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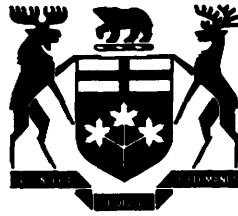
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The  
Physiography of the  
Georgian Bay-Ottawa Valley Area  
of  
Southern Ontario

By  
L. J. Chapman

**Geoscience Report 128**

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TORONTO  
1975

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**Geological Map**

(back pocket)

Map 2228 (coloured) – Physiography of the Georgian Bay-Ottawa Valley Area.  
Scale, 1:253,440 or 1 inch to 4 miles.

**Chart A**

(back pocket)

Chart A – Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7.

## ABSTRACT

The area consists mainly of rounded bedrock knobs having a thin drift cover. Several prominent fault scarps are present in the eastern part. Wisconsin glaciers overrode the area in a southerly direction depositing a sandy till. Retreat was accompanied by the deposition of eskers and kames, moraine fragments trending east-west, outwash, and glaciolacustrine sediments. Much of the latter were laid down in glacial Lake Algonquin which fronted the western part of the retreating ice sheet.

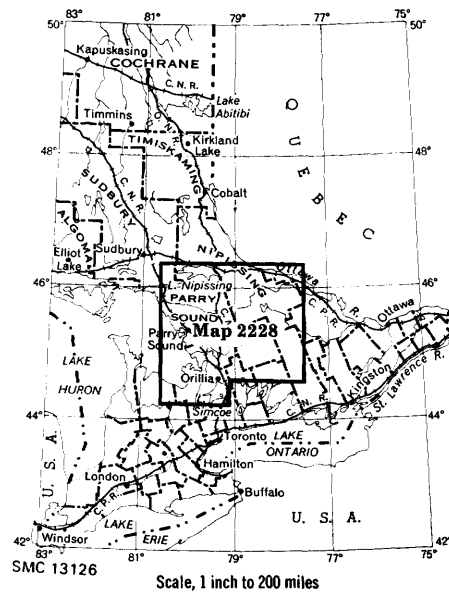


Figure 1—Key map showing location of the Georgian Bay-Ottawa Valley Region. Scale, 1 inch to 200 miles or 1:12,672,000.

Lumbering is the primary industry of the area and recreation is becoming increasingly important. Agricultural activity is limited by the climate and large areas of exposed bedrock. Mining has seen a varied development over the past hundred years and is relatively inactive at present.

Sand and gravel aggregates are sufficient for local needs. Deposits adjacent to railways are limited and, excepting crushed rock, no large-scale commercial export of aggregates is foreseeable.



The  
Physiography  
of the  
Georgian Bay-Ottawa Valley Area  
Southern Ontario  
by  
L. J. Chapman<sup>1</sup>

## INTRODUCTION

This report deals with the surface features of that part of Ontario between the well-settled agricultural area on the south and North Bay on the north. It is mostly a forested region of stony, sandy, commonly shallow soil over knobs and ridges of Precambrian rock. There is a sparse population which is augmented every summer by an influx of cottagers, sportsmen, and tourists who take advantage of the many lakes and streams. A few farming settlements occur in areas of deeper soil, the best in pockets of clay land. Although there are several small mines, mining is not a major item in the economy. Lying between Georgian Bay on the west and the Ottawa Valley on the east, it is a broadly dome-shaped region of 17,000 square miles (44,200 sq. km).

The landforms of this area commonly consist of bedrock or have cores of bedrock because generally the drift is shallow. However, the emphasis in this report is on the unconsolidated overburden left by glaciers during the Pleistocene Epoch, particularly by the last (Wisconsinan) ice sheet. This includes the sediments of associated meltwater streams and the lakes which existed during its melting and receding stages. This report is similar to the account in "The Physiography of Southern Ontario" by the author and D. F. Putnam (Chapman and Putnam 1966), which is the part of Ontario underlain by softer, sedimentary, Paleozoic rocks. Similarly, it includes a map on a scale, 1 inch to 4 miles (1:253,440), which now completes the physiographic mapping on this scale of all of Ontario south of North Bay.

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<sup>1</sup> Former Director, Department of Physiography, Ontario Research Foundation. Manuscript approved for publication by the Chief, Phanerozoic Geology Section, Geological Branch, Ontario Division of Mines, 7 November 1974.

## ACKNOWLEDGMENTS

The field work in this region was under the auspices of the Ontario Research Foundation supported by funds from the Province of Ontario. The assistance of Edwin Schalin, Bruce Hill, and Robert Janes must be mentioned. Preparation of the map was mainly done by the late William Barnard. Publication of the map and report was carried out by the Division of Mines, Ontario Ministry of Natural Resources. I am grateful for the editorial assistance of D. F. Putnam and D. F. Hewitt.

## RELIEF

Topographically, the area is a broad dome with notable irregularities (Figure 2, Chart A, back pocket). From the shore of Georgian Bay which stands at 580 feet (177 m) above sea level the land rises to over 1,800 feet (549 m). A point west of Booth Lake has an altitude of 1,925 feet (587 m) a.s.l.; a few points are over 1,800 feet (549 m); some sizeable areas stand above 1,600 feet (488 m) as mapped in Figure 2 (Chart A, back pocket). On the eastern flank, the land descends irregularly to below 600 feet (183 m) a.s.l. at the edge of the Ottawa Valley and Eastern Ontario lowland. Over all, the land slopes from the centre toward the borders at about 10 feet per mile (2 m per kilometre).

When viewed broadly the skyline is generally even. Such a peneplain is the result of subareal erosion of rocks over a long period, in this case in pre-Paleozoic time (Kay 1942). There are some monadnocks of more resistant rocks standing up above the general level.

Locally, the surface is quite rough with a relief generally of 50 feet to 200 feet (15 m to 60 m) but here and there up to 500 feet (150 m). The rock knobs are irregular in outline except in a few areas where there are fairly straight parallel ridges. The valleys between these knobs and ridges do not have a dendritic drainage pattern because of the structural control. The knobs and ridges themselves are rounded and the bedrock surfaces are smoothed and, where protected by a covering of soil, commonly show polished surfaces with parallel scratches or striae which were made by the overriding glaciers. The numerous swamps and lakes generally occupy bedrock basins, most of which must be attributed to glacial erosion. Thus the relief is dominated by bedrock forms which were fashioned by a long period of subareal erosion followed by a very much shorter but quite significant period of erosion by glacial action. Erosion by existing streams has been slight except in a few areas where sand or clay beds have been dissected. In roughly one-third of the area, the drift is scanty and here bare rocks are exposed over perhaps a third of the surface. Much of the other two-thirds is over 95 percent covered with till which tends to smooth the surface. The remainder consists of sand and clay plains interspersed with hills or ridges of sand and gravel.

## BEDROCK

This region is part of the Precambrian Shield, a vast area in Canada with bedrock of Precambrian age which provides a stable foundation in this part of the continent. Also, it is within the Grenville Province, distinguished by the presence of certain metasedimentary and metavolcanic rocks. About two-thirds of the rocks are granites, generally granite-gneisses. Next in extent are the metasediments including crystalline limestone, quartzite, and amphibolite and paragneiss, these respectively being from the metamorphism of limestone, sandstone, and various limy and sandy shales. Commonly associated with the granites are syenites and nepheline syenites. There are scattered occurrences of volcanics.

During their long history, these rocks have suffered much folding, then have been greatly worn down by erosion. The series of northwest-southeast-trending ridges around the Muskoka Lakes originated by differential erosion of folded rocks. Another example of this type of erosion of folds is the broad ridges and intervening troughs extending north and south between Lake Nipissing and Burk's Falls.

Included in the region are small areas of Paleozoic limestone which are remnants of deposits that at one time formed an extensive and, perhaps, continuous overlay on the Precambrian rocks. Some of these outliers are near the southern border. Others occur in protected depressions, commonly in downfaulted positions. They are also present in the crater near Brent, a circular depression attributed to the impact of a meteor, and in the basin of Cedar Lake. Similarly, there is Paleozoic limestone in the basin of Skeleton Lake.

## FAULTS

The evidence of faulting is widespread but faults with measurable vertical displacement are most common in the eastern and far northern parts of the region. In Figure 3 (Chart A, back pocket), most of the major faults and enough of the smaller ones to show a pattern are mapped. The latter may not always form prominent scarps but have produced visible surface lineaments and clearly affect the courses of streams.

R. E. Deane (1946), in discussing the physiography of southern Ontario, mentioned some of the faults which have such important effects on Renfrew County and adjacent areas. G. M. Kay (1942) described and named 15 faults in the area and there are others as shown in Figure 3 (Chart A, back pocket). Kay did not recognize any faults in line with the monocline which he described north of Belleville. However, L. D. Ayres, S. B. Lumbers, V. G. Milne, and D. W. Robeson (1971) show a series of them trending northeast-southwest all over the southern part of the region under discussion. The faults named by Kay have a northwest-southeast alignment and determine the course of the Ottawa River in this section and affect the whole eastern side of the map-area. The western part is marked by a different set of smaller faults having a general east-west trend and which show up as straight narrow valleys commonly followed by streams or, in places, occupied by long, narrow lakes; for example, the Still, Key, and Pickerel Rivers and Lake Caribou and Lake Noganosh.

Within this region the most prominent topographic break is provided by the St. Patrick fault-line scarp. It is a continuous northeast-facing scarp about 85 miles

## Georgian Bay-Ottawa Valley Area

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(137 km) long, as shown on Figure 3 (Chart A, back pocket). The highest section is west of Lake Clear where it rises from below 800 feet (244 m) a.s.l. to above 1,600 feet (488 m) in two places. The lowland or graben between this fault and the Coulonge Fault, which forms the abrupt edge of the Laurentian uplands of Quebec, is due to a great downfaulted block of rock. This block is itself broken by three faults each showing up as southwest-facing scarps up to 400 feet (122 m) high. Between them the rocks are tilted towards the northeast and Paleozoic limestones are preserved in the depressions. The Coulonge Fault scarp extends to Mattawa, then westward on the north side of the Mattawa Valley and Lake Nipissing. Again, underwater in the Lake Nipissing Basin, Paleozoic limestone is preserved in the depression south of the fault scarp and another small area occurs west of Nipissing village. From Lake Nipissing to Mattawa there is a lowland area partly floored by clay. From Mattawa to Chalk River there is only a narrow valley, but below there the lowland widens out into the main part of the Ottawa-Bonnechere Graben. Apart from the one just mentioned, the most definite fault-line west of Chalk River is the valley followed by the Canadian National Railways through Lake Traverse, Radiant Lake, Cedar Lake, Cauchon, Mink, and Kioshkokwi Lakes.

Above the St. Patrick scarp stand the Madawaska Highlands, their southwestern boundary being along another (Plevna) fault with a southwest-facing scarp. Thus the Madawaska Highlands are based on an upraised block of rock. The Plevna scarp is about 300 feet (91 m) high at the maximum but it is indefinite in other places. Within these highlands the Madawaska River follows a depression along a fault-line through Matawatchan Township. The Hopefield Fault mapped in Figure 3 (Chart A, back pocket) is marked by a valley with bluffs of rock on the south side.

The highest part of the region astride the west boundary of Algonquin Provincial Park drops off abruptly on the east along a fault. The area northeast of Dorset should also be mentioned because of a series of northeast-southwest faults reflected in the pattern of streams and lakes.

The major faults of the region are pre-Paleozoic or Early Paleozoic in age and the bedrock is well stabilized. Occasional tremors are recorded in the northern and eastern parts of the region but at least there have been no severe earthquakes centred here in the last 150 years.

## BROAD WARPING

In addition to the folds and faults which initiate many local bedrock features, this region has been warped to form broad arches in two directions. One extends northwestward from the Adirondack area, crossing the St. Lawrence River at the Thousand Islands, and is responsible for the appearance on the surface of Precambrian granite knobs which are buried to the east and west by younger sedimentary rocks. Called the Frontenac Axis, it extends towards Algonquin Provincial Park and divides drainage flowing towards Lake Ontario from that flowing to the Ottawa River. The second and a much larger upwarping is the Algonquin Arch. It extends northeastward from Chatham forming the upland south of Collingwood and continues to the upland in and around Algonquin Provincial Park. Together these two anticlines give the region its dome-shaped build.

## UNCONSOLIDATED QUATERNARY DEPOSITS

The unconsolidated materials on the bedrock in an intensely glaciated country such as this consist mainly of sheets of till laid down directly by the ice; of fluvial deposits, i.e. sand and gravel deposited by streams of water draining from the melting glacier; and the sediments of lakes which existed during the recession of the glacier. As a rule the glaciofluvial and outwash deposits overlie the till and the lacustrine deposits in turn overlie the aforementioned types of deposits. Where they occur, the alluvium of present streams and beaches of present lakes are uppermost and, of course, these are still in the process of deposition. They are Recent deposits, as is the peat and muck in wet depressions, and they will be dealt with briefly in this report, the main emphasis being on the Pleistocene deposits.

Map 2228 (back pocket) is the most important item of this report. It includes most, but not all, of the region under discussion. Fringe areas on the south and east are on adjoining Maps 2226 and 2227 which accompany "The Physiography of Southern Ontario" (Chapman and Putnam 1966). Because of difficult access and the forest cover, Map 2228 (back pocket) is less detailed than that of the four comparable Southern Ontario Maps 2224, 2225, 2226, and 2227 (Chapman and Putnam 1966, maps). In particular, small areas of sand and gravel hills and outwash sand terraces are seldom outlined. The two types (1) shallow, sandy, stony till and rock outcrops and (2) numerous bare knobs and ridges of rock with very shallow drift comprise a large part of the area. Separation of these two complex types is generalized, no small areas of either being mapped. Attention is focused on the Pleistocene deposits, although the larger peat bogs are marked. The alluvial sands and silts in the bottom lands of present streams are not mapped, nor are the sandy beaches on the shores of present lakes which constitute some of the most valuable real estate.

This report is written with the assumption that the reader will have the map at hand for reference.

### TILL PLAINS

Where a sheet of till forms the surface deposit, it is mapped as a till plain. However in this region the till is generally thin and commonly fails to completely cover the rock ridges. It would be impractical to map all the bare rock outcrops so associations of till plains and knobs and ridges of rock are recognized on the large map. Two types are distinguished depending on the depth of till and proportion of bare rock outcrop. Type 15 takes in the deeper till with bare rocks occupying less than 5 percent of the area; the other, Type 16, includes all the shallower till which has more rock outcrops. The mapped areas of the latter type may have as much as one-third bare rock, one-third with only a few inches of soil, and one-third with a foot or more of cover. The till is generally sandy and stony. Granitic materials predominate apart from the Eldorado-Madoc-Marmorata area and a few areas in the southwestern part of Renfrew County (Berger 1967). Carbonates in the till are found only in patches close to crystalline limestone bedrock.

The surface of the till sheet follows the contours of the bedrock and is rough except where the till is deeper and the surface drumlinized. Well formed drumlins

## Georgian Bay-Ottawa Valley Area

are nowhere numerous but there are widespread tracts with scattered drumlins set in smoothed or molded till plains. Distribution of drumlins is shown on Figure 4 (Chart A, back pocket), a map which also shows the relative numbers of drumlins and the trend of their long axes. Although groups of drumlins invariably occur in areas of deeper till, the peculiar occurrence of isolated drumlins in areas of almost bare rock must be noted as, for example, "The Ridge" south of Coe Hill.

The moulded till plains have smoothly rolling relief, the swells being elongated north and south in line with the direction of ice movement. There may be distinct flutings on the surface and crag and tail features are common, the tails of till built southward from the rock knobs. These smooth till plains are not mapped as a separate type but are associated with the drumlins mapped in Figure 4 (Chart A, back pocket). They are most extensive in western Renfrew and northern Hastings Counties with smaller tracts occurring all over the southern part of the region.

