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Ontario Geological Survey

Northern Ontario
Engineering Geology Terrain Study 56

LAC DES MILLE LACS AREA

(NTS 52B/NE)

Districts of Rainy River and Thunder Bay

by

D.G. Mollard and J.D. Mollard

1980

Ontario

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CONTENTS

		Page
1.0	Introduction	1
2.0	Physiography and Geological Setting	2
3.0	Engineering Terrain Units	3
3.1	Bedrock Knob (RN)	4
3.1.1	Description	4
3.1.2	Occurrence	4
3.1.3	Engineering and Planning Significance	4
3.2	Bedrock Plain (RP)	4
3.2.1	Description	4
3.2.2	Occurrence	5
3.2.3	Engineering and Planning Significance	5
3.3	Bedrock Ridge (RR)	5
3.3.1	Description	5
3.3.2	Occurrence	6
3.3.3	Engineering and Planning Significance	6
3.4	End Moraine (ME)	6
3.4.1	Description	6
3.4.2	Occurrence	8
3.4.3	Engineering and Planning Significance	8
3.5	Ground Moraine (MG)	8
3.5.1	Description	8
3.5.2	Occurrence	9
3.5.3	Engineering and Planning Significance	9
3.6	Hummocky Moraine (MH)	10
3.6.1	Description	10
3.6.2	Occurrence	10
3.6.3	Engineering and Planning Significance	10
3.7	Ice-Contact Delta (GD)	11
3.7.1	Description	11
3.7.2	Occurrence	11
3.7.3	Engineering and Planning Significance	11
3.8	Esker (GE)	12
3.8.1	Description	12
3.8.2	Occurrence	12
3.8.3	Engineering and Planning Significance	12

3.9 Kame (GK) 13
3.9.1 Description 13
3.9.2 Occurrence 13
3.9.3 Engineering and Planning Significance 14
3.10 Outwash Plain (GO) 14
3.10.1 Description 14
3.10.2 Occurrence 14
3.10.3 Engineering and Planning Significance 15
3.11 Raised Beach Form (LB) 15
3.11.1 Description 15
3.11.2 Occurrence 16
3.11.3 Engineering and Planning Significance 16
3.12 Glaciolacustrine Plain (LP) 16
3.12.1 Description 16
3.12.2 Occurrence 17
3.12.3 Engineering and Planning Significance 17
3.13 Alluvial Plain (AP) 19
3.13.1 Description 19
3.13.2 Occurrence 19
3.13.3 Engineering and Planning Significance 19
3.14 Organic Terrain (OT) 20
3.14.1 Description 20
3.14.2 Occurrence 20
3.14.3 Engineering and Planning Significance 20
4.0 Appendix: Examples of Terrain Unit Letter Codes 21
4.1 Simple Terrain Unit 21
4.2 Complex Terrain Unit 22
5.0 References 26

FIGURE

1 - Map of the Quetico - Nipigon area showing moraines and orientation of glacial features. 7

MAP
(accompanying report)

Map 5074 (coloured) - Northern Ontario Engineering Geology Terrain Study, Data Base Map, Lac des Mille Lacs (NTS 52B/NE). Scale 1:100 000.

Northern Ontario
Engineering and Geology Terrain Study 56

LAC DES MILLE LACS AREA

(NTS 52B/NE)

Districts of Rainy River and Thunder Bay

by

D.G. Mollard[1] and J.D. Mollard[2]

1.0 INTRODUCTION:

This report contains an inventory of regional engineering terrain conditions in the Lac des Mille Lacs map-area, Districts of Rainy River and Thunder Bay. The area, which covers NTS block 52B/NE, lies between Latitudes 48°30'N and 49°00'N and Longitudes 90°00'W and 91°00'W. The report forms part of a series of publications that provide similar terrain data for some 370 000 km^2 of northern Ontario.

