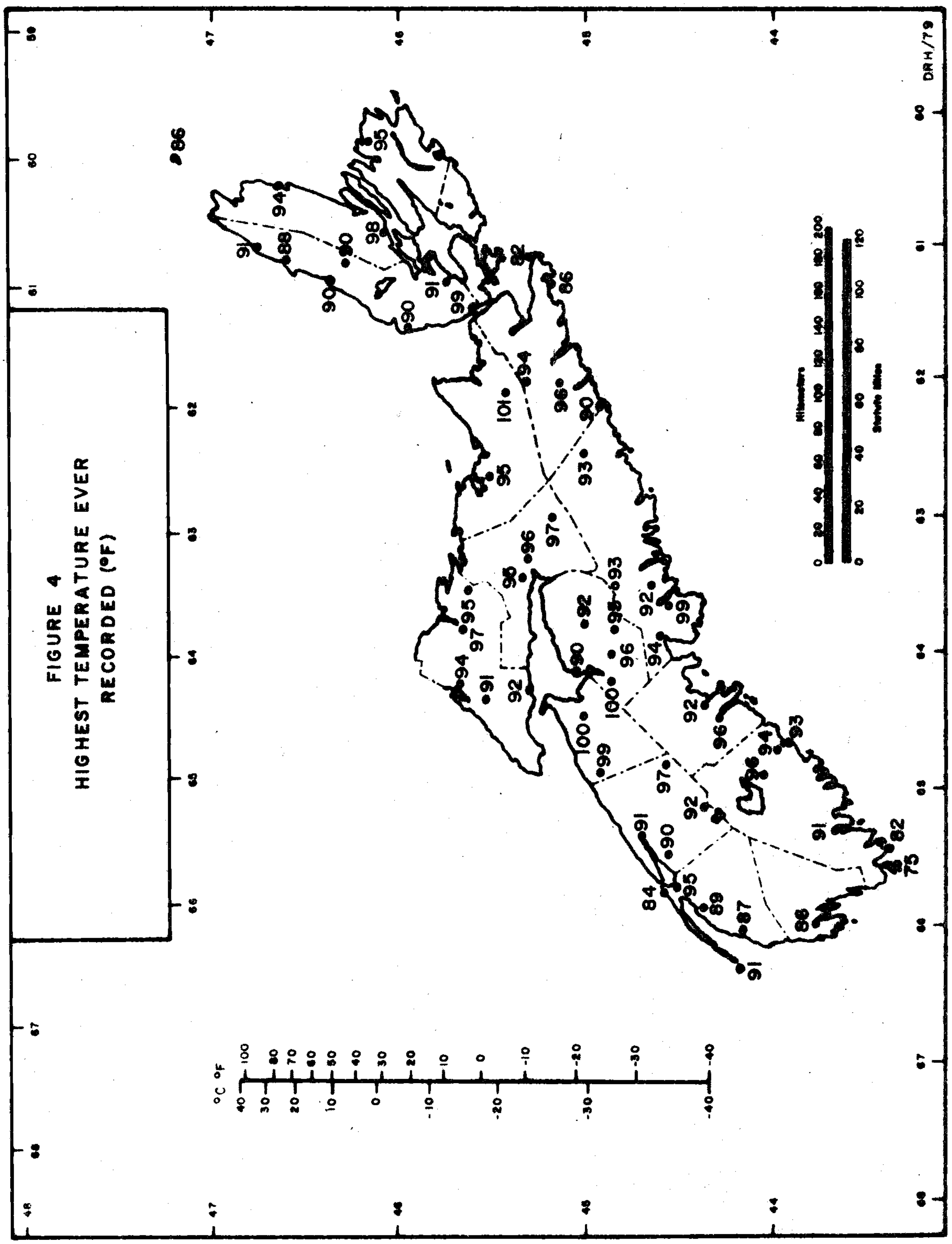
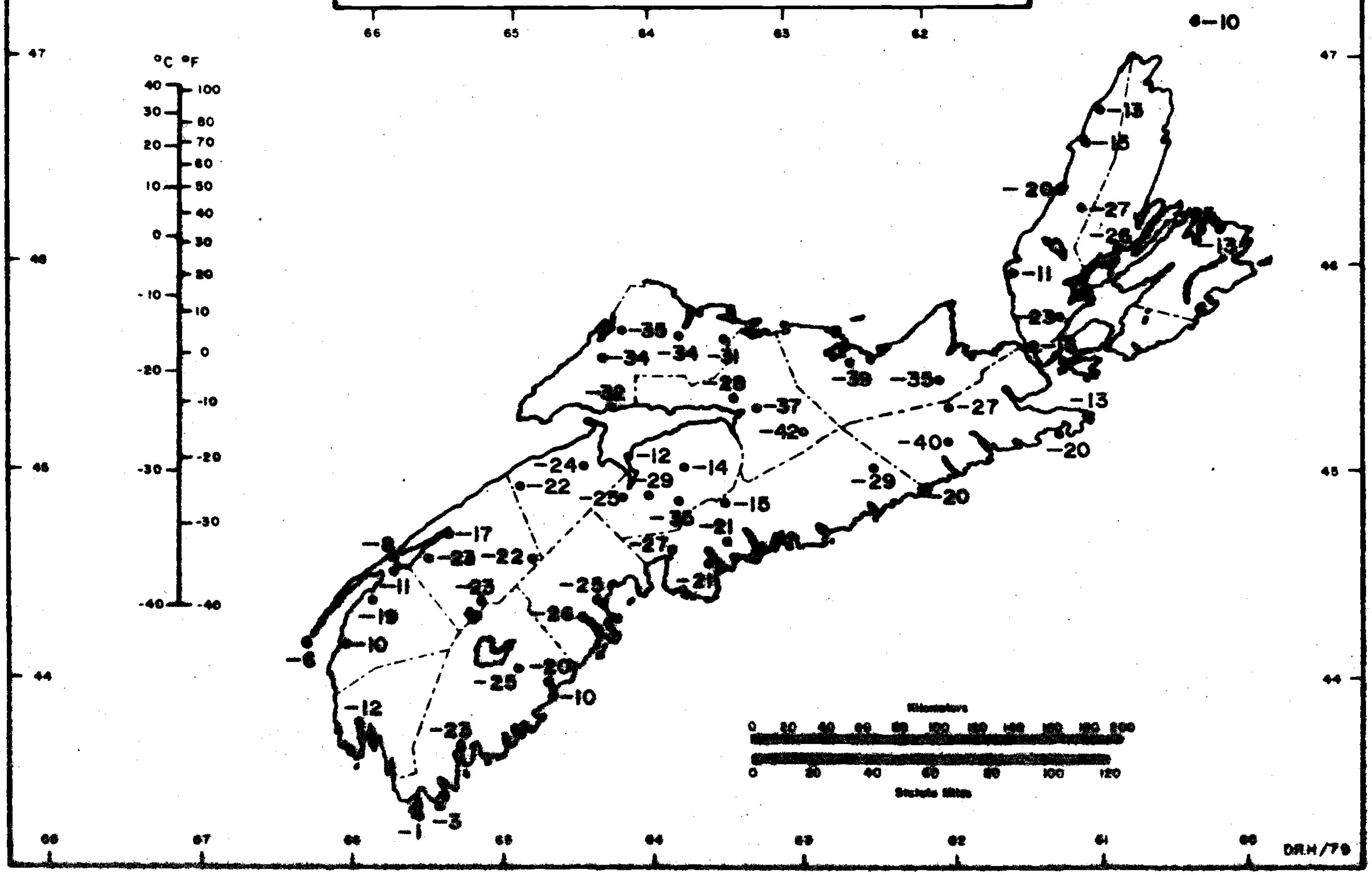


FIGURE 4
HIGHEST TEMPERATURE EVER RECORDED (°F)

FIGURE 5
LOWEST TEMPERATURE EVER
RECORDED (°F)