### **MORAINES**

Distinct continuous recessional moraines which would serve to mark the position of the ice front at one stage are notably absent between Georgian Bay and the Ottawa Valley. A few short discontinuous moraines of sandy till and glaciofluvial sand and gravel occur between Huntsville and North Bay and in Renfrew County. With one exception they trend east-west. The exception is the moraine extending along the brow of the St. Patrick scarp, as shown in Figure 5 (Chart A, back pocket). Perhaps a lobe of ice separated in the Ottawa-Bonnechere Graben to produce this moraine. The moraines found between Huntsville and North Bay were nearly all submerged in Lake Algonquin and are unusually smooth due to reduction of the hills by wave action and deposition of sands or some silt and clay in depressions. They consist mostly of sand but pockets of gravel and masses of sandy, stony till are also common. West of Mattawa extending from Grand Desert northward along the east side of Bonfield Township there is a sandy, gravelly moraine which marks the limit of advance of a late, local ice lobe which pushed westward in the Mattawa Valley (Prest 1970, Fig. XII-16; Harrison 1972).

The largest areas of morainic deposits occur as groups of kames with associated outwash. One such area is in the middle of Algonquin Provincial Park mainly in the townships of Biggar, Osler, Devine, Bishop, McLaughlin, and Bower. It does not extend westward to join with moraines near Sundridge or South River, nor can it be traced to the kames found west of Killaloe. Another smaller area of kames and outwash is in Papineau, Cameron, and Clara Townships southeast of Mattawa. This does not connect with the moraine at Grand Desert but may be related to the same ice lobe.

### **ESKERS**

Eskers are fairly numerous in the northern and eastern parts of this region as shown on Figure 4 (Chart A, back pocket). They are scarce in the south and west, only two appearing between Georgian Bay and Highway 11. Logging roads follow

eskers wherever possible inasmuch as the latter, being dry ridges of sand and gravel, are important sources of gravel. Also the deep sandy soils usually attract good stands of pine and spruce. All the known eskers are traced in some detail on the large map, whereas the general pattern of distribution may be seen at a glance on Figure 4 (Chart A, back pocket).

The longest esker in this region extends from the Mattawa Valley northeast of Bonfield to Washago, over 100 miles (160 km). It has two branches north of Fossmill; the larger one has a prominent form where it extends through Boulter Township southwest of Grand Desert and so the name Boulter is given to this esker. North of Grand Desert what is now recognized as a moraine may well be an extension of the esker overridden from the east by the Mattawa lobe, a tongue which pushed forward from the main mass of ice into the Ottawa and Mattawa Valleys. In Boulter Township this esker stands over 100 feet (31 m) high in places and may consist of two or three strands. It includes a series of deep depressions which are skirted by the forest access road built along the crest. The other branch extends from just north of Fossmill to Bonfield and beyond to the Mattawa River. It consists of a single ridge in most places less than 50 feet (15 m) high. Gravel is being taken from pits in it near Bonfield village. At Fossmill there is a gap, whereas south of there the Boulter esker consists mostly of a single ridge which continues in good form to a point east of the South River airport where there is a gap. Then it reappears and can be traced southward with some breaks to Pevensey. South of there this esker is not mapped as such because it has been levelled and spread out by wave action. The belt of sand followed closely by Highway 11 is the reworked esker with irregular bedding, typical of ice-contact deposits appearing in some exposed sections. These deposits should not be confused with the delta sands in this same belt left by streams such as the Muskoka North Branch, the East, and the South Rivers where they emptied into glacial Lake Algonquin.

West of the Boulter esker there are two small eskers, one west of Bernard Lake in a clay plain and partly buried by stratified clay; the other goes south from Burk's Falls for less than a mile (1.7 km) and also is partly overlain by clay. The lack of eskers in this wide belt east of Georgian Bay is in keeping with the scarcity of drift of any kind.

Five miles (8 km) east of Mattawa in the area adjacent to the Ottawa River, there is an esker which can be traced from this point southwestward nearly to Papineau Lake. The largest esker and, in fact the largest in the whole region, is the one which extends from Deux Rivières south for 10 miles (16 km) to Wendigo Lake and is closely followed by the Brent access road. Near Deux Rivières it is more than ½ mile (.8 km) wide and 75 feet (23 m) high with a fairly level top. It consists almost entirely of fine sand with very little gravel. East of Deux Rivières five other short eskers occur just south of the Ottawa River.

The area in Algonquin Provincial Park between the Canadian National Railways and Highway 60 has about 15 eskers. Some are in remote areas, for example, the large one west of Plumb, Robinson, and Whiskyjack Lakes. A good example is located south from Odenback on Radiant Lake. One of the longest and largest is crossed by Highway 60 at Amable Creek midway between Whitney and Madawaska. From that point it extends with several gaps for over 25 miles (40 km) northward and 10 miles (16 km) continuously southward to Wallace. It should not be surprising that there are many eskers in Algonquin Provincial Park because the till there is deeper than usual.

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East of the map-area one esker extends intermittently through Bagot and Darling Townships and there are four other shorter, small ones in Lanark County. The south-sloping part of this region has only a few eskers. South of the eastern part of the map-area two good-sized eskers go from north to south in Madoc Township. Farther west almost at right angles to these two, the Norwood esker extends across Belmont and Marmora Townships in places standing more than 100 feet (30 m) high. In Peterborough County north of the Kawartha Lakes the drift is thin and there are no eskers. In Haliburton County there is the small intermittent esker in the Irondale River valley extending for about 10 miles (16 km) upstream and downstream from Gooderham and two others south of Haliburton, one about 5 miles (8 km) long ending in a cluster of kames southeast of Canning Lake and the other a short complex one south of Canning Lake.

In all there are over 30 eskers of various lengths and sizes as mapped on Figure 4 (Chart A, back pocket).

### **OUTWASH TERRACES**

As the glacier melted, streams of water loaded with sediment flowed away and deposited the sand and gravel now found in most of the valleys. These deposits are usually more uniform than the material in kames and eskers. The bedding is generally horizontal and the landforms are flattopped but dotted with some depressions. The latter are due to the melting of ice blocks which were either left embedded during the deposition or, more likely, developed later as ice lenses. Many of the present streams have cut channels through the outwash terraces.

The texture of the outwash varies from silt and fine sand to coarse gravel. Very coarse cobbly gravel containing boulders up to 15 inches (40 cm) in diameter is found in a terrace beside Highway 17 at Klock. However it is sand and not gravel which predominates generally in the outwash.

### **LAKE PLAINS AND MARINE PLAINS**

The low-lying lands in Muskoka, Parry Sound, and Nipissing, especially for a few miles on either side of Highway 11, may contain stratified deposits of clay, silt, and sand. Generally horizontally bedded, they produce level plains on the surface. The clay and silt beds usually have regular alternate darker and lighter layers of respectively clayey and silty sediments which form the characteristic varved clay of glacial lakes. The clays here were deposited in glacial Lake Algonquin in its main and later stages (Leverett and Taylor 1915; Chapman 1954). A minor exception should be mentioned in the flat silt plain bordering Lake Nipissing and small tracts here and there along the shore of Georgian Bay. There the sediments are not varved because the lake in which they were deposited, the Nipissing, was not in contact with the glacier. It should be noted also that the Nipissing Lake plain is quite flat and does not have the scattered shallow depressions found in Algonquin plains.

The shoreline of Lake Algonquin cannot be traced precisely because of the lack of beaches and shorecliffs, but it has been determined approximately by the upper limit of lacustrine clay and sand and bare, wave-washed rocks. In areas which were never submerged, the rocks generally have at least a thin covering of soil. There

were quite a few offshore islands, as shown on Figure 6 (Chart A, back pocket).

It is now generally accepted that the weight of ice in continental glaciers cause a depression of the earth's crust, the maximum being under the thickest, inner parts of the ice sheets (Farrand and Gajda 1962). As the glacier melts, isostatic readjustment occurs and the earth's crust rises again, rapidly during the unloading and uncovering of an area, then slowly to a very low rate as a stable position is approached. In keeping with this theory, the lower lands in Muskoka, Parry Sound, and Nipissing were submerged during the recession from the area, even though the present outlet, the St. Clair River, was open at that time. The old shoreline is now found at 605 feet (185 m) a.s.l. near Sarnia, 883 feet (269 m) a.s.l. at the outlet east of Kirkfield, rising to 1,220 feet (372 m) near South River. A list of elevations of the highest Algonquin beach between Kirkfield and North Bay is given elsewhere (Chapman 1954; Goldthwait 1910). Because of the scarcity of beaches the three good beaches at the Cobb farm, 4 miles (6.5 km) west of Powassan in lot 3, concession III, Nipissing Township, should be mentioned, even though they are not upper Algonquin beaches. Their elevations were determined at 1,053 feet (321 m), 1,041 feet (317 m), and 974 feet (297 m) a.s.l., levelling from the lake nearby. The sandy terrace at the entrance to the Nipissing Ridge ski run may also be a beach. The elevation at the base is 1,106 feet (337 m) a.s.l. measured from the 715.30-foot (218.03 m) bench mark on the road southeast of Nipissing village. J. E. Harrison (1972) also mentions these and comparable beaches on the same hill. A good beach at 1,044 feet (318 m) a.s.l. a mile (1.6 km) south of the Cobb farm is well formed and definite. Beaches at Cooks Mills near the North Bay airport stand at 1,177 feet (359 m) a.s.l. (Chapman 1954; Goldthwait 1910).

The beach at Maple Lake, 10 miles (16 km) northwest of Haliburton, relates to a small annex of Lake Algonquin extending northeast of Balsam Lake to Kinmount, and to Minden and up the Gull River valley. A good-sized area of silt and fine sand occurs south of Kinmount and there is varved clay at the golf course near Minden.

In the northern part of the Algonquin lake plain there are silty clay and sand deposits around Powassan and eastward through Chisholm Township under the 1,100-foot (335-m) contour. Similarly the varved clay in Bonfield Township is found in hollows nearly up to but not above 1,000 feet (305 m) a.s.l. In Calvin Township the varved clay seldom occurs above 900 feet (274 m) a.s.l. and 850 feet (259 m) is the upper limit southeast of Mattawa.

In the Ottawa Valley below Chalk River there are also clay and sand plains in the low-lying areas. However the clay beds are irregularly stratified and not varved. Shells of marine creatures have been found in these sediments as far up the valley as Pembroke confirming that saltwater, called the Champlain Sea, submerged this lowland during and immediately after the recession of the glacier. Here again, this was due to isostatic depression of the earth's crust in this area to well below sea level. Where the western shore of this arm of the sea was against the knobby rocks of the Shield almost no beaches and bluffs were left to mark the shoreline. It is mapped approximately as for Lake Algonquin and shown on Figure 6 (Chart A, back pocket). The elevation of the shoreline is about 475 feet (145 m) a.s.l. at Almonte rising to 550 feet (168 m) at Renfrew and 590 feet (180 m) at Wylie, near Chalk River. It should be noted that the lake sediments mapped in the Golden Lake and Round Lake areas stand over 100 feet (30 m) higher than projected Champlain Sea levels of about 475 feet (145 m) a.s.l. So they must relate to a separate, likely earlier lake dammed to higher levels (Berger 1967). The till ridge just east of Mud

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Lake (formerly Wilber Lake), now cut through by a channel, apparently served as a dam long enough for considerable fine sand and silt to be deposited. The upper end of the Champlain Sea above Pembroke is occupied by sand deposits through which the Ottawa River has cut a great channel.

### **RECESSION OF THE LATE WISCONSINAN GLACIER**

The arrangement of the foregoing deposits supplemented by related evidence seen outside the region provides the main evidence from which the history of the recession of the Late Wisconsinan ice sheet in this region was interpreted. More detailed observations may change the interpretations. Moreover others do not agree with all points of the following outline (Prest 1970; Hough 1958; Stanley 1936) and there is unavoidably some discussion of controversial points.

From the alignment of the striae on the bedrock and the long axes of the drumlins it appears that the Georgian Bay-Ottawa Valley region was overridden by a single ice sheet with but two or three exceptions. The direction of the main advance was a few degrees west of south, the most westerly deflection of about 20 degrees being in the Georgian Bay area. The first exception is in the Ottawa Valley south of Pembroke where the glacier advanced down the valley slightly east of south. The second exception is in the Mattawa Valley east of Stonecliffe where a late advance towards the west of a local ice lobe is indicated. Also just south of Lake Nipissing the striae trend a little east of south as shown in Figure 4 (Chart A, back pocket).

The lack of any strong continuous moraine across the area suggests an uneventful withdrawal, interrupted only by minor halts or readvances indicated by the several small, east-west moraines found between Burk's Falls and North Bay and between Renfrew and Petawawa. Because of the trend of these moraines the front of the main ice sheet is assumed to have been east and west throughout. The group of kames in the central part of Algonquin Provincial Park may suggest a halt in the recession at that point. According to the chronology proposed by V. K. Prest (1970) the rate of withdrawal of the ice front from Kirkfield to Fossmill works out to 440 feet (134 m) per year and it slowed to 112 feet (34 m) per year between Fossmill and Mattawa.

During the recession the lower land in the east and the west was submerged and the ice front was in standing water. Northwest and north of Kingston glacial Lake Iroquois inundated the area probably up to the Rideau Lakes. When lower outlets into the Champlain Valley near Covey Hill, New York were uncovered the lake levels dropped over 300 feet (91 m) (MacClintock and Terasmae (1960). Between the Rideau Lakes and Carleton Place the border of the Shield was submerged by this Fort Ann Lake Stage which persisted until the glacier plugging the St. Lawrence Valley dwindled, allowing downdraining to sea level. From Carleton Place up the Ottawa Valley to Chalk River saltwater bathed the front of the glacier and is responsible for the clay and other sediments which floor the low ground. There are no good beaches and bluffs to mark the shoreline; it is inferred by the upper limit of the marine sediments.

The Georgian Bay area was also depressed, the depression increasing northward so that the Nottawasaga flats and lowlands around Lake Simcoe were submerged. The altitude of the St. Clair River at Sarnia (Port Huron) at that time was 605 feet (185 m) a.s.l. Another outlet channel leading westward at Chicago through the

Illinois River valley was at the same altitude and for a time shared the discharge. These outlets operated until the receding ice front reached Kirkfield and Fenelon Falls. The shoreline of this early stage is not distinct, probably because progressive isostatic uplift with the outlet or outlets being in the south produced falling water-planes. Lake Schomberg may represent these events in the Lake Simcoe area. Faint beaches at 1,025 feet (312 m) a.s.l. near Barrie and at the same altitude farther east mark the upper limits of this lake, but the main varved clay deposits lie under 850 feet (259 m) a.s.l. When the receding ice front reached Kirkfield and Fenelon Falls uncovering an outlet through the Trent Valley to the Lake Ontario Basin, the lake levels dropped likely over 100 feet (30 m) and less than 200 feet (61 m). The Kirkfield-Fenelon Falls outlet now operated as the glacier receded northward. Crustal rebound resulted in falling water-planes to the north while south of Kirkfield it resulted in rising water-planes. The rising lake waters produced strongly developed beaches and bluffs. This regime came to an end when Kirkfield finally was raised to the level of Sarnia. At this point the main Algonquin beach was formed, by far the strongest of the Algonquin beaches.

North of Kirkfield, in the region under discussion, falling water-planes failed to produce distinct shoreline features especially since the promontories within the Canadian Shield are mostly of bedrock with only a shallow drift cover. The upper limits of submergence are 960 feet (293 m) a.s.l. at Bracebridge, 1,117 feet (340 m) at Dorset, 1,129 feet (334 m) at Novar, 1,220 feet (372 m) at South River, and 1,195 feet (365 m) north of Trout Creek (Chapman 1954). The same terrace east of Bernard Lake at 1,245 feet (380 m) (Chapman 1954) is now considered not to be a beach and should be disregarded in this connection.

Because of progressive isostatic uplift the faint upper beaches found north of Kirkfield probably represent a succession of falling water-planes rather than a single level. High ground to the east persisted at least as far north as South River and probably almost to Fossmill. The first possible route low enough for outflow eastward towards the Ottawa Valley is up the South River valley past Twentyseven Lake and Denis Lake to Kawawaymog Lake (formerly Round Lake). However because of the indefinite beaches to mark the lake levels this is conjectural. The highest point is just east of Denis Lake. However there is no scoured channel in that vicinity and the Boulter esker in the initial stretch of the valley remains in good form. Also the route eastward from Kawawaymog Lake is through Waskigomog, Biggar, Birchcliffe, and Skuce Lakes, then to the Nipissing River and down that valley to Cedar Lake and the Petawawa River. Between Carl Wilson Lake and Plumb Lake the Nipissing River cuts through an esker. The passage is a narrow angling gorge, not a broad gap straight across, which leads to the conclusion that this route never served as a major outlet channel for Lake Algonquin. Harrison's suggestion of drainage northward down the Amable du Fond Valley is not tenable if we assume that the ice front extended east and west or even at right angles to the striae in the Powassan area (Harrison 1972). For these reasons it is concluded that the Kawawaymog route never served as an outlet for Lake Algonquin.