The purpose of the inventory is to assist regional engineering and resource planning studies at a level of detail consistent with a scale of 1:100 000. The terrain information is contained on the Data Base Map (OGS Map 5074, accompanying this report).

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Interpretation of black and white aerial photographs, at a scale of approximately 1:50 000, formed the basis of the terrain mapping process. The interpretation was checked against published and unpublished maps and reports which documented previous field visits and observations. During the fall of 1978, roads in the map-area were traversed and observed terrain conditions recorded as further verification of the office studies. Thus, the Data Base Map represents a reconnaissance overview of the engineering conditions of the terrain.

An engineering terrain legend was developed to facilitate the mapping and to provide a common information base for the entire map series. This legend is shown on the accompanying Data Base Map. Further discussion on the mapping techniques, legend format, and possible uses of this engineering geology information is available in the Ontario Engineering Geology Terrain Study Users' Manual (Gartner, Mollard, and Roed 1980), a companion publication to this series of maps and reports.

2.0 PHYSIOGRAPHY AND GEOLOGICAL SETTING:

Maximum local relief in the Lac des Mille Lacs map-area is 90 m; however, much of the area has local relief of less than 60 m. The relief is greatest in the south half of the area, particularly around the Shebandowan Lakes, Greenwater Lake, Burchell Lake, and Windigoostigwan Lake. Athelstane Lake, Lac des Mille Lacs, and Bedivere Lake are large lakes in the north half of the map-area, where relief is generally much less than in the south.

The glacial overburden is thicker in the eastern part of the map-area. Thick drift also occurs near Greenwater Lake in the south-central part, where till in hummocky moraine and sand and gravel in glaciofluvial landforms have been mapped. A few narrow end moraine ridges occur, and glaciofluvial deposits are widely spaced. Landforms composed of surface and near-surface bedrock are the most common terrain types.

Two east-trending belts of metavolcanics, metasediments, and minor mafic to ultramafic intrusive rocks occur in the map-area. The larger of these occupies most of the southern third of the area, while the other cuts through the central part, south of Lac des Mille Lacs. The remainder of the area is underlain by felsic igneous and metamorphic rocks (granites, gneisses, and allied lithologies).

3.0 ENGINEERING TERRAIN UNITS:

The engineering terrain units mapped are identified in terms of four components: surface material, landform, topography, and drainage. Format of the legend used in the terrain mapping is described in detail in the Users' Manual (Gartner, Mollard, and Roed 1980). Landform is a very important component because surface and near-surface materials, topographic expression, and the surface and internal drainage conditions are all related to it. Consequently, the engineering terrain units are grouped, for descriptive purposes, according to the dominant landform.

A particular landform can occur as the only component in a simple terrain unit, or as a dominant or subordinate component in a complex terrain unit. The dominant landform usually occupies more than half of a complex terrain unit. Where only one subordinate landform is shown, it usually occupies between 10 and 50 percent of the complex unit. Where two subordinate landforms are shown, the first covers the larger area. Landforms that occupy less than 10 percent of the terrain in a complex unit are rarely indicated in the terrain unit letter code. Where two or three landforms in a complex terrain unit consist of the same material, the landform letter symbols are connected by a dash. Examples of terrain unit letter codes which may occur in this map-area, and an explanation of each, are given in the Appendix.

A large number of complex terrain units has been mapped due to the widespread occurrence of irregular topography. Bedrock, which is situated at or near the ground surface throughout much of the map-area, controls the topography and therefore the surface drainage conditions. Resource development and engineering planning considerations are complicated by these complex conditions.

Noteworthy occurrences of important landforms are described with respect to location, typical materials, topography, and drainage; their significance in geotechnical investigations, regional engineering planning, and resource development is summarized.

3.1 BEDROCK KNOB (RN):

3.1.1 Description:

Bedrock knob landscape (RN) is characterized by an irregular bedrock surface having complex multiple slopes of varying steepness. The cover of glacial deposits overlying the bedrock knobs is generally thin and discontinuous. Much of the glacial overburden consists of bouldery, sand-rich till that was transported only a short distance by the ice.