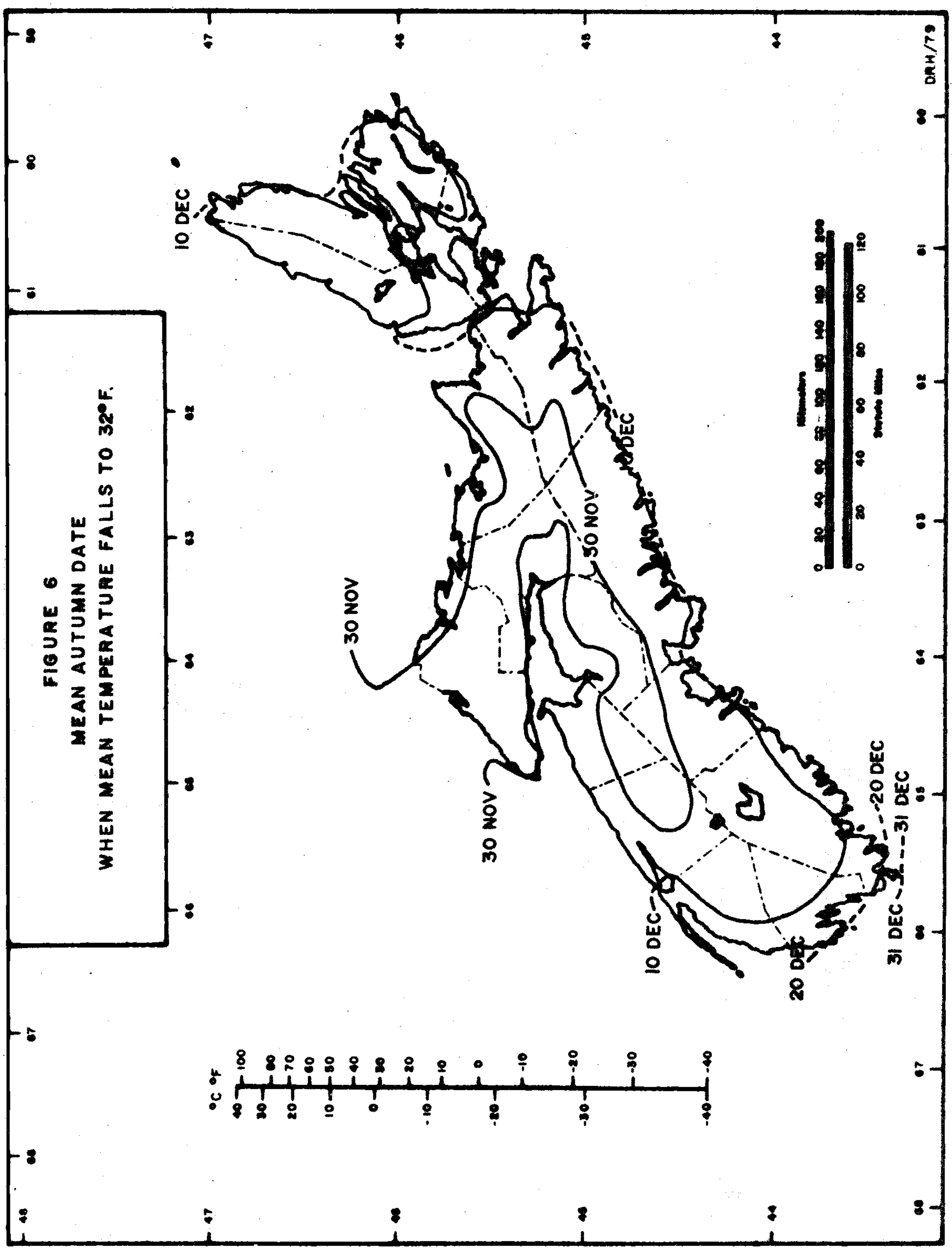


FIGURE 6
MEAN AUTUMN DATE
WHEN MEAN TEMPERATURE FALLS TO 32°F.

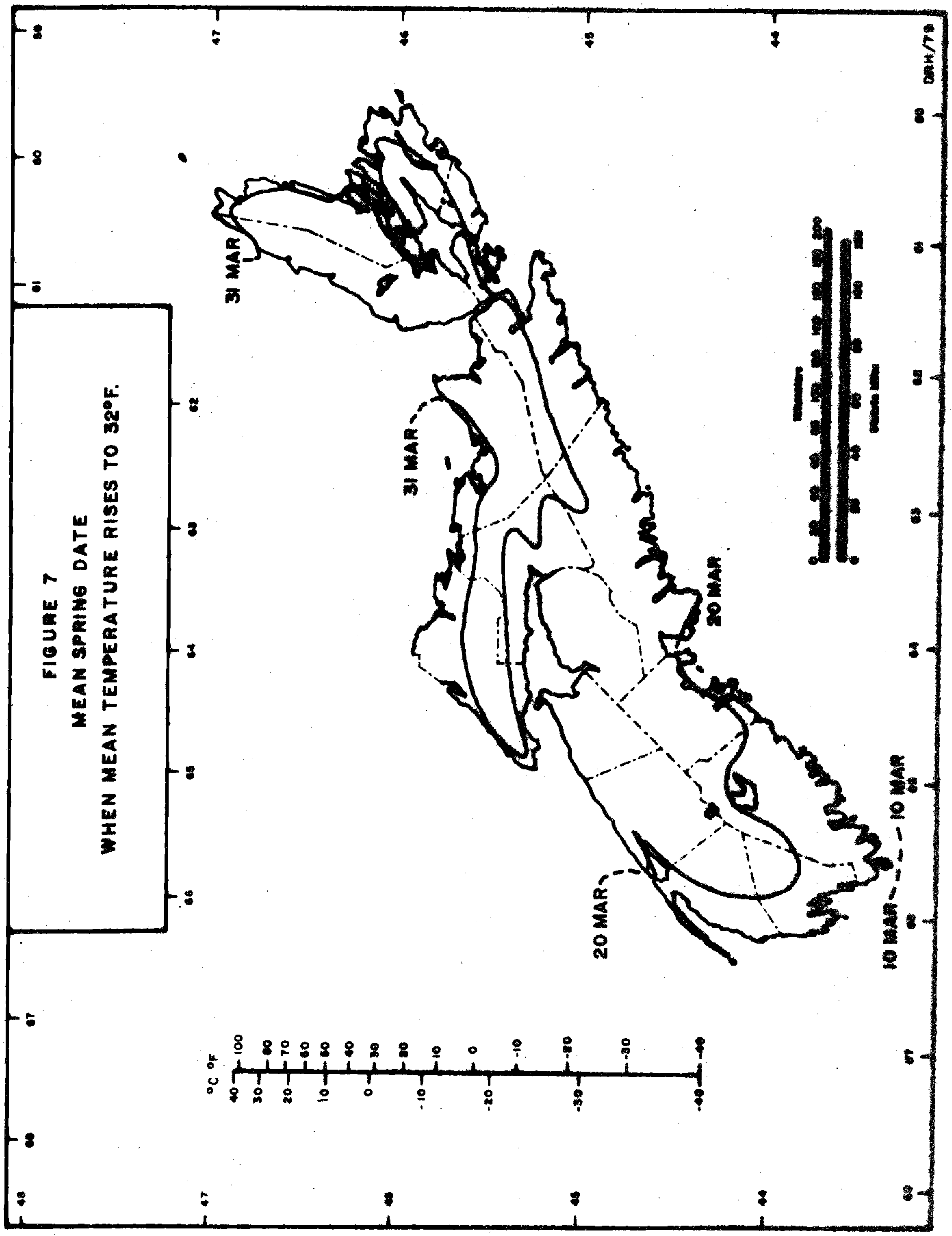


FIGURE 7
MEAN SPRING DATE
WHEN MEAN TEMPERATURE RISES TO 32°F.