Just south of Fossmill a passage which Harrison (1972) described and named the Genesee outlet probably operated for a short period. A low saddle in the Boulter esker in concession III, Himsforth Township would allow drainage eastward through low ground south of a small sandy moraine and then northward through a narrow col and eastward towards Kilrush Lake and the Petawawa River valley. A litter of boulders on the floor of this col is good evidence that it served as

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a drainage channel (Harrison 1972). Further recession of a mile (1.6 km) uncovered the valley at Fossmill which certainly served as an outlet eastward, the sill being just east of Kilrush Lake at 1,130 feet (345 m) a.s.l. (Chapman 1954). North of Fossmill lacustrine deposits are not found above the level of a water-plane at the Kilrush Lake altitude.

At the entrance to the outlet just west of Fossmill a gap  $\frac{1}{3}$  mile (.5 km) wide is cut through the Boulter esker. However the sill was just east of Kilrush Lake at 1,130 feet to 1,140 feet (345 m to 348 m) a.s.l. (Chapman 1954; Harrison 1972). The path of the outlet is followed by the railway along a fault-line through Cedar Lake, Radiant Lake, and Lake Traverse from where it split, the Petawawa River valley taking part of the flow, the remainder continuing straight on through Grand, Stratton, and St. Andrews Lakes, then down the Barron River. Both emptied into the Champlain Sea west of Petawawa and built a large delta of sand. The broader, quieter stretches of the spillway, as for example around the lakes, invariably contain trains of outwash, swamps, or bogs. Constrictions in the channel generally show the results of severe stream erosion in the form of bare rock walls and boulder-strewn floors. In the Grand Lake area a second channel through Greenleaf and Carcajou Lakes left a boulder pavement on the valley bottom. Between Grand and Stratton Lakes a neck of land is littered with big boulders and another boulder pavement occurs between Stratton and St. Andrews Lakes. Around High Falls at the outlet of St. Andrews Lake the bedrock is swept completely bare.

The Petawawa delta formed at the east end of the Fossmill outlet stands at an altitude of 590 feet (180 m) a.s.l. maximum. This is a measure of the crustal depression at that time. Near Fossmill in the Lake Algonquin Basin at the same time 590 feet (180 m) crustal depression would have placed the lake level at 605 feet (185 m) plus 590 feet (180 m) or 1,195 feet (365 m) a.s.l. This is the level of the beach north of Trout Creek (Chapman 1954). The equal amount of crustal depression at Petawawa and Trout Creek is significant. An isobase drawn through these two points would run almost east-west whereas farther south the isobases trend S68E (112 degrees) (Goldthwait 1911). To suggest greater crustal depression than this at Trout Creek at this time would involve more severe and unlikely distortion of the general pattern of warping. This supplements the evidence already cited for the conclusion that the falling beach levels at South River and Trout Creek are due to isostatic uplift rather than downdraining by outlets eastward.

The uncovering of the Genesee and Fossmill outlets would have lowered the lake level by about 160 feet (50 m) in all, a figure derived by extrapolating the Algonquin water-plane northward from the 1,195-foot (365 m) beach near Trout Creek and allowing for a few feet of water over the sill at Kilrush Lake. This drop in lake level would have uncovered the Nottawasaga flats and lowlands around Lake Simcoe and, incidentally, lower the beach lines below the Payette beach described by G. M. Stanley (1936).

Receding northward from Fossmill through Chisholm Township to Lake Nobsong the glacier left several small fragmentary east-west moraines which were partly buried by clay in Lake Algonquin. The moraines show that the ice front extended east and west here at that stage. With the uncovering of the valley occupied in part by Sobie Lake and Guilmette Lake the sill east of the latter lake was about 15 feet (5 m) below the Algonquin water-plane controlled by the Kilrush sill and drainage for a time could have passed through this valley to Kiosk and down the route of the Fossmill outlet (Prest 1970; Harrison 1972). Continuing withdrawal leaving varved clay deposits allowed Lake Algonquin to invade the lower

ground east of Bonfield and into the Amable du Fond Valley. Once this valley was open, drainage was free to pass over Kiosk and down the aforementioned Fossmill outlet channel. However the sill here was east of Mink Lake at an elevation of about 1,090 feet (333 m) a.s.l. which would have allowed lake levels to drop 60 feet to 65 feet (18 m to 20 m) below the Fossmill level.

If we continue to assume an east-west ice front one would expect the recession northward would have uncovered a succession of progressively lower outlets across the slope south of Mattawa to the Ottawa Valley eventually uncovering the Mattawa River valley. With crustal depression of over 500 feet (150 m) the lake levels in the Huron Basin could have dropped to very low levels. Actually the sill would not have been east of North Bay but in the French River area near Georgian Bay (Lewis 1970). The very low Lake Stanley Stage in the Huron Basin (Hough 1958) could have occurred only if such a low outlet to the Ottawa Valley had been open at some time.

The beaches at 1,177 feet (359 m) a.s.l. at Cooks Mills near the North Bay airport are on the Fossmill water-plane. This and lucastrine sediments around Feronia, Redbridge, and Balsam Creek required an ice dam in the Mattawa Valley and a realignment of the ice front (Chapman 1954). It is suggested that the Mattawa lobe served as this dam and that its readvance to Rutherglen closed the Mattawa Valley outlet while also overriding and obliterating the evidences of outlet channels across the slope south of Mattawa. It also left the Papineau esker which extends up the slope from near the Ottawa River to altitudes of over 1,100 feet (335 m) a.s.l. east of Papineau Lake. The readvance raised the lake level to Fossmill water-plane.

Apparently, the Mattawa lobe stayed in place long enough for differential uplift, with rising water-planes in the south, to bring the Fossmill outlet above the St. Clair River and Chicago outlets after which continued uplift with the outlet now in the south produced falling water-planes. The recession of the Mattawa lobe from the Rutherglen moraine allowed the lower lands to be submerged in Calvin Township. In the Amable du Fond River area the varved clay which provides the main evidence of submergence is not found above 950 feet (289 m) a.s.l. and the upper limits of these clays drop to 850 feet (259 m) a.s.l. southeast of Mattawa. This indicates rapidly falling lake levels which must be attributed to isostatic uplift with the outlet once again the St. Clair River. The Papineau esker is not breached above 850 feet (259 m) a.s.l. Three small streams in narrow valleys below 900 feet (274 m) a.s.l. cross the esker near the east boundary of Papineau Township, but they are not the broad gaps indicative of spillways. Thus it appears that falling lake levels stayed below the levels of the ice dam until the Ottawa River was almost reached. Starting about 2 miles (3 km) from the Ottawa River below 850 feet (259 m) a.s.l. the Papineau esker is flattened and disappears and there are water-washed rocks, indicative of a breakthrough of drainage to the Ottawa Valley. It came when the land at Mattawa was about 245 feet (75 m) below the St. Clair River outlet which held the Algonquin beach to a level of 605 feet (185 m) a.s.l. at the southern end.

In the Ottawa Valley in the area inundated by saltwater above Montreal there are two large sandy deltas with very little deltaic sand between them. One is at the upper end of the basin at 590 feet (180 m) a.s.l. maximum, this being the delta built at the mouth of the Fossmill outlet channel west of Petawawa and augmented to the north by sand deposited by drainage down the Ottawa Valley. The second one lies east of Ottawa below 240 feet (73 m) a.s.l. and since Ottawa is on nearly the same isobase at Mattawa (Farrand and Gajda 1962) is thus close to the above-

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mentioned 250 feet (76 m) of crustal depression at the time of the breakthrough at Mattawa. It is suggested that the sudden rush of water, which occurred when the dwindling Mattawa lobe at last allowed the breakthrough, cut the great channels seen in the Petawawa delta and redeposited the sand in the bay below 240 feet (73 m) a.s.l. east of Ottawa. The downdraining of the last stage of Lake Algonquin was no doubt quite sudden and with the Mattawa Valley completely clear of ice the Huron Basin water settled nearly 150 feet (46 m) to the level of the sill east of North Bay, thus initiating the Nipissing Great Lakes.

Initially, the North Bay outlet was nearly 250 feet (76 m) lower than St. Clair River valley, if the above interpretation is correct. Progressive isostatic uplift first produced rising water-planes in the south resubmerging the lowland which was uncovered by the drop in lake levels coincident with the opening of the Mattawa Valley. The main Nipissing beach was formed when the St. Clair Valley coincided with the North Bay outlet. Then, when the North Bay outlet was raised above the St. Clair River, the drainage was taken over by the latter outlet. With the outlet in the south continuing uplift raised all land above 605 feet (185 m) a.s.l. out of water. Then erosion of the St. Clair River channel lowered the lake level to 580 feet (177 m) a.s.l., the present level of Georgian Bay and Lake Huron.

Around the present Lake Nipissing the bed of the ancient Nipissing lake stage is well represented by remarkably flat silt and clay plains commonly bordered by a small but distinct bluff. Highway 17 traverses this plain east of Sturgeon Falls and in the Verner area. The sandy plain around Nipissing village can also be mentioned. Along the shore of Georgian Bay there are no large Nipissing lake plains, but there are many small ones among the rock ridges. These are the youngest deposits in the region related to the Wisconsin Glacier.

## RIVERS

Because it has a central dome the Georgian Bay-Ottawa Valley region is drained mostly by short, small streams originating near the centre and flowing to the borders. An exception to this rule is provided by the Petawawa River which flows nearly parallel to the Ottawa River. The rivers generally follow fault-lines or other bedrock lineaments and their gradients are related to bedrock structures. Being young and flowing mostly on hard bedrock the rivers have done only small amounts of grading in their channels. In a few areas the rivers have cut deeply into sand and clay beds and in these areas the land may be dissected by gullies near the river valleys.

Precipitation is 8 inches to 10 inches (20 cm to 25 cm) higher on the western slope facing Georgian Bay than on the eastern, lee side of the Algonquin Provincial Park and Madawaska Highlands. Mean annual precipitation at Beatrice is 41.4 inches (105.4 cm), whereas at Renfrew it is 32.3 inches (82 cm). Similarly, the amount of runoff averages 18 inches to 20 inches (46 cm to 51 cm) annually from the Magnetawan and Muskoka River basins respectively, but it is 10 inches (25 cm) from the Bonnechere basin. April is usually the month of highest flow and August or September the lowest.

The Severn River drains Lake Couchiching to Georgian Bay, but its main tributary, the Black River, extends from the confluence at Washago northeastward into Haliburton County. Around its source there are areas over 1,200 feet (366 m)

and 1,300 feet (396 m) a.s.l. Mostly the Black River follows a narrow, swampy or sand-floored valley, and in the Vankoughnet vicinity and several other stretches, the river takes a meandering course. Where the Black joins the Severn just east of Washago village its amber water contrasts strongly with the greenish blue water from the limestone-floored area to the south. The Severn is canalized to extend the Trent Canal system from Lake Simcoe to Georgian Bay and a hydroelectric power plant with a capacity of 4,000 kilowatts has been operating since 1909 at Big Chute.

The Muskoka River is the largest of the rivers draining the Muskoka-Parry Sound area. The South Branch rises in the edge of Algonquin Provincial Park around Canoe Lake (1,379 feet; 420 m) and Smoke Lake (1,382 feet; 421 m). From there to Lake of Bays the river follows a meandering course in a sandy valley and is called Oxtongue River. From Lake of Bays (1,034 feet; 315 m) the river falls nearly 300 feet (90 m) in the 25 miles (40 km) to Bracebridge where it joins the North Branch. Three power plants in this section together have a generating capacity of 6,500 kilowatts.

The North Muskoka rises on the western edge of Algonquin Provincial Park around McCraney Lake, being called the East River above Huntsville. The East River and its feeders follow valleys in the rock floored with sand; these valleys in the upper part have a trellised pattern. The upper part of the East River has a gradient of about 15 feet per mile (1.8 m per km), but in Chaffey Township where the sediments of glacial Lake Algonquin appear the grade flattens and the river course cuts a striking meandering pattern in a broad sand plain. From Mary Lake (921 feet; 281 m) to Bracebridge the North Muskoka flows through a sand plain cutting a trench below High Falls up to 70 feet (20 m) deep in beds of lacustrine sand and varved clays. From Bracebridge to Lake Muskoka (739 feet; 225 m) the river is entrenched in a clay plain. Below Bala the Muskoka River takes a crooked course through rocky country to Georgian Bay. Actually the Moon River and Muskoka River are part of the same system as they split from a common point west of Bala. However the Moon River is confined by bare rock ridges to a straight path northwestward to an inlet of Georgian Bay.

The Magnetawan River, like the Muskoka, has a rapid upper section in sand-floored rocky valleys, a central part where it drains level sand plains or clay plains, and a lower part through country dominated by bare rock knobs and ridges. In some of the lower part it follows fault-lines trending almost east-west eventually emptying into Georgian Bay at Byng Inlet.

The Seguin, Shawanaga, and Key Rivers all flow in narrow valleys along fault-lines on their way to Georgian Bay. The same applies to some sections of the Pickerel and French Rivers, a good example appearing where Highway 69 crosses the French River.

The South River is tributary to the French, the main section draining sand and clay plains south of Lake Nipissing. Near the town of South River the sand plain stands at over 1,150 feet (350 m) and the river drops 500 feet (150 m) in its 40-mile (64 km) course to Lake Nipissing (640 feet; 195 m). Two power plants at Elliot Chute and Bingham Chute together generate 2,200 kilowatts. Near Trout Creek and Powassan the river has cut deeply into sand and clay beds and considerable dissection has resulted in these areas. The river extends beyond the town of South River into the rocky uplands to the east. It rises at Winifred Lake (ca. 1,400 feet; 427 m a.s.l.), follows a straight swampy valley northwestward then turns southwest through outwash sand and gravel, commonly alongside a nicely formed esker. Near South River

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airport it reaches the level sand plain which is a delta formed in glacial Lake Algonquin.

At North Bay the divide between drainage to Georgian Bay and to the Ottawa River occurs just east of the city. The Mattawa River follows the depression along the Coulonge Fault. From Lake Talon to Mattawa this mostly takes the form of a rock-walled canyon up to 300 feet (90 m) deep. Indeed the north wall rises over 500 feet (150 m) in places. Several tributaries enter the Mattawa River from the south, draining the clay flats and rock knob complex of Bonfield, Calvin, and Papineau Townships. The largest of these is the Amable du Fond, which rises at Kawawaymog Lake and proceeds to drain Waskigomog, Wilkes, and Kioshkokwi Lakes where it crosses the abandoned Fossmill outlet channel and drains a section of it northward.

During the life of the Nipissing Great Lakes the Mattawa Valley carried the whole discharge from the upper Great Lakes. Evidence of a much larger river is seen in scoured, bare rock walls and in boulder pavements well above the present stream. For example, south of the main intersections in the town of Mattawa the wooded land is littered with big boulders. In the 80 miles (130 km) between Mattawa and Petawawa the feeders on the south side of the Ottawa River are all small streams which generally drain only the first tier of townships. Between Deux Rivières and Bissett Creek, two small streams drain a former, alternative channel of the Ottawa River.

The Petawawa River and its extension up through Radiant Lake, Cedar Lake, and Cauchon Lake to Mink Lake follows fault-lines through much of its course. Around the lakes the gradients are low and there usually are sandy outwash plains. These are separated by narrow valleys with bare rock walls and boulder pavements in the bottom. This was the route followed by the drainage from glacial Lake Algonquin during the Fossmill to Mink Lake stages and when first opened it no doubt carried a great discharge.

The Barron River valley served as a second channel for Fossmill drainage below St. Andrews Lake. Between Stratton and St. Andrews Lakes there is a strip of land strewn with big boulders. Leading northward from St. Andrews, the Barron River first drops over a pretty little waterfall about 10 feet (3 m) high which, oddly, is called High Falls. The discharge from Stratton Lake drops down steep rapids just west of the above-mentioned falls and the rocks around the rapids are swept bare. After taking a northward course for 2 miles (3 km) the Barron River turns sharply eastward and follows a fault-line through a sandy area towards Petawawa, joining the Petawawa River west of the town of that name.