3.1.2 Occurrence:

Occurrences of knobby bedrock (RN) are less common in the Lac des Mille Lacs area than in neighboring map-areas. Rock knobs are the dominant bedrock landform throughout the southeastern part and most of the western third. In these areas, an irregular bedrock surface is commonly covered by a thin mantle of bouldery till. Bedrock knob terrain is underlain mainly by felsic igneous and metamorphic rocks (granites, gneisses, and allied lithologies).

3.1.3 Engineering and Planning Significance:

Two principal engineering considerations are the large volumes of rock that must be excavated during construction and the generally uniform and solid foundation conditions at shallow depths. However, due to difficult topography and the existence of rock fractures, bedrock knob terrain is considered poor for most types of light construction and for waste disposal. Drilling and blasting are required during the construction of almost all types of engineering works.

3.2 BEDROCK PLAIN (RP):

3.2.1 Description:

The bedrock plain unit (RP) has a low-lying, undulating to rolling surface. The bedrock is generally mantled by a thin and variable cover of glacial

material, consisting mainly of boulder-rich sandy till. The rock plains display considerable local variation. They may consist of bare bedrock or may be covered by till or fine-grained water-laid deposits.

3.2.2 Occurrence:

Bedrock plains (RP) occur only in a few isolated areas, specifically around Tilly Lake in the western part of the area and in the southeast corner of the area. In the latter instance, the bedrock surface is covered by a discontinuous mantle of bouldery till.

3.2.3 Engineering and Planning Significance:

Engineering and construction problems relate mainly to the cost of bedrock excavation. Foundation materials are strong, have a low compressibility, and a permeability that is controlled almost entirely by rock fractures. Bedrock plains are poor construction and waste disposal sites, but are still considered better than areas mapped as bedrock plateau (RL), bedrock knob (RN), or bedrock ridge (RR). Drainage courses tend to follow eroded zones of weakness in the underlying bedrock. Many of these depressions occupy preglacial channels that were enlarged by glacial erosion. A large proportion of the ground water in this landform is confined to fractures in the upper 45 to 60 m of bedrock. Permeability varies from impervious to highly pervious, depending on the spacing, depth, and width of fissures in the bedrock. Rock materials have high compressive, shearing, and bearing strengths. Position of the water table varies with topography, being closer to the surface beneath depressions. By careful route selection and proper design of vertical alignment, rock cuts on lower class roads can be avoided or at least the volume of rock to be blasted can be minimized. This is possible because of the low relief surfaces of the bedrock plains.

3.3 BEDROCK RIDGE (RR):

3.3.1 Description:

The bedrock ridge unit (RR) consists of long, narrow, subparallel and intersecting bedrock ridges of varying height. Thickness of drift over the

masked bedrock surface varies substantially over short distances. In general, it is relatively thin (1 to 2 m) on ridge tops and thicker on the lower slopes and in the depressions between rock ridges.

3.3.2 Occurrence:

Small areas of rock ridges (RR) are located west and south of Burchell Lake in the southwestern part of the map-area and northeast of Greenwater Lake in the southeast-central part. Rock ridges have generally formed on volcanic rock types. Ridge crests are probably bare bedrock. Where rock ridges are the dominant landform, they can occur alone (RR) or with subordinate amounts of rock knobs (RR(RN)). Isolated pockets of organic material can occur between rock ridges (RR(OT)).