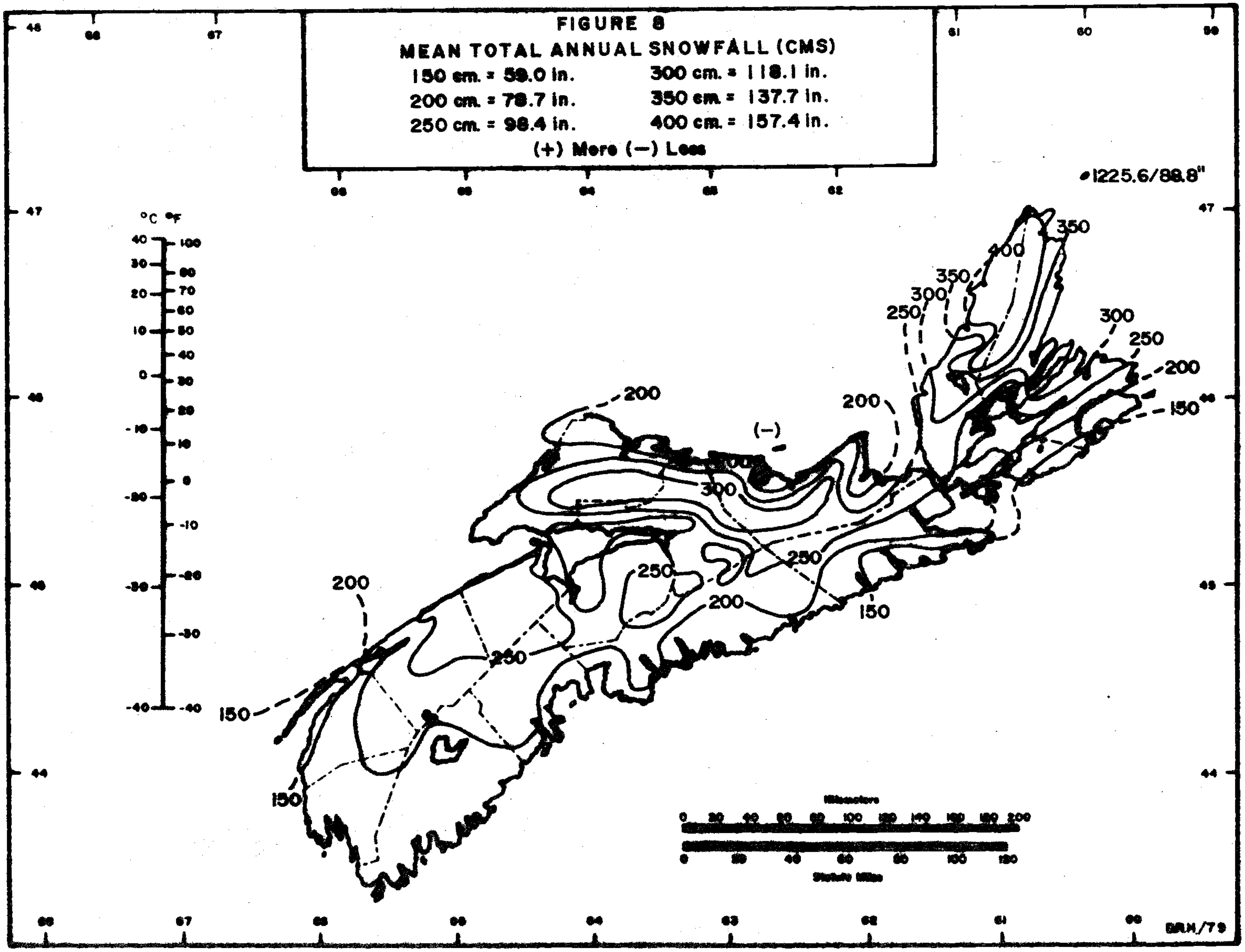


FIGURE 8

MEAN TOTAL ANNUAL SNOWFALL (CMS)

150 cm. = 59.0 in. 300 cm. = 118.1 in.
200 cm. = 78.7 in. 350 cm. = 137.7 in.
250 cm. = 98.4 in. 400 cm. = 157.4 in.

(+) More (−) Less

A P P E N D I X "B"

POPULATIONS OF UNINCORPORATED PLACES IN SHUBENACADIE-STEWIACKE RIVER BASIN

POPULATIONS OF UNINCORPORATED PLACES IN SHUBENACADIE-
STEWIACKE RIVER BASIN

	1961	1966	1971	Ave. Annual Population Increase (1961-1971)
Admiral Rock	133	102	123	-
Alton	134	131	144	1%
Antrim	52	35	-	-
Barney's Brook	-	-	-	-
*Beaverbank	870	846	1,234	4.2%
*Beaverbank Villa	Not listed	711	776	-
Brentwood	143	169	205	4.3%
Brookfield	653	654	658	1%
Burnside	68	62	51	-
Carrol's Corner	269	217	274	1%
Chaplin	96	84	99	1%
Cloverdale	-	-	-	-
Coldstream	59	57	67	1.3%
Cook's Brook	96	80	95	-
Dean	207	201	171	-
Dutch Settlement	351	403	441	2.5%
Elmsdale	592	689	807	3.6%
Eastville	124	96	90	-
Enfield	907	1,100	1,418	5.6%
*Fall River	266	279	969	26.4%
Five Mile River	71	52	53	-
*Fletcher Lake	197	315	394	10%
Gay's River	41	62	41	-
Georgefield	65	64	58	-
*Grand Lake (Station)	185	169	243	3.1%
Green Creek	-	-	-	-
Green Oaks	92	85	80	-
Horne Settlement	-	-	154	-
*Kinsac	135	180	274	10.3%
Lake Egmont	-	-	-	-

(Cont'd)

POPULATIONS OF UNINCORPORATED PLACES IN SHUBENACADIE-STEWIACKE RIVER BASIN (Cont'd)

	1961	1966	1971	Ave. Annual Population Increase (1961-1971)
Lakeview	187	200	237	2.680%
Lantz	729	763	1,190	6.330%
Maitland	233	230	243	0.430%
McPherson Corner	46	57	65	4.130%
*Middle Beaverbank	Included with Beaverbank	129	178	-
Milford Station	623	740	740	1.880%
Montague Gold Mines	122	67	422	24.590%
Middle Stewiacke	217	230	287	3.230%
Newton Mills	135	131	137	0.150%
Nine Mile River	197	217	289	4.670%
*North Beaverbank	-	58	98	-
North Salem	114	112	101	-
Oldham	151	150	162	0.730%
Otter Brook	51	62	80	5.690%
Pembroke	50	42	55	1.0%
Pleasant Valley	151	141	106	0.0%
Princeport	76	74	79	0.400%
Renfrew	-	-	-	-
Roulston Corner	-	-	-	-
Sandy Cove	-	-	-	-
Shubenacadie	808	817	812	0.50%
Shubenacadie Indian Reserve	375	450	510	3.600%
South Maitland	192	188	203	0.580%
Stewiacke Town	1,042	982	1,040	-
Stewiacke Cross Roads	-	-	-	-
Stewiacke East	130	125	217	6.700%
Upper Nine Mile River	169	135	192	1.360%
Upper Rawdon	245	229	265	0.820%
Upper Stewiacke	291	270	249	-
Urbania	72	90	81	1.250%

(Cont'd)

POPULATIONS OF UNINCORPORATED PLACES IN SHUBENACADIE-STEWIACKE RIVER BASIN (Cont'd)

	1961	1966	1971	Ave. Annual Population Increase (1961-1971)
*Waverley	1,142	1,216	1,419	2.4%
West St. Andrews	63	81	70	1.1%
*Windsor Junction	595	558	583	-
Wittenburg	83	100	128	5.4%
Total	14,095	15,300	18,881	3.4%

*Headwater Area

Source: Statistics Canada 92-771 March, 1971.

A P P E N D I X " C "

HYDROLOGY

SUMMARY OF SYNTHETIC STREAMFLOWS

for

A SELECTED LOW FLOW YEAR (1968)
(all values in cfs)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean
Loon	3.9	2.9	6	5.8	1.9	1.9	1.1	0.2	0.0	0.4	3.2	10.8	3.2
Charles	19.5	10.8	31	26.3	8.1	10.8	5.4	1.3	.5	1.4	19.0	50.5	15.4
First	3.3	2.9	6.6	5.2	1.2	8	2.1	0.1	0.0	0.2	4.0	11.2	3.7
Second	12.4	6.5	8.8	10.5	5.9	4.5	2.8	1.0	0.4	0.7	4.4	12.8	5.9
Powder Mill	36	20.8	35.5	36.2	16.7	16.9	11.3	2.3	1.0	2.2	20.5	59.5	21.6
William	85	52.5	121	108	112	69	14.8	11.5	4.4	6.8	73.0	198	71.3
Soldier	32	30.5	65.5	44.5	18.7	19.6	11.45	5.3	3.4	4.6	38.0	94	30.6
Miller	47	30.5	85	55	23.5	24.5	12.7	3.5	3.9	6.7	50.5	115	38.1
Thomas	143	83	235	177	135	105	27.5	15.5	8.3	18.5	130	332	118
Fletcher	163	87	265	196	140	119	30.5	15.4	8.6	20.6	150	369	130
Lewis	5.3	3.0	8	7.4	2.1	2.8	1.4	0.4	0.2	0.3	4.4	13.5	4.0
Springfield	7.1	3.8	8.8	8.8	3	3.2	1.9	0.6	0.2	.5	4.9	15.5	4.8
Fenerty	15.6	13.5	48.5	32	11.7	16.8	5.8	1.5	0.65	2.8	35	66	20.8
Beaverbank	113	45.5	189	132	41	69	24.5	5.0	1.1	12.4	137	257	85
Kinsac	130	68	210	177	43	83	35.7	5.0	0.3	15	152	325	104
Grand	522	255.5	537	552	218	240	143.7	37.5	19.1	38	304	928	316