The Petawawa is second in size to the Madawaska among the streams flowing from this region into the Ottawa River. It has a mean flow of 1,610 cfs (46 m<sup>3</sup>/s) or an average yearly runoff of 13 inches (33 cm) from its basin. May and September are the months of highest and lowest discharge, the recorded figures being 4,300 cfs (122 m<sup>3</sup>/s) and 680 cfs (19 m<sup>3</sup>/s) respectively.

The Indian River, which empties into the Ottawa at Pembroke, follows the flat-bottomed, sandy or swampy valley in its upper part which is followed by the Canadian National Railways. The river begins at Kathmore but the valley continues along a fault to St. Andrews Lake. The Fossmill drainage undoubtedly came to St. Andrews Lake from where most of it went down the Barron River. However at peak flow some may have passed on to Kathmore and down the Indian River. A small delta in the vicinity of Alice occurs where the valley reaches the level of the Champlain Sea.

The streams flowing into the Ottawa River have been discussed before (Chapman and Putnam 1966) so the comments here will be restricted to a few, mostly supplementary, points. The Bonnechere and Madawaska Rivers drain the Bonnechere Graben and the Madawaska Highlands and southern part of Algonquin Provincial Park. The Bonnechere stays mainly within the lowland and has a fairly straight course and narrow drainage basin. The divide between Bonnechere and Madawaska drainage occurs not far west of the St. Patrick Fault. The Madawaska rises in the area south of Opeongo Lake (1,323 feet; 403 m) where the highest lands stand above 1,600 feet (488 m) a.s.l. It takes a southeasterly course, connecting several good-sized lakes including Bark (1,027 feet; 313 m) and Kamaniskeg (928 feet; 283 m). Near Combermere the main river is joined by the York River which drains the Bancroft area flowing northeast across the line of faults in that area. The Madawaska follows faults from Bark Lake to Matawatchan then turns abruptly eastward to the Ottawa River at Arnprior. Above Stewartville where a dam and power plant is built, the river has a steep gradient dropping from 800 feet to 350 feet (244 m to 106 m) a.s.l. in 25 miles (40 km). The St. Patrick Fault is still effective even if the scarp is not prominent in this area. Four power plants on this river together have a capacity of 449,000 kilowatts. The dam at Barrett Chute has flooded the valley upstream for over 20 miles (30 km) to Griffith.

The source area of the Mississippi River is north of Mazinaw Lake in an area of shallow drift. Mazinaw Lake fills a straight trough 7 miles (11 km) long, the west wall formed by a fault scarp 150 feet to 200 feet (45 m to 60 m) high. Downstream the river consists of several short sections connecting a series of rock-girt lakes the largest of which are Kashwakamak, Cross, and Dalhousie Lakes. The river has not graded its channel appreciably even though there are rapids in several stretches. Because it drains an area of mainly shallow drift, the Mississippi has a variable regimen, the average flow in April (3,330 cfs; 95 m<sup>3</sup>/s) being nearly ten times that of the September average (345 cfs; 9 m<sup>3</sup>/s).

There are no large rivers on the southerly slopes draining onto the Paleozoic rocks and eventually into Lake Ontario. Southwest of the Mississippi River there are several small streams tributary to the Napanee, Salmon, and Moira Rivers. For the most part, they have not cut deep channels because erosion is held in check by bedrock sills. Thus they lead from one lake to the next and one bog to the next and may, in places, cut shallow channels through outwash sand and gravel deposits. West of this the rivers belong to the Trent River system.

The Crowe River, Eels Creek, Mississauga, Burnt and Irondale, and Gull Rivers are all small streams draining the south-sloping part of the Shield north of the Kawartha Lakes. They are all fairly short, small streams, the largest being Crowe River with a mean annual flow of 722 cfs (20 m<sup>3</sup>/s). Extensively, these drainage areas have very shallow drift. Bare rock is prevalent and from this type of surface, drainage flows away like water off a roof and the seasonal regimen is quite variable; the mean flow of the Crowe, for example, in April is 2,390 cfs (68 m<sup>3</sup>/s) and in September it is 87cfs (2 m<sup>3</sup>/s). The Burnt River and its tributary, the Irondale, also drain thin drift country but they mostly flow in valleys 1/2 mile to 3/4 mile (3/4 km to 1 km) wide occupied by outwash terraces and hills of glaciofluvial sand and gravel. At Kinmount the Burnt River enters a broader, level lake plain and has cut a channel up to 40 feet (12 m) deep into stratified sands and silt. The upper part of the Burnt drainage area has many lakes and this applies throughout the Gull River basin which tends to stabilize the flow of the river.

## GRAVEL AND SAND

Sand and gravel for roads, buildings, and other construction is always needed in any area. This section deals with the deposits of these materials in the Georgian Bay-Ottawa Valley region in a general way, indicating the type, amount, and quality of deposits found throughout the region. Locally, the primary concern is to find enough for local needs but the possibility of finding large deposits of good gravel and sand on rail for transport to Toronto has been considered also. This latter possibility is raised because the deposits near the Metropolitan area are rapidly being exhausted and the prospect is attractive because gravel pits in unsettled areas would have no neighbours to disturb and rail haul would replace gravel trucks on highways.

Glaciofluvial deposits in eskers and kames, outwash, and alluvium consist mainly of sand and gravel, therefore, a map showing these deposits gives a lead towards finding useful aggregates. They are shown on the map attached to this report, but having a scale of 1 inch to 4 miles (1:253,440) it is too small to show small occurrences so many useful deposits are not outlined. Many of the mapped areas of these deposits include too much fine sand, silt, and clay for use as aggregates. An inventory of the tonnage of useful sand and gravel and a separation of the coarser and clean sand from finer grades is well beyond the scope of this survey.

In much of Parry Sound, particularly in the areas mapped as "Rock Ridges and Shallow Drift" (Type 16), gravel deposits are quite limited. This holds true in all scattered areas of this type mapped in the southern part of the whole region. The central and northeastern part has generally deeper drift on the bedrock and more gravel.

The most common source of granular material in this region is the outwash in the valleys. Railroads and highways and logging roads follow along these level sand terraces as much as possible for obvious reasons. The material in these terraces is mostly sandy, less frequently gravelly, and may be silty. Also, the deposits are usually shallow. Good outwash gravel beds over 15 feet (5 m) deep are not easy to find. Some of the larger gravel deposits of this type are located as follows:

1. At Hickey Settlement on Highway 62 north of Bancroft.
2. West of Alice along the Indian River west of Pembroke.
3. At Wylie near Chalk River.
4. On Highway 17 at Klock.
5. North of Kawawaymog Lake, east of South River, probably the largest outwash gravel deposit.

Similar to the glacial outwash is the much younger alluvium deposited by the present streams. Usually these alluvial terraces are small and the beds shallow.

Scattered throughout the whole region, kames are also tapped frequently for gravel. In the form of rounded irregular hills and even small humps they consist of gravel, coarse sand, fine sand, and silt irregularly interbedded. There may be boulders, singly or in clusters, as well as masses of dirty, unstratified gravel. Variability is a problem and often leads to selective excavation to take out pockets of gravel leaving the fine sand. Good-sized gravel pits in kames occur along Highway 11 at Powassan, Novar, Emsdale, and Scotia and in this same area numerous small pockets of gravel occur in the fragmentary sandy moraines. In the southern part of the region kames are mostly separate and widely distributed. In Algonquin Provincial Park an extensive belt of kames and outwash occurs in the Tim River

area away from roads and railways. Two more belts of kames occur west of Killaloe and west of Deux Rivières, both containing generally sandy material.

As with outwash, the main limitation of the material in the kames of this area is the preponderance of fine sand. They include very few large, uniform gravel deposits although uncounted small deposits provide road metal throughout the region.

Eskers are made of material similar to kames. They mostly appear as one or two thin, crooked ridges, long stretches of which would be required to contain a large tonnage of sand and gravel. What appears to be the bulkiest esker in the region is the one extending south of Deux Rivières and with minor exceptions it consists of very fine sand. Eskers are most numerous in Algonquin Provincial Park, one of the large ones crossing Highway 60 and the railway 5 miles (8 km) west of Madawaska village; a pit at that point is in good gravel. In northern Lanark County a very good gravel pit in an esker at White is worth noting. A very small esker in the Irondale River valley east and west of Gooderham provides gravel in an area where other sources are scarce. The longest esker in the region, the one which crosses Boulter Township and extends southward, has no large pits in it where it is largest in Boulter, Chisholm, Ballantyne, Laurier, and Joly Townships. Although it appears to be mostly sandy there are many exposures of gravel and it represents a possible source of gravel for rail transport. The extension of this esker southward, modified by wave action, provides sand and gravel for Bracebridge, Gravenhurst, and Washago.

The gravel in this region is usually clean, free-flowing, and of hard, sound material. Weathered granite which readily disintegrates is a problem, particularly where it is abundant as in the North Bay-Mattawa area. Too much mica in the sand also may be a problem in that area. The preponderance of the finer grades limits the usefulness of most of the sand in all parts of this region.

The prospect of shipping sand and gravel on existing railways to Toronto has been mentioned already. However before seriously suggesting this prospect, the availability of large deposits of sand and gravel of good quality should be considered. The following is based on a survey of large deposits on rail in the region under discussion. It was assumed at the outset that a large deposit was one of at least 15,000,000 tons (13,605,000 metric tons), which is about one year's requirement of processed sand and gravel for Toronto and district. "On rail" was taken to be within 4 miles (6 km) of a railway.

With this in mind all our information from field observations and airphoto interpretation was reviewed along all railways in the Georgian Bay-Ottawa Valley region. Any gravel deposit with some possibility of meeting the above-mentioned qualifications was listed. Thus fourteen prospects were listed and these were all revisited to examine any exposures assessing the amount and noting the quality of the sand and gravel.

Eleven of the fourteen either clearly failed to meet the quantity limit or were ruled out because of a preponderance of fine sand. This leaves three prospects, two being eskers where they are crossed by the Canadian National Railways at Fossmill and west of Madawaska village and the third in kame and outwash deposits north of South River. Test holes would be needed to check the grading of the sand and stone content of these three prospects. At Fossmill weathered granite which is unstable and would require repeated, more costly crushings may be a problem. In the third prospect both quantity and quality are doubtful and would have to

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be verified by test holes and sieve analyses of samples.

Even if all three of these prospects proved adequate they would represent quite limited reserves of aggregates on rail in this area.

### THE RELATION OF PHYSIOGRAPHY TO SOILS

The type of weathering and profile development in the soils of any region is governed primarily by climate. This is a region of cool, moderately moist climate. Mean annual temperature varies from 42°F (5.5°C) in the southern parts of lower altitude to under 40°F (4.4°C) in the uplands of Algonquin Provincial Park. Rain-fall and snowfall are heaviest on the westerly slope facing Georgian Bay and lightest on the eastern, lee slope, varying from a high of 41 inches (104 cm) of annual precipitation at Beatrice to a low of 32 inches (81 cm) at Renfrew. As a rule, precipitation exceeds evaporation except in June, July, and August when upward movement of water in the soil predominates over downward movement. Moisture deficiencies are fairly common but on the deeper soils severe droughts are rare. On the average the runoff varies from 20 inches to 10 inches (50 cm to 25 cm) a year. Strongly developed Podzol soils develop under wetter conditions than these and this region lies in the warmer part of the Podzol zone. In keeping with these temperature and moisture regimes the soil profiles on the uplands and on sandy materials are usually weak Podzols. Orthic, Melanic, Brunisols appear in the warmest, drier southeastern section (Martini, Protz, and Chesworth 1970). On lacustrine silt and clay Orthic, Gray Brown Luvisols are found on well drained sites as they are on calcareous shaly tills occurring around Eldorado just south of the southern border of the map-area. These better soils on silt and clay and calcareous till serve to illustrate the important effect of parent materials of soils. In these circumstances it is more critical than the effects of temperature and moisture variations.

The vast majority of soil in this region is forested, being non-agricultural mainly because of the rock outcrop and associated shallow soil, rough topography, stones, and swamp. Sandy texture, acidity, and low fertility all contribute to low crop productivity on what deep soil there is. However in the upland part of Renfrew, Lanark, Lennox and Addington, and Hastings Counties there is a sprinkling of farms on the deeper, smoother areas of till. Viable farms are primarily in drumlin areas.

In view of the usually acidic character of the soil it would not be surprising to find more productive soil in areas where crystalline limestone bedrock is found. This appears to be the case only in limited areas directly over the limestone. Generally, throughout the area in which crystalline limestones occur there are no appreciable amounts of carbonates in the till.

Except in Algonquin Provincial Park and Haliburton County, the soils are mapped and described by the Provincial-Federal soil survey in reports for Renfrew, Lanark, Frontenac, Lennox and Addington, and Hastings Counties and the Parry Sound District (Gillespie, J. E., Wicklund, R. E., and Matthews, B. C. 1963; 1964; 1966; Gillespie, J. E., Wicklund, R. E., and Richards, N. R. 1962; Hoffman, D. W., Miller, M. H., and Wicklund, R. E. 1967; Hoffman, D. W., Wicklund, R. E., and Richards, N. R. 1962).

The soil classification developed by foresters (Hills 1953; 1959) differs from the

above-mentioned agricultural classification in two respects. First, it separates the shallow soils over Precambrian rocks into three classes, rather than two. These are 36 inches to 12 inches (91 cm to 31 cm), 12 inches to 2 inches (31 cm to 5 cm), and 2 inches (5 cm) to bare rock. These depths vary an inch (2.5 cm) more with coarse, dry, sandy materials and an inch (2.5 cm) less with clay loam. This finer subdivision is needed because of the effect of depth and resulting soil moisture supply and root range on tree growth. Also, noncalcareous parent materials are divided into two types, one containing largely granite and the other having more basic rocks in the mixture. This is done because of known effects on tree growth. For example, the more acidic type produces better quality yellow birch than the more basic type whereas the reverse holds true for sugar maple. The land classification developed as a basis for forest management has been applied to all of the Georgian Bay-Ottawa Valley region and maps on the scale of 1:125,000 are available for the whole region (Berger 1972).

## AGRICULTURE

Within the Georgian Bay-Ottawa Valley region there are about 335,000 acres (1,350 km<sup>2</sup>) of improved land of which about 200,000 acres (810 km<sup>2</sup>) are cropped. About 140,000 acres (570 km<sup>2</sup>) of this is clay loam or silt loam in lake plains. Nearly 10,000 acres (40 km<sup>2</sup>) are based on shaly till in the Eldorado-Madoc-Marmorata area in Hastings County. The remainder is mostly in the upland areas of deeper till with moulded, drumlinized surfaces.

In size, the majority of farms fall within the 180 acre (73 ha) to 400 acre (162 ha) category, the average size being 240 acres (97 ha). A few dairy farms near the towns produce fresh milk, the group around Powassan, south of North Bay, being worthy of special mention. Milk for cheese is produced around Eldorado in Hastings County for the one cheese factory still operating within the whole region. Similarly, in the Sundridge area cream is supplied to the one creamery producing butter in this region. From the upland part of Lanark some cream goes to the creamery at Almonte and cream is trucked from Muskoka and Parry Sound to Lindsay. Small acreages of potatoes may be seen and some poultry specialization but the main crops are hay and oats or oats and barley mixed, produced as winter feed for beef cattle and hogs. Some corn for silage is also grown. Many of the farmers supplement the farm income by work away from the farm. Generally, it must be said that agriculture is not flourishing in this region. However it may also be stated that the farms of the region have a latent capacity to produce food which some day may be needed.

## FORESTRY

The 97 percent or 16,500 square miles (41,250 km<sup>2</sup>) of the region with non-agricultural soils are forested except for scattered open clearings and bare rock areas. The clearings are mostly on dry sandy soils and are not extensive. Rock outcrops make up less than 10 percent of the area and are most extensive in Parry Sound, Muskoka, and the southern part of the region. Some trees do grow on jointed and porous rock but mostly rock outcrops are bare. Very shallow soils over rock

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produce a scrubby growth of red oak, jack pine, and, less commonly, other species. The deeper well drained soils on glacial till support good hardwood forest, sugar maple and yellow birch being the main species. Hemlock groves, balsam fir, and scattered white pines are intermingled although the pines, particularly, have been well culled out for lumber. The pines (white, red, and jack) concentrate on the sandy and gravelly soils of the outwash terraces, kames, and eskers, white pine thriving on the finer sands and jack pine taking over on coarse, dry sands. Sandy soils also support some white spruce. Black spruce and white cedar are found on swamplands and bogs. These latter wetlands occupy about a tenth of the area and are patchy in distribution.