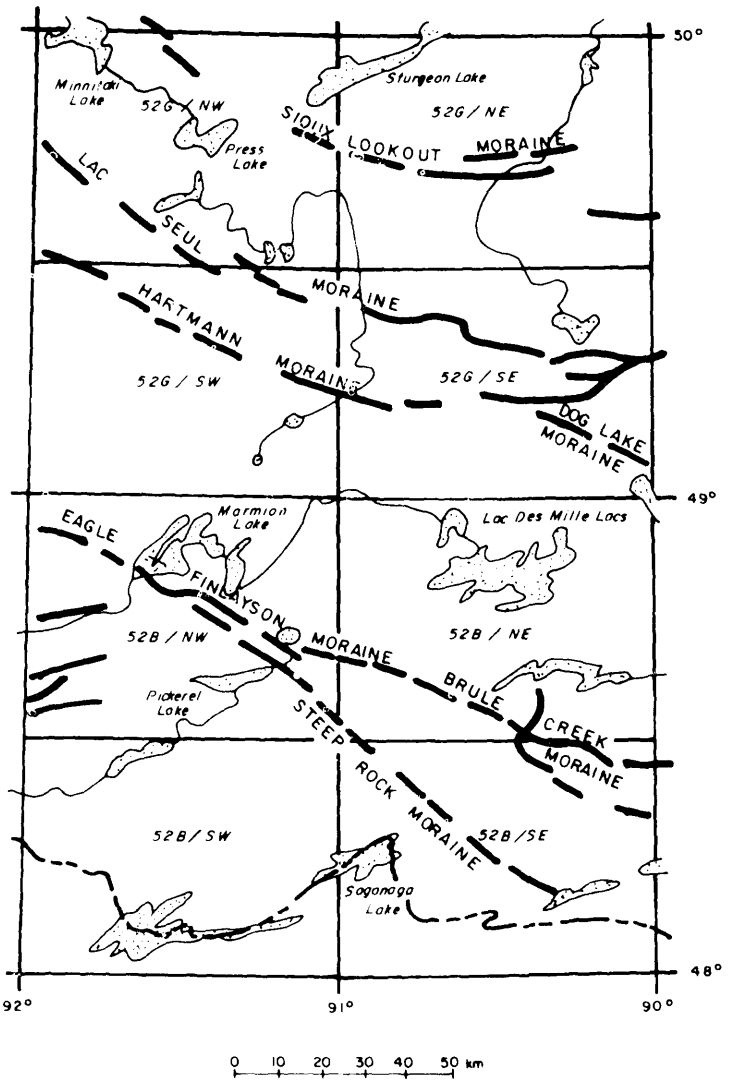
3.3.3 Engineering and Planning Significance:

The main construction problem is the large quantities of very hard rock that often must be excavated during construction. Drilling and blasting costs can be very high. Bedrock ridge terrain is considered poor for most types of engineering, construction, and resource development. It also has a low rating for waste disposal due to irregular relief, the presence of rock fractures near the ground surface, and the high cost of earthwork construction.

3.4 END MORAINE (ME):

3.4.1 Description:

End moraine (ME), which forms either prominent or inconspicuous till ridges, was deposited along the margin of the glacier. Although the ridges are usually lone and narrow, they can be hummocky in places. End moraine consists largely of ice-deposited till and boulders, with minor inclusions of water-laid silt, sand, and gravel. Segments of end moraine, composed mainly of till, occur with hummocky moraine (MH), kames (GK), and ice-contact deltas (GD) and in large moraine complexes which are identified by name in Figure 1. The bedrock surface is nearly always buried in areas of end moraine; there are exceptions, however, and in a few places end moraine ridges have a core of solid rock.



NOTE: Moraine segments shown in the figure do not necessarily all occur on the Data Base Map accompanying this report.

FIGURE 1 - MAP SHOWING MAJOR MORAINES IN NTS 52B AND 52G (MODIFIED FROM ZOLTAI 1965, FIGURE 3)

3.4.2 Occurrence:

Large segments of the Brule Creek Moraine occur between Greenwater Lake and the Shebandowan Lakes in the southeastern part of the map-area (Figure 1). Elevations of 500 to 520 m are common along these end moraine segments. Smaller end moraines occur south of Greenwater Lake near the southern margin of the area. An end moraine on the east shore of Greenwater Lake probably has a core of bedrock in places.