SUMMARY OF SYNTHETIC STREAMFLOWS

for

A MEAN FLOW YEAR
(all values in cfs)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Mean
Loon	5.4	4.8	5.1	7.1	4.7	2.2	1.2	1.2	1.7	2.4	5.1	6.2	3.9
Charles	15	18	24.5	36.5	23.5	10.5	5.7	7	8.9	12	26.5	29	26.0
First	5.3	5.4	4.6	6.8	4.5	1.6	1.2	1.0	1.7	2.7	6.1	6	3.9
Second	10.1	9.2	8.8	11.0	10.8	6.3	3.5	2.9	3.2	4.1	7.4	10.4	7.3
Powder Mill	36.0	37.0	35.0	43.0	37.5	17.5	9.4	9.7	11.5	15.5	32	40	27.0
William	93.7	89	100	141	102	45.5	25.5	29.5	36.5	48.0	108	117	115
Soldier	48.0	40.5	46.0	73	48.0	21.5	12.5	15.5	18.5	23.5	55.0	57.0	38.2
Miller	61.0	52.0	57.5	91.5	61.5	26.0	16.0	19.8	23.5	30.5	69.0	73.0	48.4
Thomas	166	151	167	246	176	76.5	44.0	52.0	64.0	83.0	186	205	135
Fletcher	186	170	185	280	197	86.5	48.3	60.5	71.0	95.5	208	232	152
Lewis	7.6	5.8	6.5	9.0	6.5	2.7	1.6	1.9	2.4	3.4	7.7	7.8	5.2
Springfield	7.6	7.5	8.6	10.3	9.3	3.4	2.2	2.3	2.8	2.9	7.1	10.2	12.3
Fenerty	36.4	27.5	36.5	52.0	35.0	14.5	8.2	12.8	13.0	18.0	40.0	41.0	27.9
Beaverbank	140	112	133	211	139	56.5	35.5	37.5	53.0	77.5	157	169	110
Kinsac	171	137	159	250	169	71.5	42.5	60.0	67.0	87.5	191	201	134
Grand	511	455	465	693	566	246	140	157	197	238	496	639	400

SUMMARY OF STREAMFLOW MEASUREMENTS

STREAM	DATE 1974	GAUGE HEIGHT (feet)	DISCHARGE (cfs)	DRAINAGE AREA ($mi.^2$)
Beaver River:				
Below Lewis Lake	June 11	3.09	2.1	1.8
	July 9	3.06	1.4	
	Aug. 6	3.05	0.83	
	Sept. 9	3.06	0.96	
Below Hamilton Lake	May 31	1.50	154	14.2
	July 9	0.79	14.4	
Below Tucker Lake	May 29	3.21	168	23.9
	July 9	2.27	20.1	
	Aug. 6	1.52	3.1	
	Sept. 5	2.03	11.6	
At Middle Beaverbank	May 29	3.86	218	26.8
	July 9	2.02	18.5	
	Aug. 6	1.93	3.1	
	Sept. 5	2.01	13.5	
	Oct. 8	2.36	35.3	
	Oct. 29	3.40	143	
At Outlet Springfield Lake	June 3	2.78	9.7	2.2
	July 12	2.42	5.2	
	Aug. 8	1.52	0.89	
	Sept. 5	1.72	1.3	
At Outlet Fenerty Lake	June 3	2.56	46.4	9.7
	July 12	2.32	30.6	
	Aug. 8	1.54	1.2	
	Sept. 9	1.82	6.3	
Jarrett Brook below Rasley Lake	May 29	-	39.7	2.9
	July 9	-	0.82	
	Aug. 6	-	0.00	
	Sept. 5	-	2.8	
Rawdon River:				
Above Shubenacadie Lake	May 30	3.33	427	48.8
	July 8	2.31	47.3	
	Aug. 5	1.93	10.8	
	Sept. 3	1.62	1.7	

SUMMARY OF STREAMFLOW MEASUREMENTS (Cont'd)

STREAM	DATE 1974	GAUGE HEIGHT (feet)	DISCHARGE (cfs)	DRAINAGE AREA (mi.^{2})
Shubenacadie River:				
Sucker Brook below First Lake	July 9	0.94	1.4	1.4
	Sept.5	0.68	1.3	
Outlet Second Lake	May 28	1.45	5.3	2.7
	July 4	1.26	3.6	
	Aug. 6	0.92	1.0	
	Sept.9	0.64	0.46	
Outlet "3 Mile Lake"	May 28	1.85	12.7	4.1
	July 4	1.16	6.1	
	Aug. 6	0.94	3.2	
	Sept.4	0.88	1.9	
Outlet Powder Mill Lake	May 28	1.83	29.6	10.3
	July 3	1.76	23.5	
	Aug. 7	1.29	6.4	
	Sept.5	1.35	6.1	
Mitchell Brook near Lake Charles	May 28	1.37	12.7	4.0
	July 4	1.12	4.3	
	Aug. 8	0.91	1.5	
	Sept.4	1.08	4.2	
Below Lake Charles	May 27	0.87	15.7	7.9
	July 4	0.64	6.9	
	Aug. 8	0.47	3.1	
	Sept.3	0.44	2.4	
	Sept.24	0.55	4.6	
Fall River below Soldier Lake	May 31	2.56	92.9	14.4
	July 4	2.27	23.7	
	Aug. 7	2.15	4.2	
	Sept.4	2.19	3.7	
Fall River above Lake Thomas	May 27	1.54	46.8	17.2
	July 4	1.25	26.2	
	Aug. 7	0.81	7.1	
	Sept.3	0.66	3.2	
Outlet Lake William	May 27	4.08	68.1	29.4
	July 3	4.18	47.8	
	Aug. 8	3.72	16.3	
	Sept.3	3.60	12.0	

SUMMARY OF STREAMFLOW MEASUREMENTS (Cont'd)

STREAM	DATE 1974	GAUGE HEIGHT (feet)	DISCHARGE (cfs)	DRAINAGE AREA ($mi.^2$)
Shubenacadie River (Cont'd):				
At Lake Thomas	June 14	0.98	96.1	49.4
	July 4	0.90	77.9	
	Aug. 7	0.44	27.4	
	Sept. 3	0.28	12.2	
Below Lake Fletcher	May 30	3.37	277	56.2
	July 8	2.30	84.6	
	Aug. 5	2.03	26.0	
	Sept. 3	1.66	16.4	
	Sept.25	2.40	73.6	
At Enfield	May 30	3.93	609	150
	June 11	3.60	438	
	July 8	3.28	255	
	July 24	3.14	161	
	Aug. 5	2.87	88.1	
	Aug. 23	2.61	48.5	
	Sept. 4	2.64	52.1	
	Oct. 8	3.43	259	

Precipitation and Evaporation Records

The following chart provides precipitation values broken down by sub-area.

PRECIPITATION ANALYSIS

Meteorologic Station	Hydrologic Unit (Sub-Area)[2]	Mean Annual Total Precipitation (inches) (1961-1971)	Mean Annual Total Precipitation (inches) Long Term Mean	Ratio of Precipitation to Recorded Mount Uniacke
Mount Uniacke	H	57.7	56.6	1
Halifax International Airport	E,G,I	57.4	56.4[3]	0.99
Bedford	B,C,D,F	55.7	54.7[3]	0.97
Westphal	A	53.7	52.6[3]	0.93

NOTES:

1. - Used for the Development of Long Term Mean Monthly Runoff.
2. - See Map 18
3. - Estimated by comparing station to the Mount Uniacke Station for the period 1961-1971.

5.5 (Cont'd)

SUMMARY OF PRECIPITATION AND EVAPORATION ESTIMATES

	LOW FLOW YEAR		MEAN FLOW YEAR	
	Evap.	Prec.*	Evap.	Prec.*
Month	(In.)		(In.)	
January	0.0	4.7 - 5.6	0.0	4.3 - 5.8
February	0.0	2.9 - 3.6	0.0	4.2 - 5.4
March	0.3	4.4 - 6.0	0.3	4.2 - 4.9
April	1.0	2.7 - 3.1	1.0	3.7 - 4.2
May	3.46	2.9 - 4.0	3.44	4.2 - 4.4
June	3.65	6.4 - 4.7	4.03	2.9 - 3.3
July	5.56	.3 - .9	4.65	3.1 - 3.6
August	4.40	1.5 - 2.1	3.92	3.7 - 5.5
September	2.64	1.2 - 2.6	2.56	3.6 - 4.0
October	1.87	3.5 - 4.7	1.57	4.5 - 5.3
November	0.7	7.3 - 9.9	0.7	6.0 - 7.0
December	0.0	7.3 - 7.7	0.0	5.8 - 7.0

* Range in Precipitation as determined from selected meteorological stations.

COMPARISON OF MEAN ANNUAL ESTIMATES OF EVAPOTRANSPIRATION - PRECIPITATION

River Basin	Mean Annual Precipitation (inches)	Mean Annual(4) Streamflow (inches)	Mean(5) Annual Runoff (inches)	Mean Annual(6) Evpo-transpiration (inches)
East River (at St. Margaret's Bay)	52.1 (1)	35.2	35.6	16.5
Musquodoboit River (at Crawford Falls)	54.0 (2)	39.3	39.5	14.5
Beaver River (near Kinsac)	56.7 (3)	39.2	39.5	17.2

NOTES:

(1) As determined from Meteorologic Station at St. Margaret's Bay.