This region accounts for one-third of the maple syrup produced in Ontario, not a major item in the economy but one which supplements many farm incomes.

It was through lumbering that this part of Ontario was opened up, the history of lumbering being a story in itself which cannot be dealt with here. It will suffice to say only that the country is dotted with the dilapidated or burned-out and overgrown remains of lumber camps and sawmills. Even now, there are close to 200 sawmills operating in this region. Most are small, handling less than 500,000 board feet (152,530 m) a year, the bulk of the lumber being turned out by about 10 of the largest mills. At first, the hardwoods were passed by in favour of the pines but now the hardwoods, used for plywood, furniture stock, and pulpwood, account for over half of the current cutting. Pulpwood of black spruce off wetlands, poplar, and hardwood chips account for about one-third of the current harvest. Possibly because there are no large continuous stands of pulpwood there are no paper plants in this region, the wood going to pulp mills outside its boundaries.

Anyone visiting this area in summer might well conclude that recreation and tourism are the most important sources of income. However lumbering in its several forms is still the primary industry by a wide margin, and will likely maintain this position.

## **MINING**

The region under discussion has seen a great deal of varied mining activity over the years. At the present time nepheline syenite is being mined by two companies at Blue Mountain in Methuen Township; marble is quarried at Madoc and Eagle Lake; talc is mined at Madoc; dolomitic marble is quarried for the production of magnesium at Haley in Renfrew County; limestone is quarried in Orillia Township and sand and gravel are quarried at numerous locations. In previous years, graphite was mined at Black Donald Mines in Renfrew County, near Hybla in Hastings County, and at Harcourt in Haliburton County. Corundum was mined at Craigmont and Jewelville in Renfrew County and at Burgess Mines in Hastings County. Uranium was mined at Bancroft and Wilberforce. Feldspar was mined in many places in the region, particularly at Hybla, Madawaska, Verona, and Burk's Falls. A mica mining industry flourished for many years near Sydenham and Perth and apatite was mined in the same areas. Several interesting copper prospects have been opened up near Parry Sound. Iron was mined at Bessemer, Coe Hill, and Irondale and is being mined at Marmorata. Diatomite was mined in the area between Bracebridge and Huntsville. A columbium mine was opened on the Manitou Islands in Lake Nipissing. Molybdenum has been mined near Wilberforce in Haliburton

County and near Griffith in Renfrew County. A small fluorspar mining industry flourished for many years at Madoc. Other deposits of the mineral were opened at Wilberforce. Gold was first discovered in Ontario at Eldorado in Hastings County and numerous small gold mines have operated in Lennox and Addington County. Beryl was mined for a time in Lyndoch Township, Renfrew County. The area has seen a varied development of mines over the past hundred years.

## RECREATION

The forests, streams, and more than 4,000 lakes in this region and the fish, game, and wildlife have made it a summer recreational area for city dwellers. Deer hunting causes a brief flurry of activity in the fall and there is some partridge and duck hunting. In recent years skiing and snowmobiling have created some business in winter and many cottages are used on weekends all year. The winter sports are related to the fairly heavy snowfall (75 inches to 125 inches; 190 cm to 320 cm, mean annual) and persistent snow cover. There are now 19 ski resorts in operation. Another recreational activity flourishing in this region is rock collecting, the Bancroft area in particular being a mecca for rock hounds. In Algonquin Provincial Park, a natural park of 2,910 square miles (7756 km<sup>2</sup>), the streams and lakes are used for canoe routes through wilderness as well as camping. Finally, this region affords a wealth of lovely natural landscapes and it is no accident that Tom Thompson lived here and roamed the hinterland to paint the scenes which caught his eye. Cavalcades of motorists come to see the autumn colours when they are most brilliant and indeed the beauty of lakes, streams, rocks, and forest is one of the attractions at any time of year.

## SUMMARY

This account of the physiography of the region between Georgian Bay and the Ottawa Valley, which is underlain by Precambrian rocks, is comparable to our earlier report (Chapman and Putnam 1966) on the Southern Ontario area underlain by softer, sedimentary rocks of Paleozoic age. The bedrock is broadly arched, the central crown standing about 1,200 feet (370 m) above the borders. On the eastern flank particularly the rocks are broken by some major faults with large horst and graben structures providing distinct topographic irregularities. Locally, the surface is quite rough, erosion by Pleistocene glaciers resulting in rounded knobs and ridges of granite and other rocks with hollows between them, some of which are now occupied by lakes, bogs, or swamps.

In contrast to Southern Ontario the unconsolidated mantle left by the glaciers is generally shallow. However the differences in depth and composition of the drift produce differences in soils and terrain which control land use and the main emphasis of this report is on the description and mapping of these deposits. The map is on a base with a scale 1 inch to 4 miles (1:253,440) and so completes the mapping on this scale for all of Ontario south of North Bay. On the map the till sheets with scattered drumlins, the few end moraines, the eskers, kames, outwash terraces, and the sand plains and clay plains of the extinct lakes are distinguished.

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Areas with very thin drift and numerous rock outcrops are demarcated from areas of deeper till and fewer exposures of bare rock. The story of the deposition of the various Pleistocene deposits is related closely to the recession of the last glacier. This includes the history of the lakes that inundated a broad belt east of Georgian Bay. The history is complicated as it involves successive outlets at various levels and simultaneous tilting of the lake basin caused by isostatic depression and uplift of the earth's crust. Some confusion exists, particularly as to the identity of the outlets, and this account should help to clarify the history of these lake stages and their relationship to features found outside the region.

Only 3 percent of the area is cleared and cultivated, the farmland being on the deep clay, silt, and fine sand deposits of extinct lakes and on deeper, commonly drumlinized tills. Most of the till plains, broken as they are by numerous rock outcrops, are forested as are the eskers, kames, and nearly all the outwash terraces. The correlation between these deposits and the classification of soils for both agriculture and forestry is discussed briefly. The variety of crops is limited by climate in this area resulting in a simple system of farming with beef and hogs as the main products. Agriculture is generally not prosperous but there is here, a latent capacity to produce which may be needed some day. Lumbering constitutes the main industry of the region.

Although there are mines working nepheline syenite deposits and small marble quarries are producing terrazzo chips and building stones this is not a very important mining country. Gravel and sand deposits are usually adequate for local needs but in some areas of shallow drift gravel is scarce. A survey of gravel deposits on all the active railways in the area found only limited prospects. If concrete aggregates are to be obtained in this area for transport by rail to Toronto, it will be by quarrying rock and crushing it, some right to sand sizes.

The lakes, streams, woods, and fish and game make summer recreation important in this region. In recent years the winter sports of skiing and snowmobiling have increased rapidly. In autumn the brilliant colours of the foliage attract cavalcades of tourists and, indeed, the natural beauty of the landscape is worth a trip at any time of year.

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ODM9034

Photo 1—Outwash sand terrace with rock knob in background.



ODM9035

Photo 2—Coarse cobbly outwash in the Ottawa Valley west of Deux Rivières at Klock on Highway 17.



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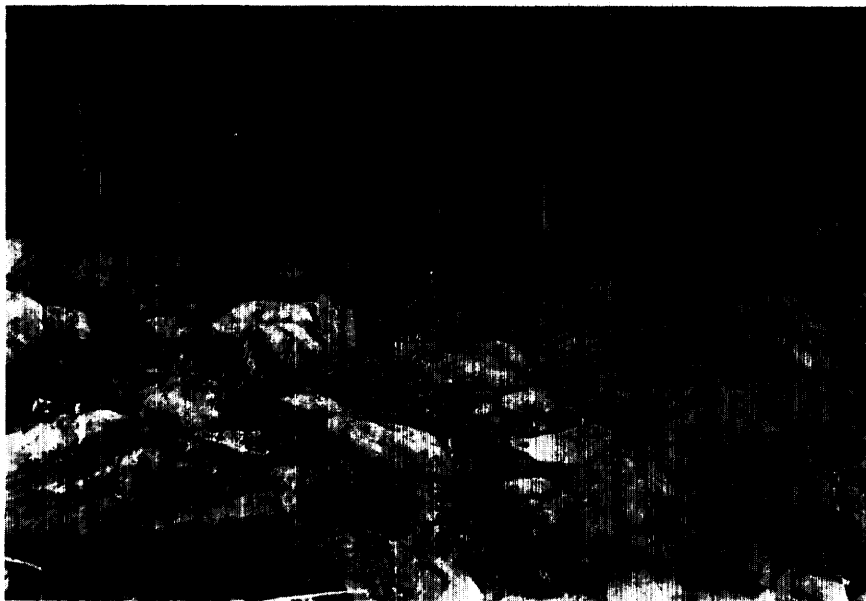
Photo 3—Clay flat and rock ridge in Lake Algonquin Plain.



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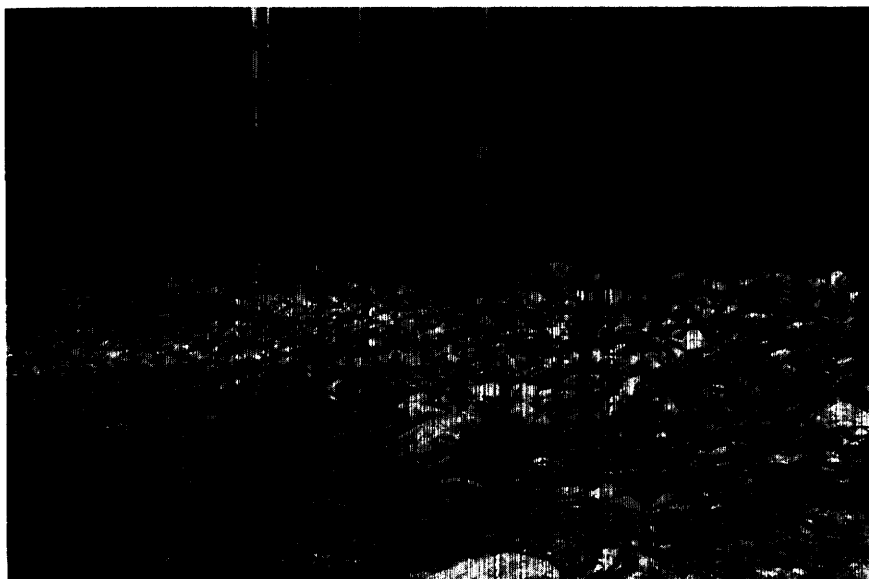
Photo 4—Varved clay, Highway 17 near Rutherglen.

Georgian Bay-Ottawa Valley Area



ODM9038

Photo 5—Boulder pavement in Fossmill Outlet Channel near Achray, Ontario.



ODM9039

Photo 6—Cobbly outwash, Mattawa Valley, Eau Claire, probably related to Early Lake Nipissing discharge.

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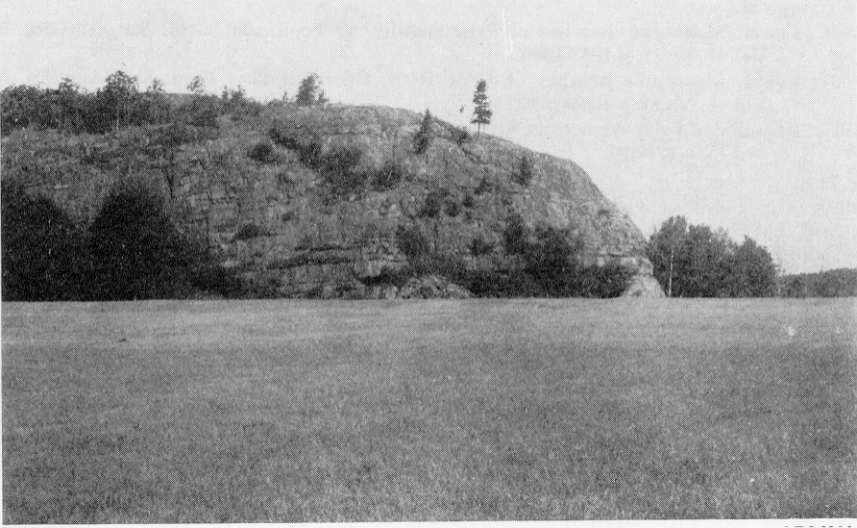
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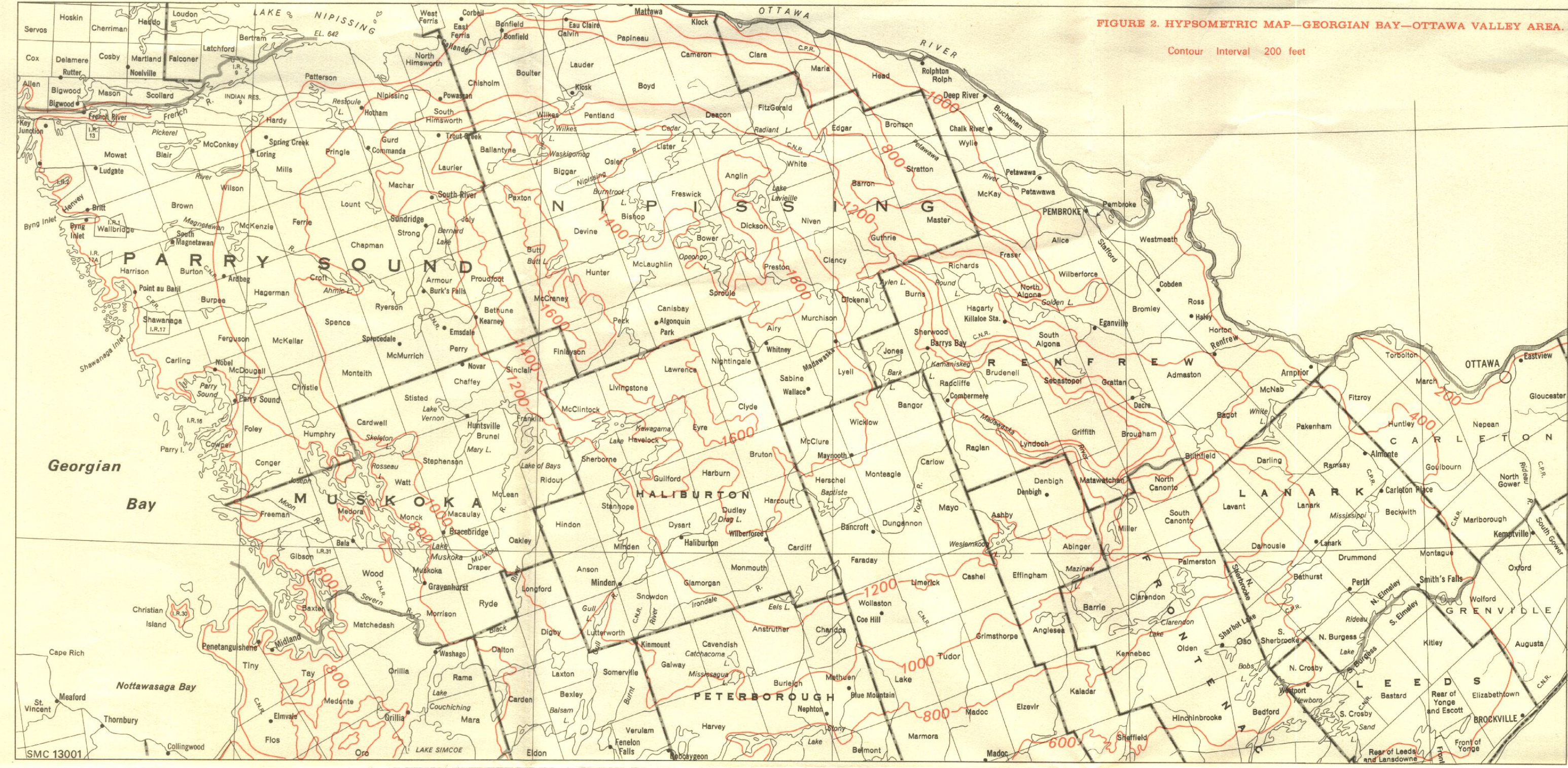