Other end moraines are situated in the southwest-central part of Lac des Mille Lacs map-area, south of Crayfish Lake and south of the settlement of Huronian. An end moraine ridge has been mapped along the south shore of Athelstane Lake, in the east-central part of the map-area. This ridge is approximately 18 km long and occurs in association with knobby stratified deposits (ME(GK)).

3.4.3 Engineering and Planning Significance:

An important characteristic of end moraines is their variability. Layers of unsorted and unstratified material of varying sizes can both underlie and overlie sequences of layered silt, sand, and gravel. In general, the boulder content of this landform is high. End moraines in the map-area commonly exhibit variable permeability and internal drainage, low compressibility, and high bearing strength. The water table is low in end moraine ridges. Where the unit consists of till that is high in sand- and gravel-sized material, and where sources of stratified sand and gravel are scarce, the coarse till may sometimes be crushed and used as a source of road-surfacing material. End moraines may present excavation dificulties during the building of roads and structures due to the abundance of small and large boulders.

3.5 GROUND MORAINE (MG):

3.5.1 Description:

The term ground moraine (MG) refers to an extensive deposit of till forming an undulating to rolling plain. Although till is generally composed of an assortment of particle sizes (including clay, silt, sand, gravel, cobbles, and boulders), till deposits in this map-area have a high sand and boulder

content. The thickness of till in ground moraine varies from less than 1 m to many tens of metres. The landform is mapped as MG where the till is thick enough to mask the topographic effect of underlying bedrock. In general the till layer forms a mantle less than 3 m thick over the bedrock and is mapped as MG/R. Till in ground moraine tends to be thicker in bedrock depressions and thinner over bedrock ridges and knobs.

3.5.2 Occurrence:

Ground moraine (MG) deposits are common in the Lac des Mille Lacs map-area. The thickness of till overlying the bedrock increases across the map-area toward the northeast. Most ground moraine, however, forms only a thin veneer over the bedrock. Such a situation is widespread across the northern part of the area and in the southeastern part. The unit (MG/R) is commonly found in association with such subordinate landforms as rock knobs (RN), glaciolacustrine plains (LP), and organic terrain (OT). Ground moraine occurs extensively in the western half of the map-area as the subordinate landform in the complex terrain unit RN(MG/R). The relief on ground moraine units in this vicinity is generally undulating and is less irregular than in the southern part of the map-area due to a greater thickness of till.

3.5.3 Engineering and Planning Significance:

The till in ground moraine is coarse and bouldery, and has moderate permeability and internal drainage, low compressibility, and high bearing strength. Water table position varies with relief, being lower beneath knolls and low ridges and higher beneath depressions. The till in many of the depressions is covered by thin deposits of peat and muck.

The suitability of ground moraine for road and other light foundation construction is fair to good. The fact that the till often forms only a thin mantle over the bedrock (MG/R) has a great deal of significance in road building. Road construction through this type of terrain is difficult owing to the bouldery nature of the till and the probability of encountering bedrock in cuts. The suitability of ground moraine for waste disposal varies from poor to fair.

3.6 HUMMOCKY MORAINE (MH):

3.6.1 Description:

Although some hummocky moraine deposits formed along an active ice front, most of the sediments which make up this landform accumulated on the surface of stagnant glacial ice. In time, the buried ice melted and deposited a layer of unsorted till and, in places, washed glacial debris. Most hummocky moraine consists of steep-sided knobs and short ridges separated by undulating to flat areas and swampy kettle hole basins. Soil materials in hummocky moraine include till, usually as the dominant constituent, and subordinate amounts of stratified silt, sand, and gravel in pockets or lenses. Hummocky moraine can be very bouldery. Scattered kames (GK) are a common subordinate landform.