(2) A rough estimate based on meteorologic stations at Middle Musquodoboit and Halifax International Airport and on surface water studies carried out by Montreal Engineering Co. Ltd. for the A.D.B., January, 1969.

(3) As determined from the meteorologic station at Mount Uniacke.

(4) Determined from records at Hydrometric Station.

(5) Mean Annual Runoff

(6) Mean Annual Precipitation
- Mean Annual Runoff (excludes evaporation from lake surfaces)

A P P E N D I X "D"

PUMP TEST DATA

APPENDIX

Pump Test Data

Within the province, there are existing regulations concerning pump testing of wells to determine the long term safe yield. Such pump testing is not normally considered a necessity, and because of the expense, it is impractical for domestic situations. Nevertheless, the data aquired from pump tests is vital when planning water supply systems for communities, industry or large institutions requiring large quantities of water. Sections 26, 27 and 28 of the Well Drilling Act dictates that for other than domestic purposes an adequate test shall be of not less than seventy-two hours and shall include recovery measurements.

Within the Shubenacadie-Stewiacke River Basin, there has not been a number of wells requiring pump testing since the well drilling act came into effect. Those for which data have been obtained are listed as follows.

NO.	OWNER	LOCATION	DATE	DRILLER/TEST CO	DEPTH OF WELL	STATIC WATER WELL	GEOLOGY	PUMPING RATE GPM	YIELD AS 20 YR I GPM
1	N.S. Housing Commission	Brookfield (11-E-3-C-98)	4/2/76 7/2/76	Hingley/Rockingham Hardware	34			8	8
2	Industrial Machinery	Hammonds Plains Rd (11-D-12-D-82)	31/3/76 3/4/76	H. J. Edwards/ Michauel Pumps	448	1	0-24 sd gr bldrs 24-448 qtz	10	13
3	N.S. Dept. Public Works	Millers Lake Well# 1 (11-0-13-A-45)	10/12/76 13/12/76	H.J. Edwards/ Rockingham Hardware	275	19	quartzite	2	0.25
4.	N.S. Dept. Public Works	Millers Lake Well# 2 (11-D-13-A-45)	6/12/76 9/12/76	H.J. Edwards/ Rockingham Hardware	272	11	quartzite	10	6
5.	Halifax International Airport Hotel	Enfield (11-D-13-D-24)	7/1/77 10/1/77	Bomaster/J. Fader	250	11	slate	22.5	11
6.	Sackville Mobile Home Estates	Middle Sackville (11-D-13-14-34)	30/11/68	/Rockingham Hardware	225	6	slate	16	3
7.	Shields Trailer Court	Enfield (11-D-13-D-50)	27/7/71	J. Gilles/Enfield Hardware		4			
8.	Springfield Estates	Upper Sackville (11-D-13-A-59)	3/5/73	Harold Verge/ G. Steves for Can-Bri	138	14	slate	40	31
9.	Woodbine Trailer Court	Beaverbank Rd. (11-D-13-A-32)	30/11/73	Whitewater/Rockingham Hardware	547	63.7	0 ·20 cl& bldrs 20-547 slate	15	Ave 13
10	Century Park	Sackville (11-D-13-A-34)	17/11/72	Bomaster/Rockingham Hardware	500	16	0-39 cl 39-500 black slate	10	Ave 10
11	Maple Ridge Subdivision	Lr. Sackville (11-D-12-D-104)	21/3/68	/Rockingham Hardware	195	9	Goldenville	17	6.5

NO.	OWNER	LOCATION	DATE	DRILLER/TEST CO	DEPTH OF WELL	STATIC WATER WELL	GEOLOGY	PUMPING RATE GPM	YIELD AS 20 YR 1 GPM
12	Laurie Provincial Park	Wellington (11-D-13-A-102)	24/4/74	/NS Dept. Mines	132	39.9	Goldenville Form	2	41
13	Oakfield Park	Oakfield (11-D-13-D-47)	19/10/73	H. Vergel/H. Verge	225	67.2	0-156 cl.sd 156-225 qtz	3.25	2.0
14.	Woodbine Trailer Court	(11-D-13-C-64)	2/12/75	Bomaster/N.S. DOE	275	58.4	0-20 cl&sd 20-100 qtz 100-275 sl	35	16
15	Uniacke Mobile Homes, Well #1	South Uniacke (11-D-13-B-98)	27/7/72	/Rockingham Hardware	120	25	Slate & Quartzite	7.8	3
16	South Uniacke Trailer Park	South Uniacke (11-D-13-L-2)	31/10/72	/Rockingham Hardware	300	17	Slate and/or Quartzite	6	21
17	Uniacke Mobile Homes Well# 2	South Uniacke (11-D-13-B-98)	2/10/73	Bomaster/Rockingham Hardware	629	39.6	0-13 cl 13-629 qtz	59	2.3 ave
18	Shubenacadie Park	Shubenacadie (11-E-3-B-80)	4/6/74	N.S. Mines?/Dept. of Mines		4.6	Windsor-gypsum	2	
19	N.S. Housing Com.	Brookfield (11-E-3-C-98)	4/2/76		34	8.25	Sands & gravel		15
20	Test Hole #100	Fraser Brook (11-E-6-A-811)	9/8/66	N.S. Mines/N.S. Mines	170	11.8	0-10 cl 20-170 sh& gypsum	5	7.0
21	Hants East Rural High School	Milford (11-E-3-B-40)	18/3/73			17.8			45
22	Canada Cement Co. Well#1 Well#2	Brookfield (11-E-6-B-2)	21/5/64 28/5/64	Hoppe Bros/Hopper Bros	375 405	14 20	Windsor -90' 0-45 cl 45-405 shale	202 =	200 10
23	Observation Well #1 Well # 2	Brookfield (11-E-6-A-2	13/1/68	Dept. Mines/Dept. Mines	14 22	4.8 4.4	Surficial/Windsor		
24.	Test Hole #319	Brookfield (11-E-6-A-2)	13/1/68	Dept Mines/Dept. Mines	86	3.5	0-70 sd&gravel 70-86 shale & siltstone	164	307 ave

APPENDIX E

WATER QUALITY DATA

APPENDIX E

Water Quality Data

1. List of 9 well samples in specific geologic environment

   A. Dug wells in clay till over Windsor bedrock

   B. Dug wells in sand till over Meguma bedrock

   C. Dug wells in clay till over Meguma bedrock

   D. Dug wells in sand till over Horton bedrock

   E. Dug wells in clay till over Riversdale bedrock

   F. Drilled wells in Meguma bedrock

   G. Drilled wells in Riversdale bedrock

   H. Drilled wells in Windsor bedrock

   I. Drilled wells in Windsor bedrock (higher density of wells)

2. Table - Summary of data on Arsenic

3. Table - Characteristics of community water sources

4. Table - Summary water chemistry data - Hardwood Lands

A. Chemical Parameters (ppm)*	Shubenacadie	Enfield	Stewiacke	Pleasant Valley	Elmsdale	Lantz	Dutch Settlement
Na	9.6	14	8.9	5.2	16	17	12
K	6.4	1.8	1.8	10.1	1.8	1.8	1.0
Ca	52	82	68	43	96	43	25
Mg	9.6	8.2	8.8	2.4	8.9	6	2.7
Hd	185	232	199	106	274	135	73
Alk	170	201	182	112	266	103	59
SO_4	65	27	32	16	22	49	30
Cl	7	23	20	7.6	18	8.2	11
F	0.1	0.2	0.2	<0.1	0.2	0.2	0.1
Si	8	8.8	8.0	4.3	10	12.4	2.5
PO_4	0.02	0.09	0.04	<0.02	0.08	0.08	0.12
N	0.6	0.2	1.6	1.6	0.5	0.3	0.2
NH_4	0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1
As	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Fe	0.6	0.2	0.20	0.3	0.25	1.1	0.2
Mn	1.6	0.13	0.17	0.9	0.2	0.3	0.2
Pb	<0.005	0.02	0.005	0.005	0.009	0.007	0.01
Cu	0.02	0.04	0.02	0.05	0.03	0.09	0.04
Zn	0.001	0.42	0.01	0.05	0.19	<0.005	0.08
TS	270	276	223	146	334	191	132
TDS	264	272	217	141	332	187	131
Col (TCU)[1]	20	16	17	28	25	27	32
Turb (JTU)[2]	12	1.6	2.2	3.0	2.4	8.5	9
Cond (umho/cm)[3]	278	356	340	240	438	260	185
pH (units)[4]	7.2	7.2	7.4	7.2	7.2	7.0	7.5

Notes

*Except color, turbidity, conductivity and pH, all parameters are expressed in ppm.
1 True Color Unit, Platinum - Cobalt Scale; 2 Jackson Turbidity Unit; 3 Micro Mhos/Centimeter; 4 Has significance in controlling corrosion and scaling tendency of water.