FIGURE 2. HYPOMETRIC MAP—GEORGIAN BAY—OTTAWA VALLEY AREA.  
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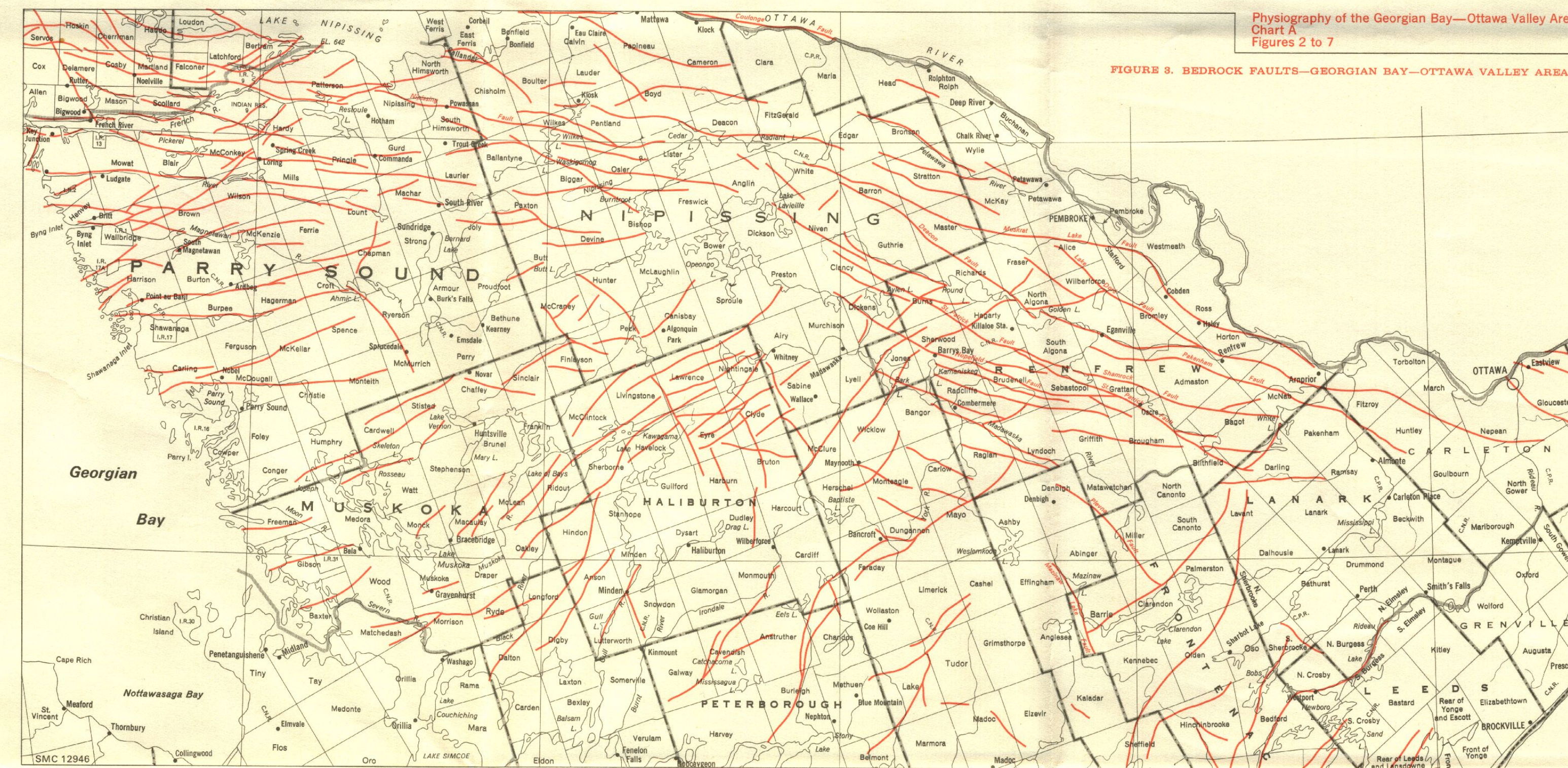


FIGURE 3. BEDROCK FAULTS—GEORGIAN BAY—OTTAWA VALLEY AREA.

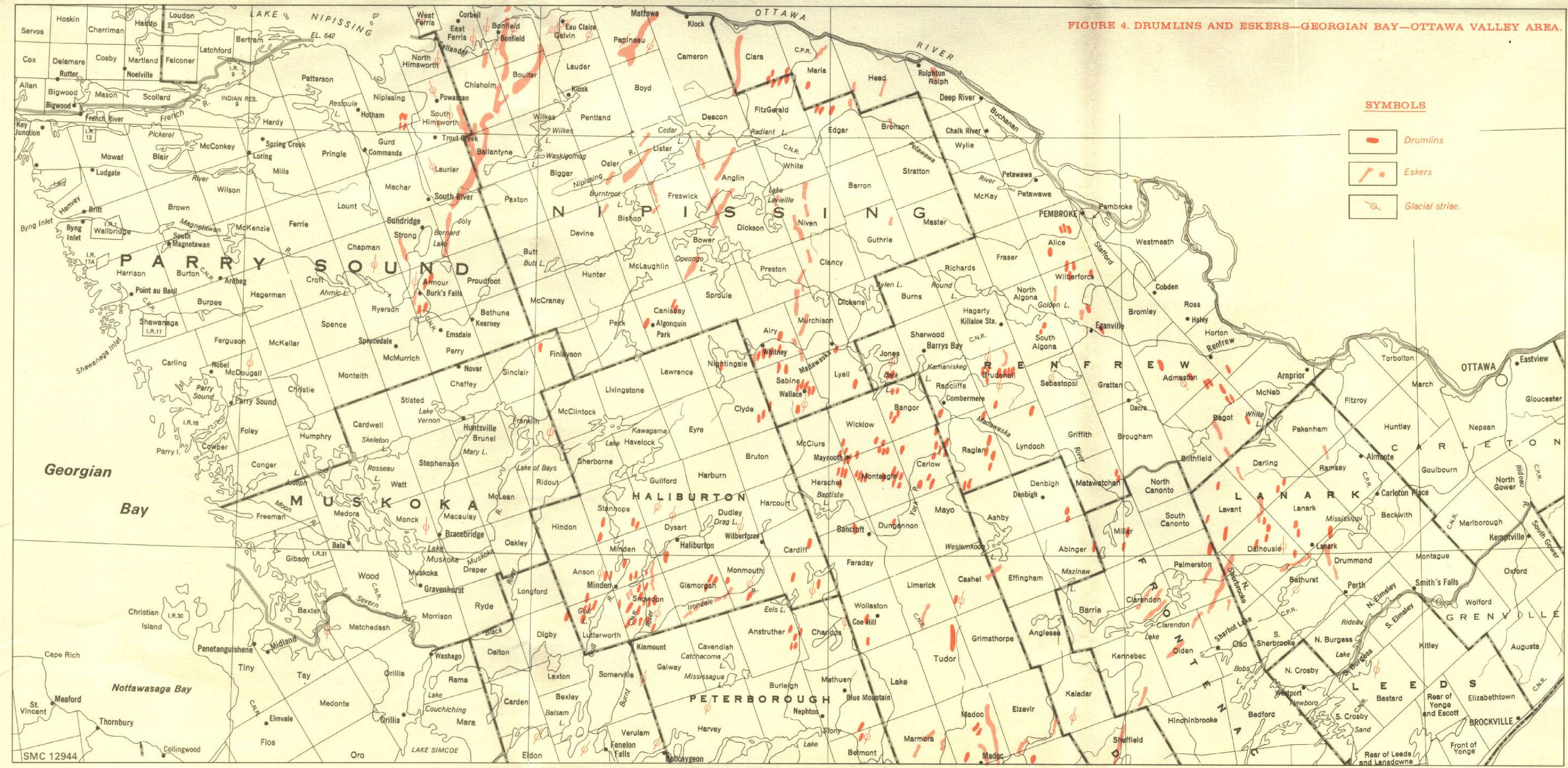


FIGURE 4. DRUMLINS AND ESKERS—GEORGIAN BAY—OTTAWA VALLEY AREA.

**SYMBOLS**

- Drumlins
- Eskers
- Glacial striae

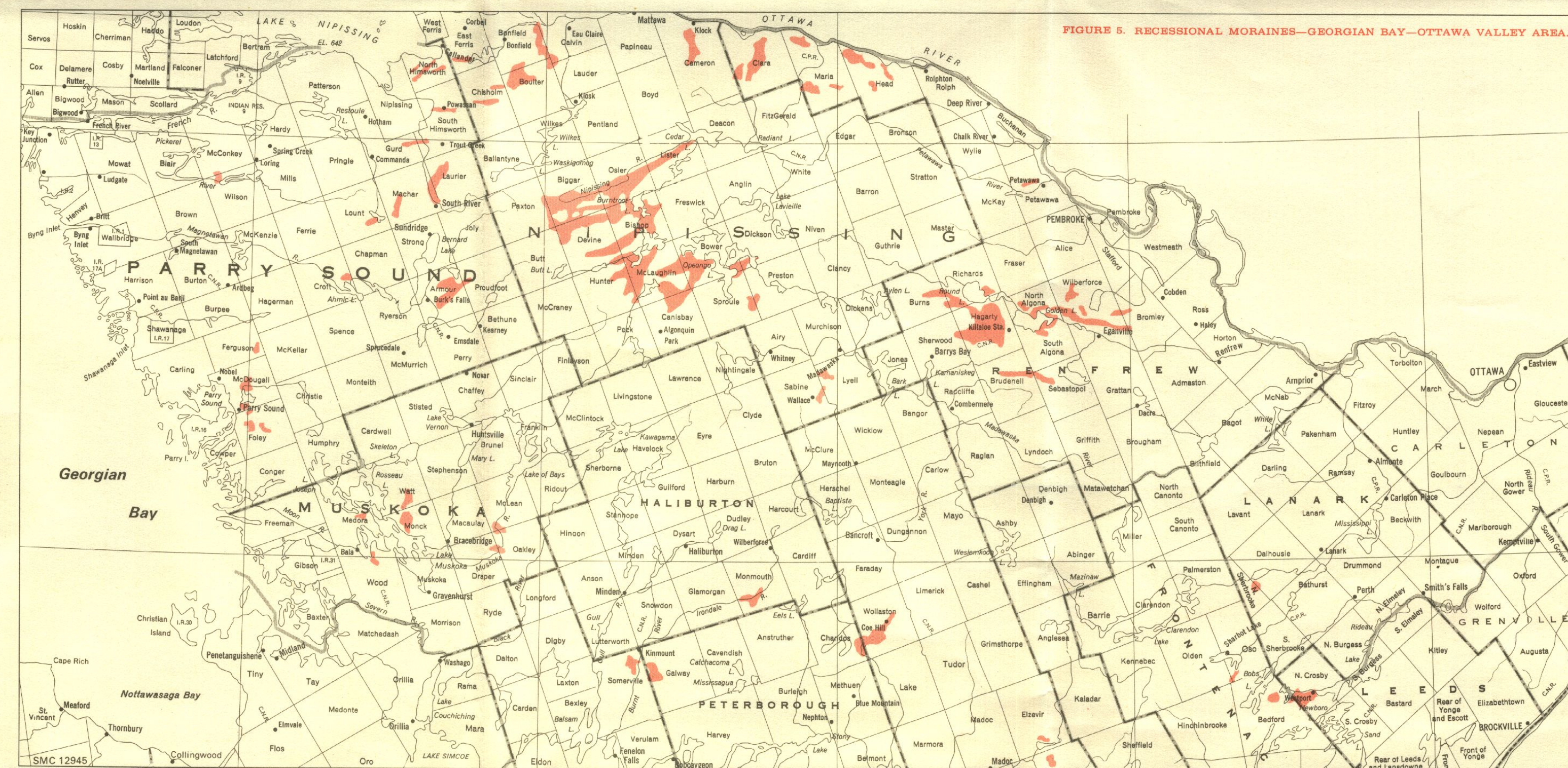


FIGURE 5. RECCSSIONAL MORAINES—GEORGIAN BAY—OTTAWA VALLEY AREA.

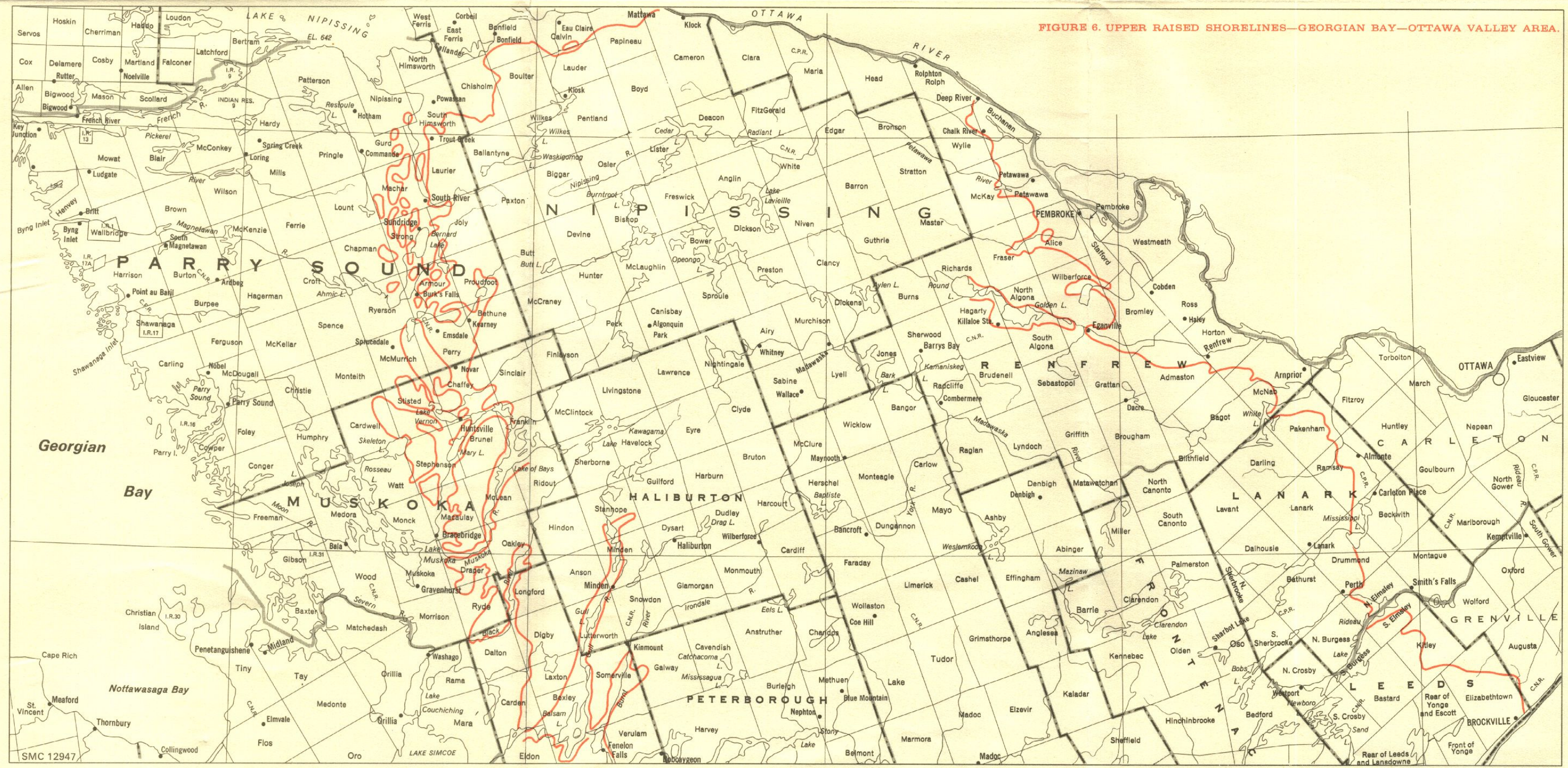


FIGURE 6. UPPER RAISED SHORELINES—GEORGIAN BAY—OTTAWA VALLEY AREA.