3.6.2 Occurrence:

Areas of hummocky moraine (MH) are commonly located on the north side of major moraine complexes (Figure 1). A large expanse of this landform occurs southeast of Lac des Mille Lacs in the central part of the map-area. Other smaller occurrences are located south and southeast of Athelstane Lake in the east-central part of the area, east of the settlement of Huronian in the west-central part, and south and northeast of Greenwater Lake in the southern part. Hummocky moraine commonly occurs in association with kames (MH(GK)).

3.6.3 Engineering and Planning Significance:

Engineering considerations include the large quantities of material that may have to be excavated during construction, a high content of boulders, and rapid changes in the nature of the materials. Pockets of sand and gravel constitute small sources of construction material of variable quality.

Although variable, most areas of hummocky moraine have moderate permeability and internal drainage, low compressibility, high bearing strength, and low shrink-and-swell potential. In depressions, the till deposits are commonly covered by thin, water-laid silt and clay, which in turn are overlain by peat and muck deposits. Hummocky moraine is considered fair to poor for general construction purposes and for waste disposal.

3.7 ICE-CONTACT DELTA (GD):

3.7.1 Description:

Esker deltas, kame deltas, and delta moraines are all varieties of the ice-contact delta. Some of them are quite large in area and important in terms of the volume of recoverable sand and gravel which they contain. Individual beds, consisting mainly of sand or gravel, are usually better sorted, cleaner, and less variable than stratified deposits in esker (GE) and kame (GK) landforms. The beds in this unit are also typically less folded and faulted and are more continuous. It is worth noting that materials in many ice-contact deltas are coarse (*i.e.* gravelly) on the north and northeast sides and finer (*i.e.* sandy) on the south and southwest sides. These conditions indicate the parts of the delta which were, respectively, closest to and farthest from the glacial front against which the delta was built.

3.7.2 Occurrence:

The most conspicuous ice-contact delta (GD) in the map-area is located south and west of Greenwater Lake. Here, sand and gravel were deposited in glacial lake waters that reached elevations of 470 to 490 m. These deposits, which are sometimes associated with end moraine (ME), extend from the eastern shore of Greenwater Lake as far west as Burchell Lake. Small glaciofluvial deltas, whose surfaces are at elevations of 470 to 490 m, occur south of Crayfish Lake in Ames Township and west of Athelstane Lake in the central part of the map-area.

3.7.3 Engineering and Planning Significance:

Ice-contact deltas are good potential sources of concrete and blacktop aggregate. They are also favorable sites for the construction of airstrips, roads, and other types of engineering works. Because the subsoils are highly permeable, deltaic landforms are relatively poor areas for waste disposal. Larger deposits, however, are generally good ground water prospects, especially where sand and gravel horizons are thick and extend below the water table. Ice-contact deltas possess high bearing strength and good workability in wet weather. Slopes are stable and subsoils are well drained. Away from the steeply sloping margins of this landform,

earthwork volumes and excavation costs are normally low. Reservoirs and sewage lagoons in ice-contact deltas must be lined to prevent excessive leakage.

3.8 ESKER (GE):

3.8.1 Description:

The ridged landform represented by the esker symbol (GE, >>>) also includes crevasse fillings. Both occur as long, narrow, sand and gravel ridges that can be winding or straight and may widen in places. Some of these elongate ice-contact stratified drift ridges include braided, branching, beaded, and kettled segments. Most of the ridges trend roughly parallel to the last direction of glacial flow. The cores of many eskers and crevasse fillings contain complexly layered units, consisting of sandy gravel and gravelly sand, that exhibit collapse structures (*i.e.* folds, faults, and pinch-outs of strata). Some silt and fine sand units (water-laid), boulders, and till pockets may occur within the central parts of eskers and crevasse fillings, as well as along their flanks.

3.8.2 Occurrence:

Most of the eskers in the Lac des Mille Lacs map-area occur in association with other glaciofluvial landforms, such as outwash plains and kames. Eskers form part of two outwash-esker-kame complexes in the central part of the map-area, while an esker is associated with an outwash deposit west of Edar Lake in the western part of the area. Eskers occur in other terrain units throughout the map-area, but are generally of minor significance and have little effect on the engineering conditions or resource potential of the unit in which they are found.