Chemical Parameters (ppm)*	B	C	D	E	F	G	H	I
Na	10.2	18	5.2	12	13	23	27	52
K	3.2	4.3	3	5.6	1.1	1.5	4.2	4.5
Ca	28	24	45	38	24	170	184	340
Mg	4.2	4.2	6.2	7.8	3.2	20	22	46
Hd	65	110	165	121	72	510	525	100[illegible]
Alk	58	78	150	116	59	78	148	168
SO_4	19	22	9	15	18	430	386	795
Cl	8.2	42	22	20	14	8.8	7.5	8
F	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.3
Si	5.2	6.9	8.1	6.2	10.2	12	6.5	8.2
PO_4	0.02	0.03	0.02	<0.02	<0.02	<0.02	0.02	0.02
NO_2+NO_3	0.8	0.9	0.7	0.41	<0.1	<0.1	<0.1	<0.1
NH_4	<0.1	<0.1	0.3	0.1	<0.1	0.1	<0.1	<0.1
As	<0.005	<0.005	<0.005	<0.005	<0.009	0.007	<0.005	<0.0[illegible]
Fe	0.2	0.55	0.2	0.3	0.2	0.4	0.6	0.9
Mn	0.3	0.48	0.5	0.3	0.3	0.3	0.18	0.36
Pb	0.04	<0.005	0.005	0.006	0.005	0.006	0.006	0.0[illegible]
Cu	0.06	0.01	0.02	0.04	0.04	0.06	0.02	0.02
Zn	0.20	0.006	0.16	0.008	0.03	0.46	0.02	0.0[illegible]
TS	120	222	230	167	146	752	721	134[illegible]
TDS	118	220	226	163	142	746	716	1342
Col (TCU)	25	24	18	10	15	17	22	24
Turb (JTU)	5.7	3.6	0.7	2	3.8	52	6.9	12
Cond (umho/cm)	130	175	285	226	173	804	755	129[illegible]
pH (units)	7.1	6.6	7.5	7.3	7.3	6.8	7.5	7.4

*Except color, turbidity, conductivity and pH, all parameters are expressed in ppm.

RESULTS OF ARSENIC TASK FORCE PROBE

Total No. of Wells, percentage Contamination	Location	No. of samples taken	No. Contaminated/ No. of sample type Taken				
			Drilled	Dug	Spring	Lake	Stream
0%	Elmsdale	2	-	0/2	-	-	-
0%	West Gore	3	-	0/3	-	-	-
0%	Tanglewood Dr. (Lewis Lake)	6	0/3	0/3	-	-	-
47%	North Brookfield	15	1/5	6/10	-	-	-
10%	Rawdon Gold Mines	10	1/4	0/5	-	0/1	-
	Fall River						
15%	Silversides	39	6/37	0/2	-	-	-
63%	Collins Park	30	19/30	-	-	-	-
0%	Wellington	23	0/8	0/12	0/1	0/1	0/1
27%	Oldham	69	2/24	10/37	4/7	1/1	-
23%	Waverley	203	29/75	15/117	0/3	0/8	-
16%	Montegue Mines	19	2/10	1/9	-	-	-

CHARACTERISTICS OF COMMUNITY WATER SOURCES

Location	Mainly Dug	Mainly Drilled	Half & Half	Spring	Lake	Central Service Water/Sewer		Imported	Remarks
1. Ardoise			x						-satisfactory supply, old homes have mostly dug wells while new homes have mostly drilled.
2. Ellerhouse			x						-satisfactory supply.
3. Cameron Lake	x								-satisfactory supply.
4. Mount Uniacke		x							-satisfactory supply.
5. Springfield Lake			x		x				-drilled wells are satisfactory, homes adjacent lake use lake water.
6. Lower Sackville			x			x	x		-mostly centrally serviced from First Lake. Sufficient quantity from wells, high manganese and iron noted in dug and drilled wells.
7. Middle Sackville		x				x			-combined drilled and central servicing.
8. Maroon Hill	x								-adequate supply.
9. Lucasville Rd.			x						-dug wells get low in summer but few go dry.
10. East Uniacke			x	x					-good quantity from spring fed wells, poor quality in some drilled wells.
11. Lewis Lake	x								-sufficient quantity
12. Middle Beaverbank				x	x			x	-some families import due to lack of quantity or contamination.
13. North Beaverbank			x						
14. Kinsac Road	x			x	x			x	-dug wells low in summer, some residences draw water from a local spring; some cottages use lake.
15. Lakeview Road	x								-sufficient quantity.
16. Sucker Brook Rd.	x								-sufficient quantity.
17. Waverly Rd.	x				x	x	x		-high iron and manganese in dug and drilled wells, many homes use Lake William.

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CHARACTERISTICS OF COMMUNITY WATER SOURCES

Location	Mainly Dug	Mainly Drilled	Half & Half	Spring	Lake	Central Service Water/Sewer	Imported	Remarks
18. Fall River		x						-iron and manganese in drilled wells.
19. Windsor Junction	x							-iron and manganese in drilled wells, new homes mainly drilled.
20. Waverley Village			x					-sufficient quantity.
21. Fall River Station to Fletcher Drive		x						
22. Howe Ave.		x						
23. Collins Park		x						
24. Lake Fletcher Highway					x			
25. Wellington Station	x							
26. East Shubenacadie	x							-quality acceptable, dug wells tend to silt up due to clayey soil, most dug wells are low in summer.
27. Shubenacadie	x						x	-similar situation to East Shubenacadie, many residents use MacLeans Brook as a supplementary supply during peak summer months, although Public Health has marked the brook water as requiring boiling before use.
28. Mill Village			x	x				-springs provide most reliable quantity, hard water dug and drilled, a number of dug wells go dry in summer.
29. Stewiacke	x					x		-some drilled wells report high iron and manganese, good quantity reported in shales.
30. Cooks Lake Rd.	x			x				-satisfactory supply from springs.
31. Cooks Brook	x							-many dug wells go dry in peak summer months, few drilled wells due to presence of gypsum as bedrock.

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CHARACTERISTICS OF COMMUNITY WATER SOURCES

Location	Mainly Dug	Mainly Drilled	Half & Half	Spring	Lake	Central Service Water/Sewer	Imported	Remarks
32. Milford Station	x							-few drilled wells due to gypsum deposits, high iron, manganese and hardness present in drilled and dug wells.
33. East Stewiacke	x			x				-springs provide sufficient quantity, dug wells have shown high iron and manganese values, variable as to number of dug wells which go dry in summer.
34. Alton	x						x	-during summer many dug wells get low, Alton School house well is used (1976) as a supplementary supply although it has yielded a high coliform count under testing.
35. Brookfield	x			x				-some wells go dry in summer but most are adequate with springs being most reliable source.
36. Upper Stewiacke	x			x				
37. Shortt's Lake					x			-some dug wells and a couple of drilled wells, with most residenses using boiled lake water.
38. North Salem	x							-adequate according to one sample taken.
39. Admiral Rock	x							-adequate according to one sample taken.
40. Urbania	x							-adequate according to one sample taken.
41. Pleasant Valley			x					-adequate according to one sample taken.
42. Green Creek	x							-quality acceptable in one well sampled, but goes dry in summer.
43. Latties Brook	x			x				-sufficient quantity and hard water in one well.

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CHARACTERISTICS OF COMMUNITY WATER SOURCES

Location	Mainly Dug	Mainly Drilled	Half & Half	Spring	Lake	Central Service Water/Sewer		Imported	Remarks
44. Georgefield	x								-adequate supply reported from one well sampled.
45. Cneesefactory Corner	x							x	-sampled well goes dry.
46. MacPhee's Corner	x			x					-springs used mostly for agri-culture purposes, few drilled wells due to gypsum deposits.
47. Barr Settlement Rd.	x			x					
48. Centre Rawdon	x								-sufficient quantity from one sampled well.
49. West Gore	x								-McCloud Brook is used for most agricultural purposes while dug wells serve domestic needs.
50. Gore Road	x							x	-one well sampled goes dry.
51. East Gore									
52. Upper Rawdon	x								-dug wells normally provide ade-quate supply, drilled wells have reported high iron and manganese.
53. Roulston Corner	x								-new homes have mostly drilled wells although gypsum deposits cause hardness problems, dug wells tend to go dry in summer.
54. Elmsdale	x			x		x	x	x	-during peak summer months dug wells get low and Nine Mile River plus a spring on Ess Road are used as sources of supplementary supply.
55. Upper Nine Mile River	x								-adequate supply from one sample well.
56. Hardwoodlands				x					-water is often hard and high in iron and manganese.
57. Renfrew Road	x			x					-from one sample, dug well pro-duced insuffient quantity.