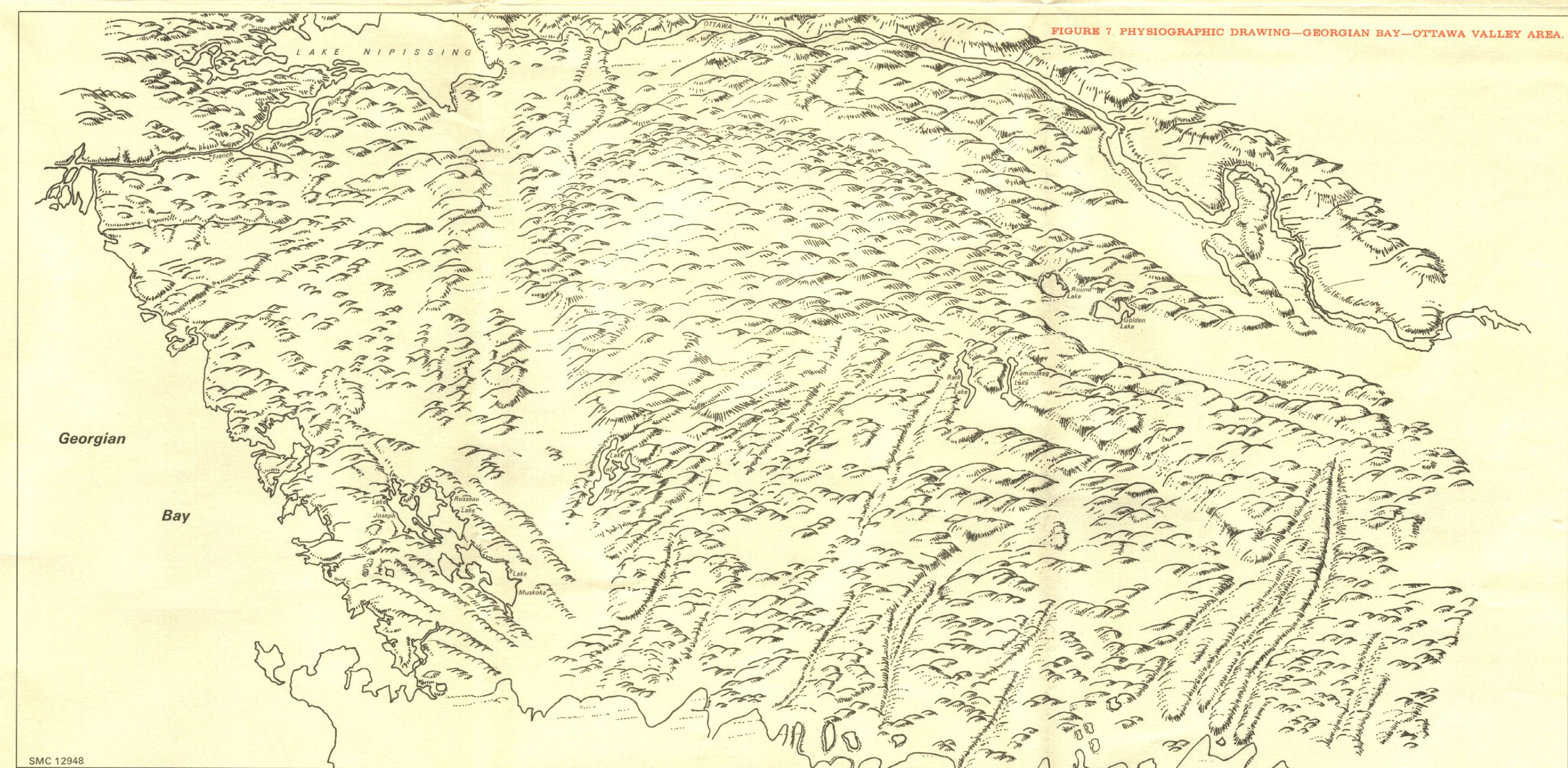
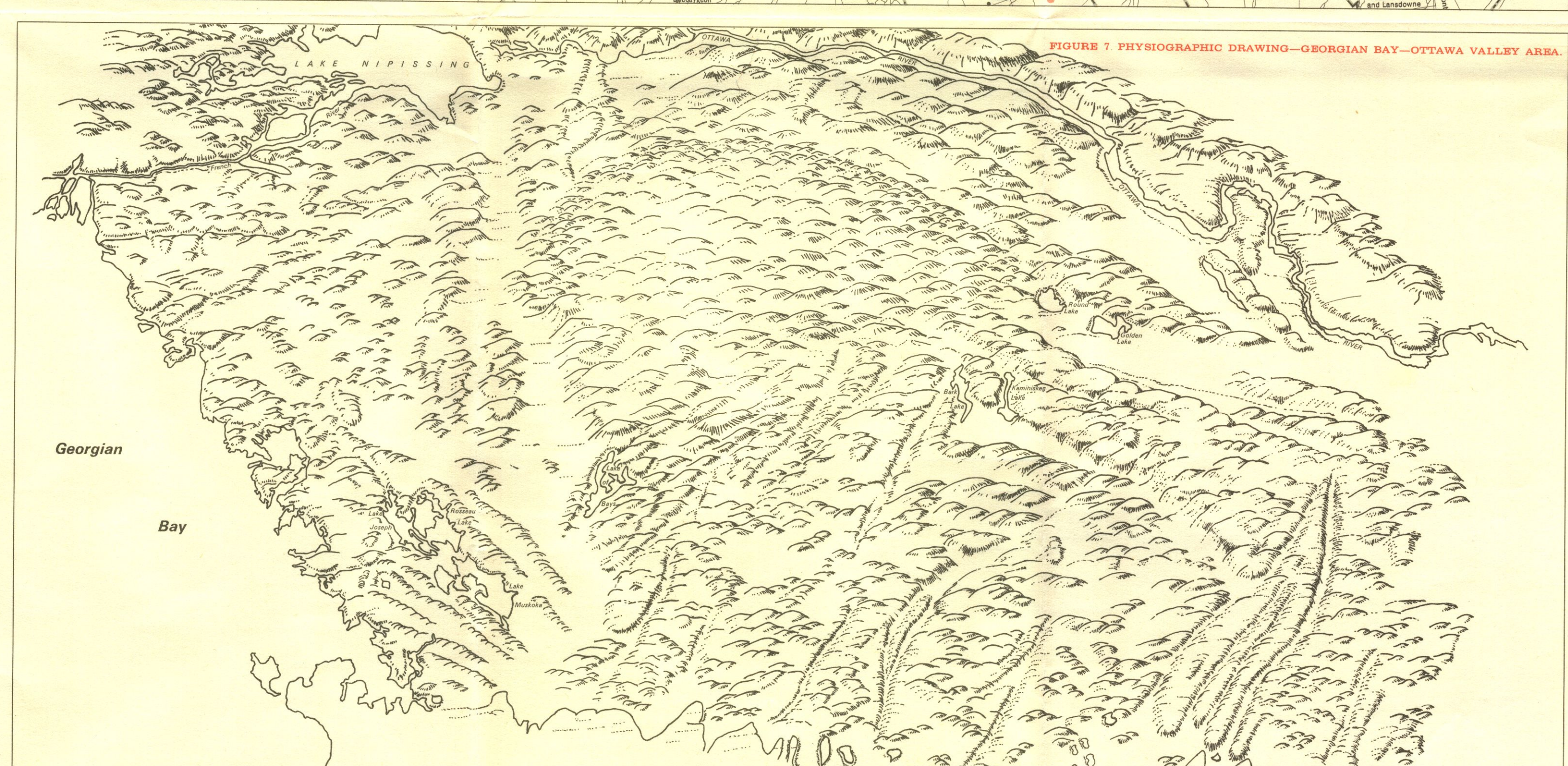
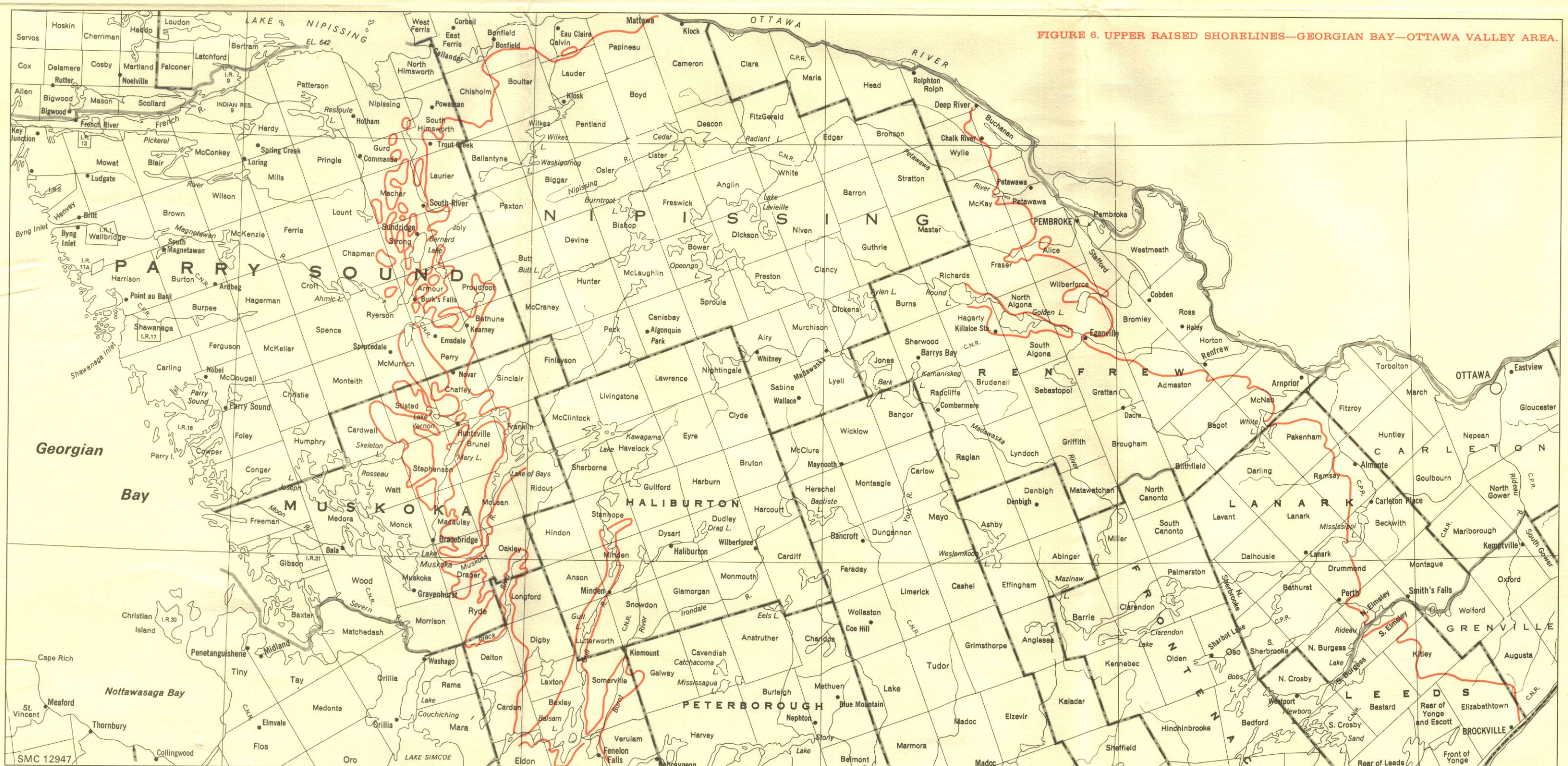
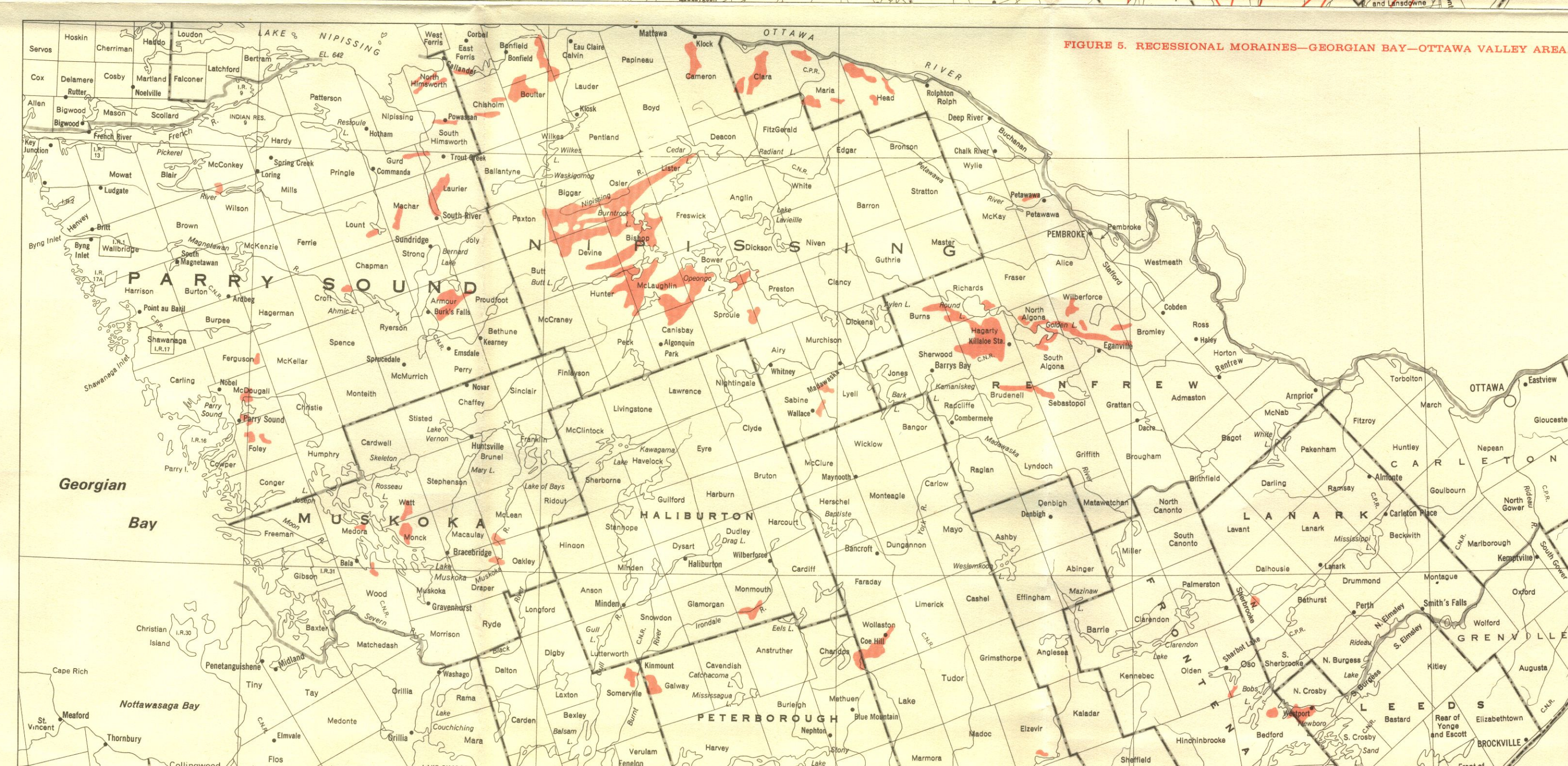
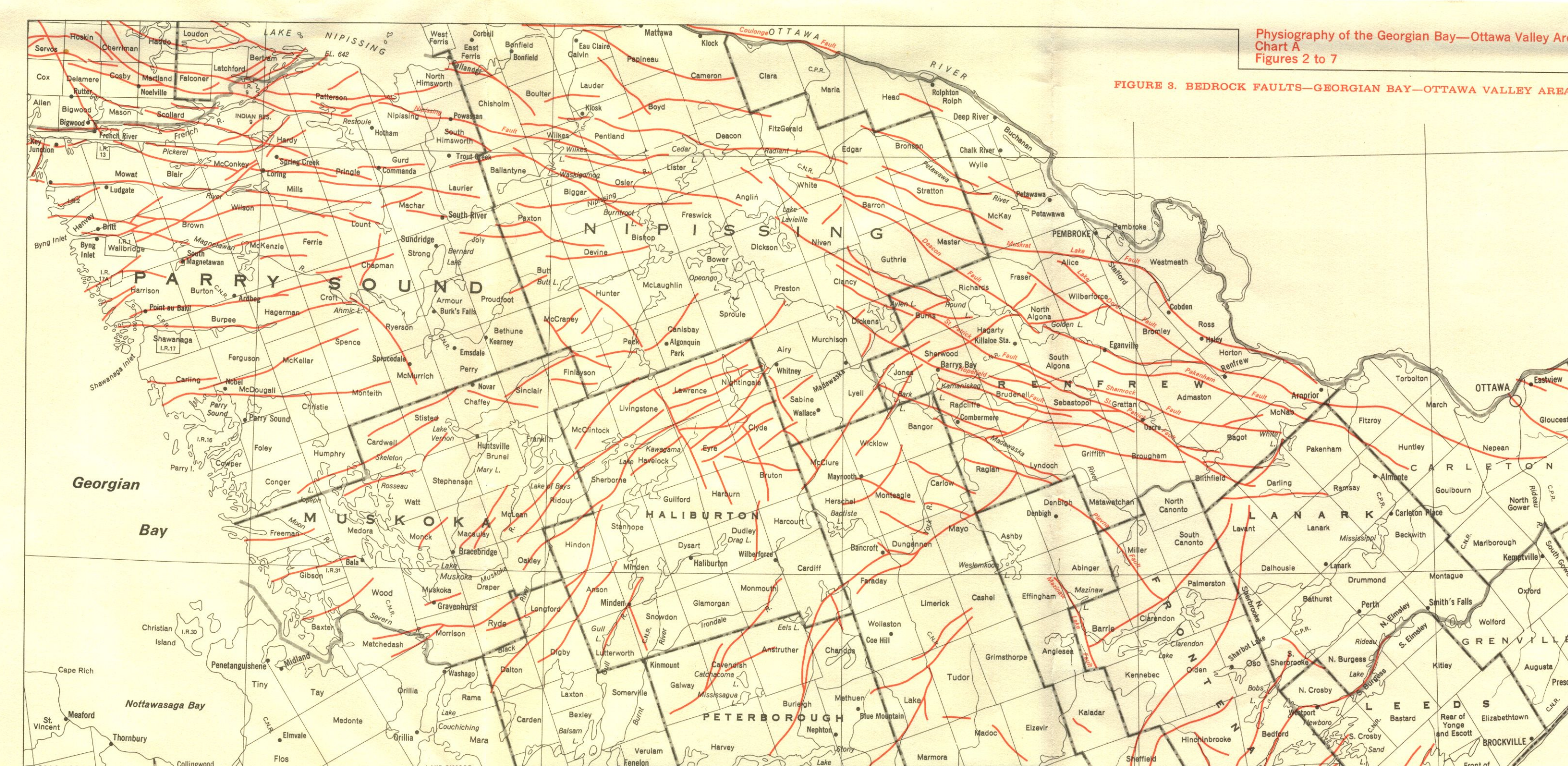
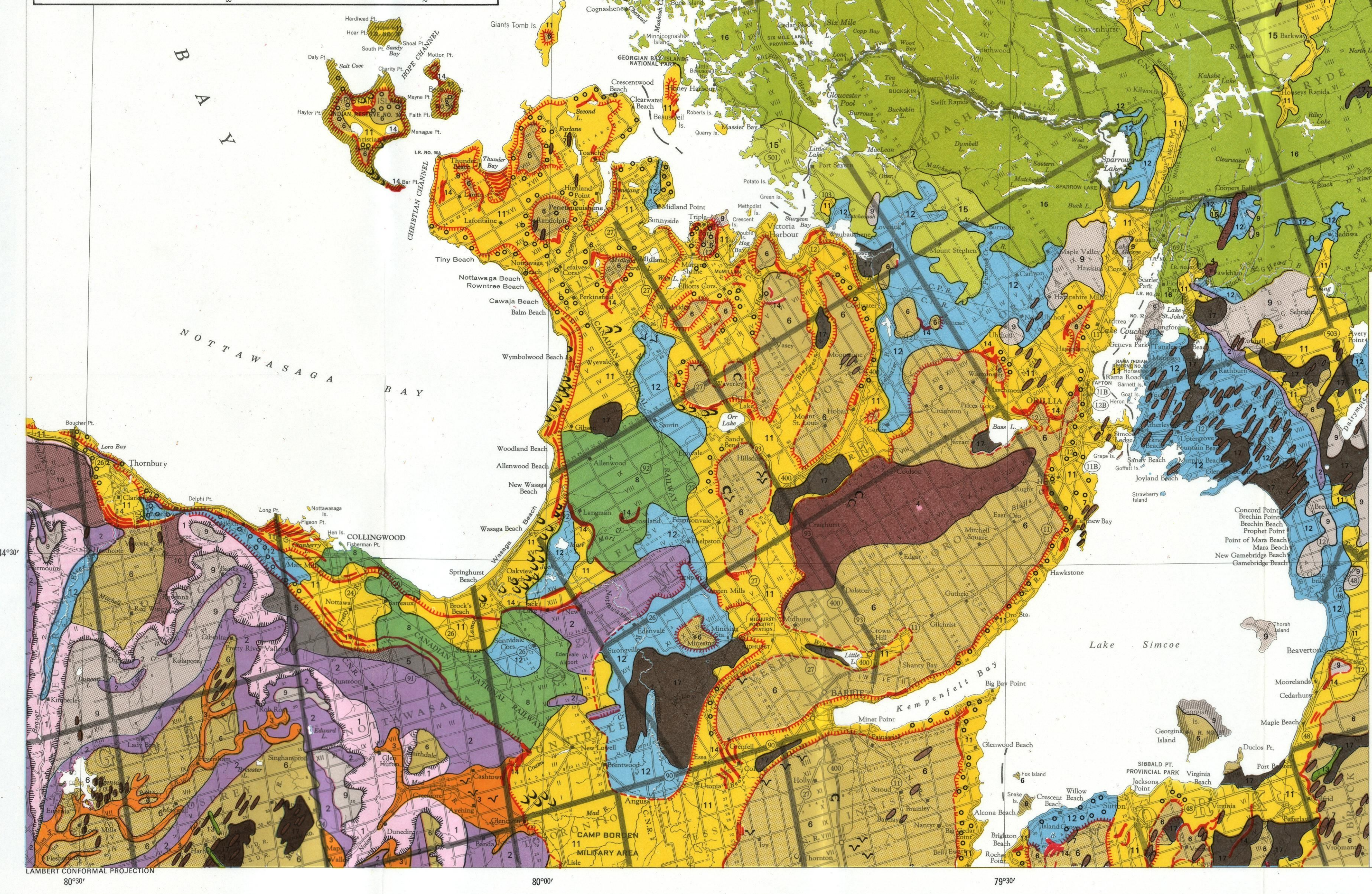
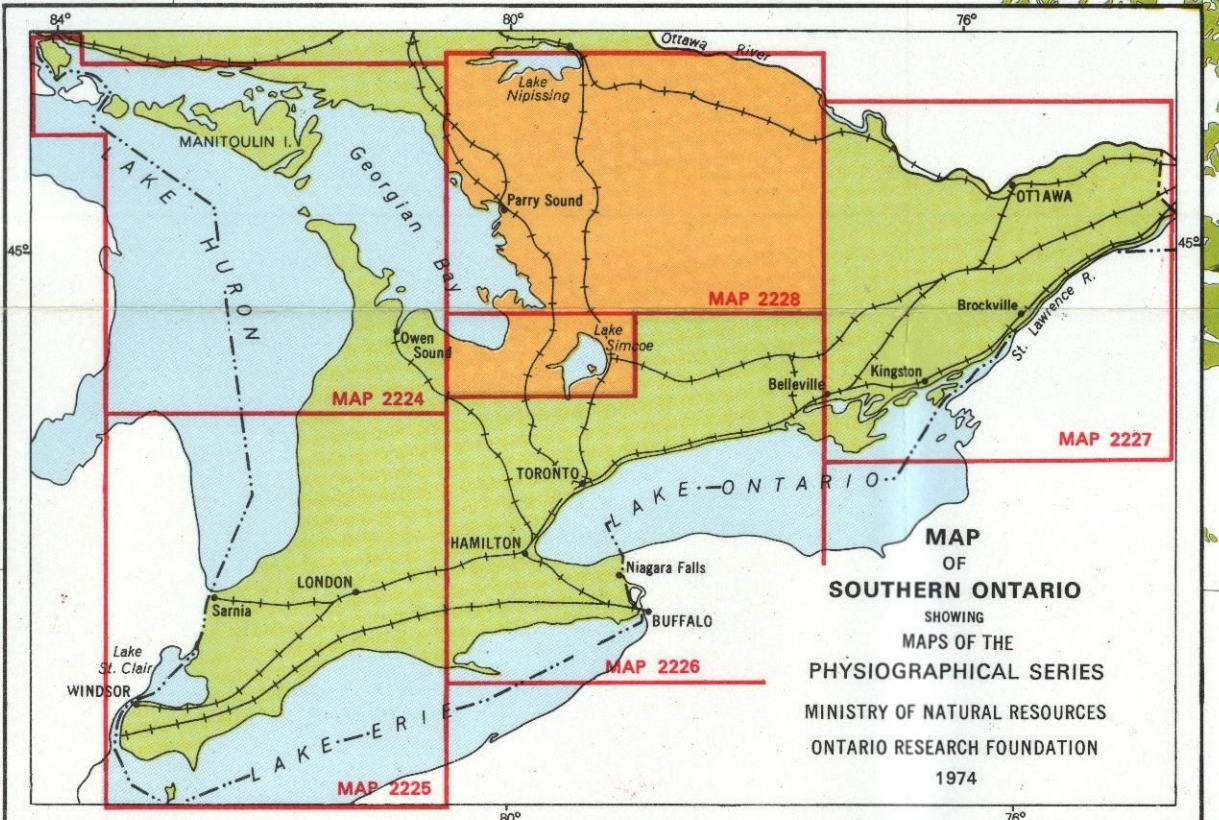
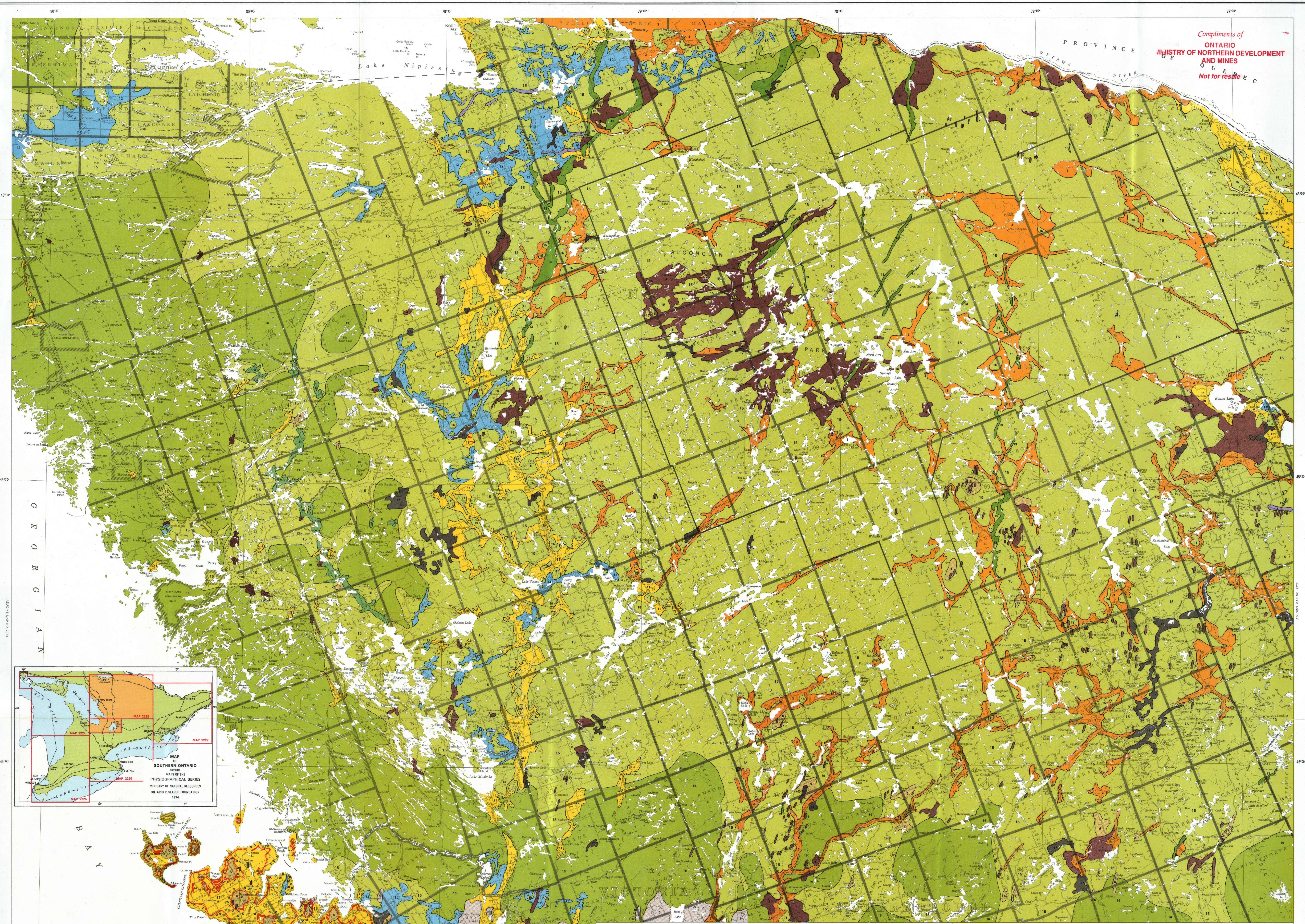


FIGURE 7. PHYSIOGRAPHIC DRAWING—GEORGIAN BAY—OTTAWA VALLEY AREA.



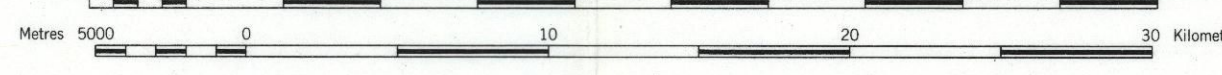
Physiography of the Georgian Bay—Ottawa Valley Area  
Chart A  
Figures 2 to 7

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MINISTRY OF NATURAL RESOURCES  
ONTARIO RESEARCH FOUNDATION  
MAP No. 2228  
PHYSIOGRAPHY  
OF THE  
**GEORGIAN BAY-OTTAWA VALLEY AREA**

To accompany "THE PHYSIOGRAPHY OF GEORGIAN BAY-OTTAWA VALLEY AREA" by J. J. CHAPMAN  
Scale 1:253,440 or 1 inch to 4 Miles



| PHYSIOGRAPHIC               |                        | LEGEND                    |                      | GEOGRAPHIC               |     |
|-----------------------------|------------------------|---------------------------|----------------------|--------------------------|-----|
| 1 ESCARPMENTS               | 7 DRUMLINS             | 12 CLAY PLAINS            | 17 PEAT AND MUCK     | INTERNATIONAL BOUNDARY   | --- |
| 2 TILL MORAINES             | 8 BEVELLED TILL PLAINS | 13 ESHERS                 | SYMBOLS              | INTERPROVINCIAL BOUNDARY | --- |
| 3 SPLAWAYS                  | 9 LIMESTONE PLAINS     | 14 BEACHES AND SHORCLIFFS | 18 BOULDER PAVEMENT  | COUNTY BOUNDARY          | --- |
| 4 KAME MORAINES             | 10 SHALE PLAINS        | 15 SAND DUNES             | 19 SAND DUNES        | TOWNSHIP BOUNDARY        | --- |
| 5 TILL PLAINS (UNDRUMLINED) | 11 SAND PLAINS         | 20 DISSECTED TERRAIN      | 20 DISSECTED TERRAIN | MUNICIPAL BOUNDARY       | --- |
| 6 TILL PLAINS (DRUMLINED)   |                        | 21 MUD FLOW SCARS         | 21 MUD FLOW SCARS    | INDIAN RESERVE           | --- |

Physiography by J.J. Chapman and D.F. Peiman, Ontario Research Foundation.

Cartography prepared by W.A. Barnard, based on maps compiled by Ontario Dept. of Highways.

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