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CHARACTERISTICS OF COMMUNITY WATER SOURCES

Location	Mainly Dug	Mainly Drilled	Half & Half	Spring	Lake	Central Service Water/Sewer		Imported	Remarks
58. Horne Settlement	x								-one dug well displayed sufficient quantity.
59. Enfield	x					x	x		-most homes on central service, remainder on mainly dug wells due to bedrock character numerous wells go dry in summer.
60. Frenchman's Road	x				x			x	-cottages use lake water, most have sufficient quantity although one home trucks in water.
61. Cocheran Road and Point					x				-all cottages use Little Lake
62. Oldham Road			x						
63. Old Guysborough Rd.			x						
64. Dutch Settlement	x								-few drilled wells due to gypsum deposits, numerous complaints of insufficient quantity.
65. Lantz	x					x			-adequate supply from dug wells, Shubenacadie River feeds central system.

WATER QUALITY VALUES SUMMARY
(HARDWOODLANDS)

Chemical Characteristics	66	65	75	74	73	72	76	77	80	64	63	80b	43
Na	85	55	5.3	7.5	9.6	35	5.8	6.4	7.0	19	32	16	11
K	6.5	3.5	0.9	1.6	1.1	14	12	0.9	1.5	3.1	4.1	1.0	1.7
Ca	234	100	64	76	132	74	88	14	15	680	105	58	78
Mg	59	14	8.9	9.6	14	6.1	12	2.6	3.2	41	7.4	7.2	11
Hd	832	310	197	230	388	211	276	46	50	870	293	174	241
Alk.	160	170	200	225	220	170	295	45	51	170	210	90	270
SO_4	763	235	20	12	162	36	8	12	8	1400	68	74	6.0
Cl	5	3.5	3.0	10	14	74	7.0	4.5	9.2	15	48	6	4.0
F	.3	0.3	0.1	0.2	0.1	0.1	0.1	<0.1	<0.1	0.3	0.1	0.1	0.1
Si	7.4	7.8	7.5	8.4	7.8	8.0	7.2	4.1	4.3	8.6	6.5	7.8	9.8
PO_4	<0.02	0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	0.03	0.02	0.04	0.3	0.02
$NO_2 + NO_3$	0.1	<0.1	<0.1	0.6	0.2	3.5	0.1	0.2	0.2	<0.1	0.3	<0.1	<0.3
NO_4	0.3	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	0.2	0.2	0.1	<0.1	<0.1	0.1
As	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005

(Cont'd)

WATER QUALITY VALUES SUMMARY
(HARDWOODLANDS)
(Cont'd)

Chemical Characteristics	66	65	75	74	73	72	76	77	80	64	63	80b	43
Fe	0.2	0.4	$<$ 0.1	0.1	$<$ 0.1	$<$0.1	0.1	1.8	0.6	2.2	0.1	$<$ 0.1	0.1
Mn	0.3	0.1	$<$ 0.05	0.2	$<$ 0.05	$<$0.05	0.5	1.7	1.2	0.7	0.3	$<$ 0.05	0.1
Pb	0.005	0.006	$<$ 0.005	$<$0.005	$<$ 0.005	$<$0.005	0.008	0.02	0.007	0.006	0.02	$<$ 0.005	0.006
Cu	0.03	0.02	0.03	0.02	0.03	0.01	0.04	0.02	0.01	0.01	0.10	0.01	0.05
Zn	0.01	0.15	0.02	0.009	0.04	0.02	0.02	0.03	0.01	0.02	0.02	0.03	4.5
TS	1299	511	209	271	467	359	333	229	137	2228	391	234	277
TDS	1294	509	208	268	465	358	331	69	79	2219	389	232	275
Col.	15	15	15	20	10	15	15	30	45	40	20	15	15
Tb.	6.6	4.5	0.4	1.5	0.5	1.0	1.4	15	35	25	1.6	1.4	1.0
Cond.	1296	648	324	324	540	486	421	103	108	1944	540	350	432
pH	7.4	7.6	7.7	7.2	7.4	7.2	7.6	6.8	7.2	7.0	7.7	7.4	7.2
Well Dr. or Dg.	Dr.	Dr.	Dr.	Dg.	Dg.	Dg.	Dg.	Dg.	Dg.	Dr.	Dg.	Dr.	Dg.
Charac, Dp.	150'		225'	clay	till	clay	till	clay	till	30'	till	120	till

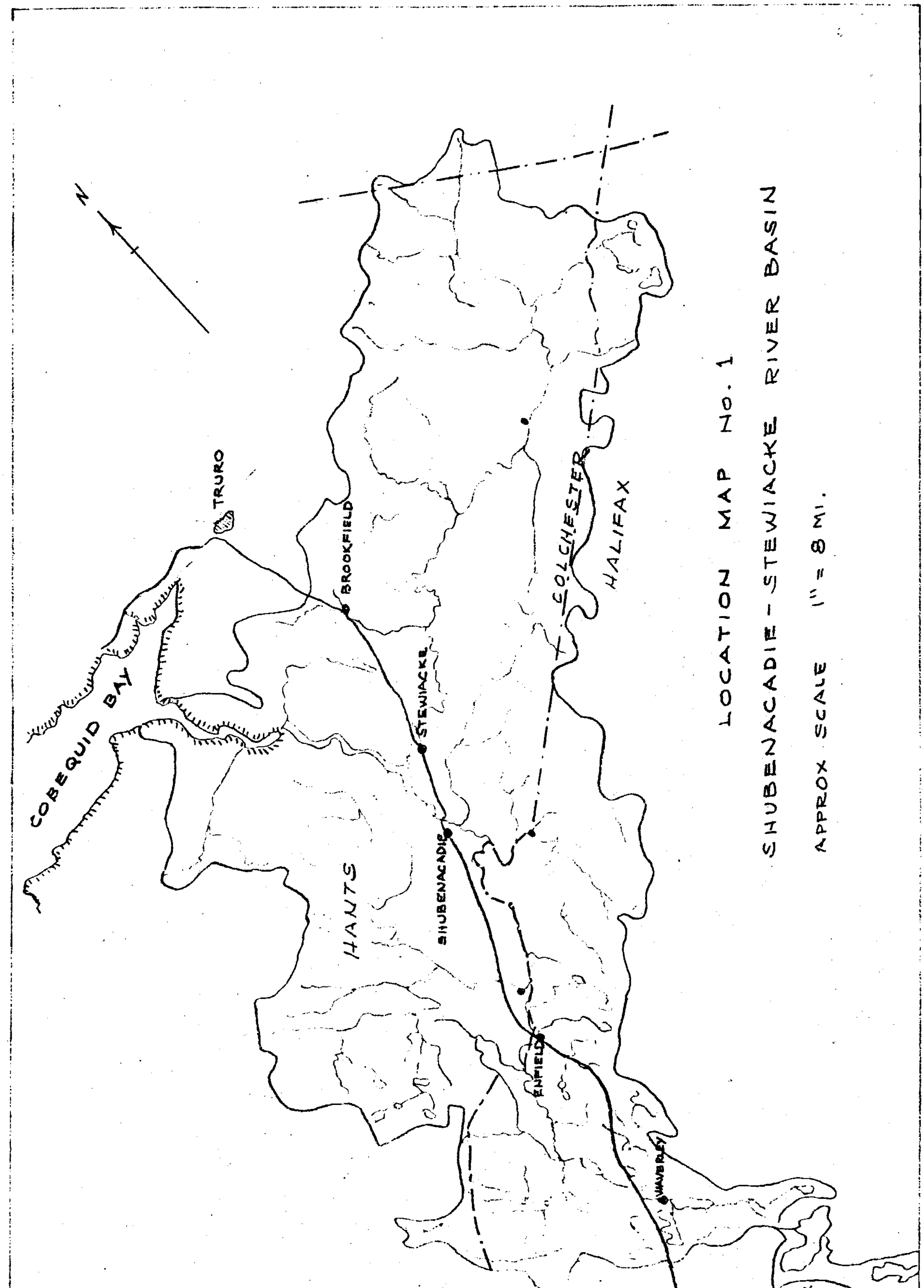
APPENDIX "F"
MAPS

Composite map, scale 1:50,000,is available from N.S. Department of Environment files.

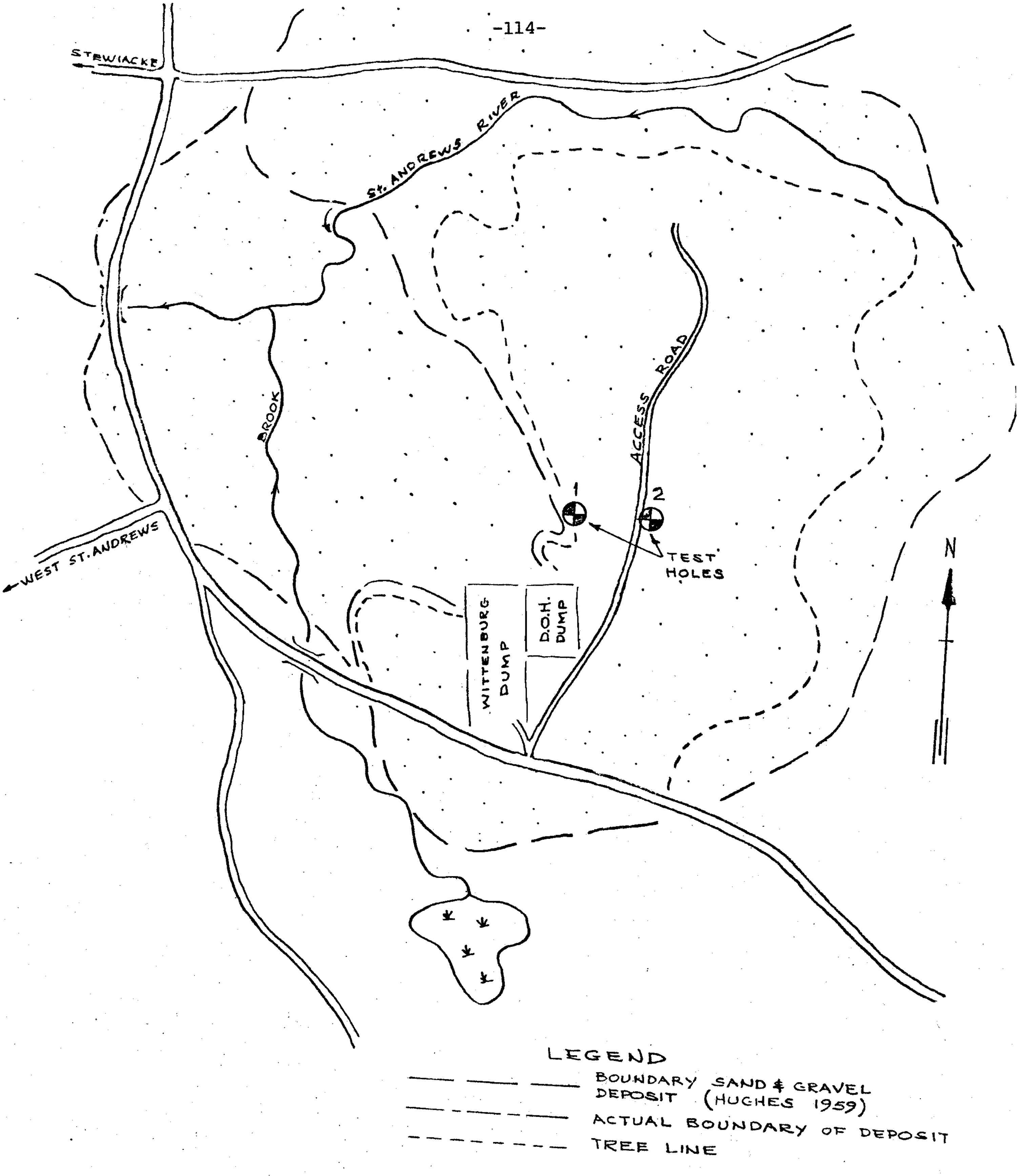
MAP #1 - Location Map   Shubenacadie-Stewiacke River Basin

MAP #2 - Surfical Map   Hardwood Lands Area

MAP #3 - WITTENBURG DUMP SITE & GRAVEL DEPOSIT

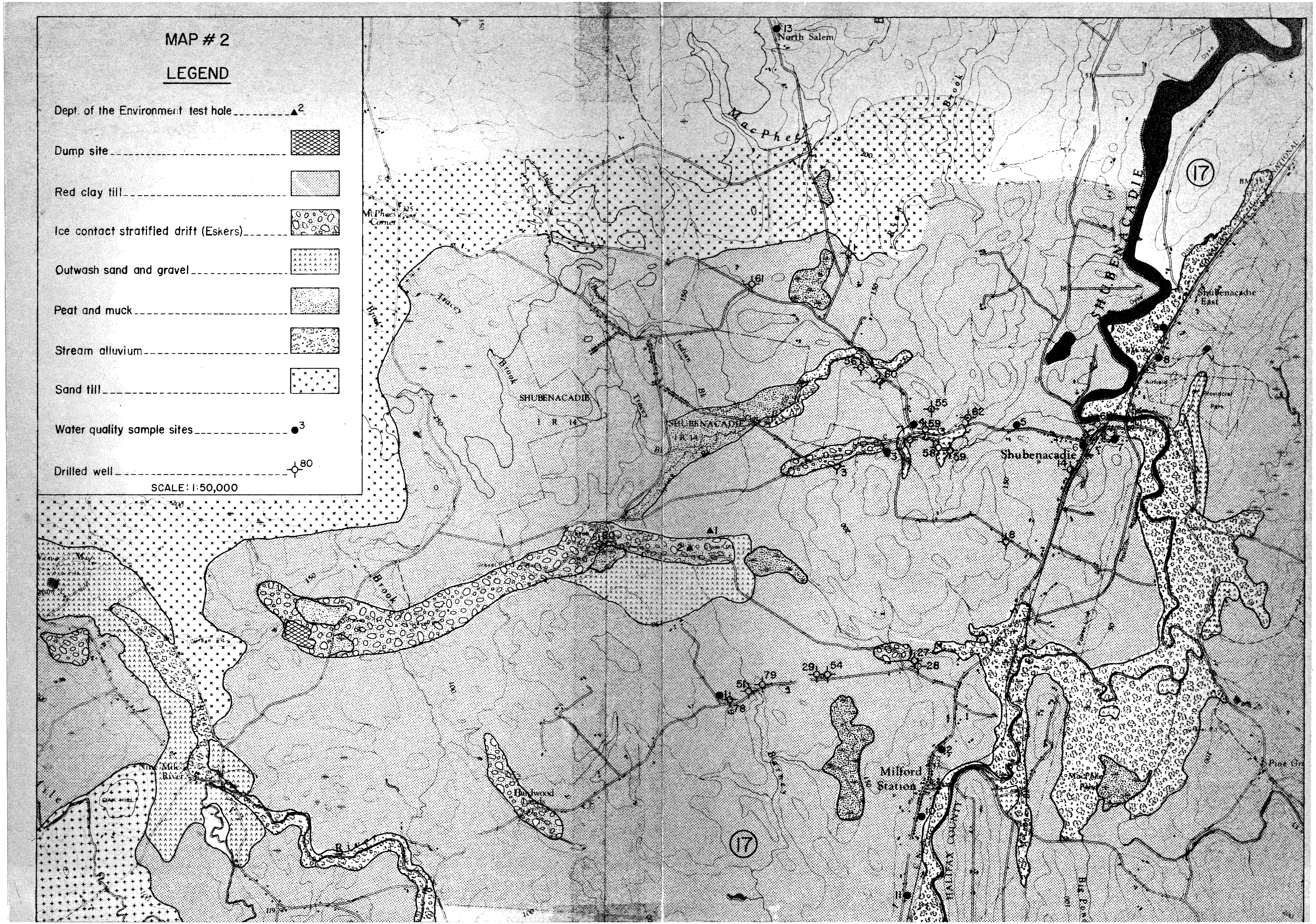

N
TRURO
BROOKFIELD
STEWIACKE
SHUBENACADIE
ENFIELD
WAVERLEY
HALIFAX
COBEQUID BAY
HANTS
COLCHESTER
HALIFAX
LOCATION MAP No. 1
SHUBENACADIE - STEWIACKE RIVER BASIN
APPROX SCALE 1" = 8 MI.

Map #2 - See envelope at back of report



MAP No. 3

WITTENBURG DUMP SITE & GRAVEL DEPOSIT
SCALE 1" = 1320'


MAP # 2
LEGEND
Dept. of the Environment test hole
Dump site
Red clay till
Ice contact stratified drift (Eskers)
Outwash sand and gravel
Peat and muck
Stream alluvium
Sand till
Water quality sample sites
Drilled well
SCALE: 1:50,000
North Salem
SHUBENACADIE
Shubenacadie
Shubenacadie East
SHUBENACADIE I R 14
Milford Station
Nine Mile River
Hardwood Lake
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