3.8.3 Engineering and Planning Significance:

Eskers and crevasse fillings are relatively small and isolated landforms in this map-area, and are generally inferior to ice-contact delta and glacial outwash deposits as sources of good quality granular construction materials.

Typically, the unit possesses high permeability and good internal drainage, low compressibility, high bearing strength, low frost susceptibility, and low shrink-and-swell potential. Where esker ridges are steep-sided, narrow, and winding, they may be unsuitable for use as transportation routes. They may trend in the wrong direction for route location purposes, but in regions that are dominated by large expanses of swamp and bedrock, eskers are frequently considered as good route location possibilities. Where the sand and gravel in large eskers extends many metres below the water table, the unit represents a potential source of ground water for domestic and, possibly, municipal and industrial use.

3.9 KAME (GK):

3.9.1 Description:

Kames occur either as steep-sided single knobs or as clusters of several knobs in kame fields and kame moraine. The larger, steep-sided kames usually have an irregular surface; in a few places, they contain deep kettle hole depressions. Most are composed of complexly interbedded sand and gravel strata which regularly exhibit fold, fault, and pinch-out structures. Kames also contain variable but usually minor amounts of silt, till, and boulders. Large kame deltas are discussed in Section 3.7; kame terraces are rare.

3.9.2 Occurrence:

Kames (GK), which are common in the Lac des Mille Lacs map-area, are usually found in association with hummocky moraine (GK(MH)), outwash (GO(GK), GO-GK), and eskers (GK-GE). In this area, many of the kames have a bouldery surface, similar to that of hummocky moraine. The complexly layered materials in kames can be highly variable and include isolated pockets of silt, till, and boulders, as well as clean strata of sand and gravel. Kames are common on the north side of prominent end moraines. The symbol (GK) designates individual kames as well as large clusters of kames in kame moraine. Individual kames and kame fields may occur as part of a major moraine complex (Figure 1) or may be located far beyond its boundaries. Kames occur in the central part of the map-area as part of several outwash-esker-kame complexes (GO-GK, GK-GE, GO).

3.9.3 Engineering and Planning Significance:

In general, kames have high permeability and good internal drainage, low compressibility, high shear strength, and good bearing capacity. Position of the water table varies with relief, being nearer the surface beneath kettle depressions and deeper beneath ridges and knobs. Although the granular materials in kames provide good foundations for buildings and small engineering works, the quantities of material that must be excavated during construction can be moderately high. Waste disposal sites require special design procedures and costly construction in order to function properly. Kames should be avoided as waste disposal sites. They vary from poor to good as sources of sand and gravel aggregate, depending upon their size and compositional variability.

3.10 OUTWASH PLAIN (GO):

3.10.1 Description:

Outwash deposits include plains, fans, deltas, and valley trains of varying sizes, all consisting mainly of sand and gravel. Most outwash sediments were drained from the front of a melting glacier and accumulated in flooded lowlands and valley bottoms. Although most outwash deposits were formed in proglacial positions, some accumulated over masses of stagnant glacier ice, resulting in pitted or kettled surfaces. Outwash landscapes that show abandoned channel scars, braid bars, or deep kettle holes are commonly coarse in texture (*i.e.* gravelly and cobbly rather than sandy).

3.10.2 Occurrence:

Small to moderately sized outwash deposits (GO) occur in many locations within the Lac des Mille Lacs map-area. The greatest concentration is found in the south-central, central, and eastern parts of the area. These largely proglacial sediments occur on both sides of the Brule Creek Moraine (Figure 1). Examples occur east of Kashabowie Lake in the central part of the area and north of Laughren Lake in the southwest-central part. The surfaces of these deposits lie between 470 and 490 m in elevation. Occurrences of outwash not associated with major moraines are found (1) southwest of Laughren Lake in the southwestern part of the area, (2) west of

Chief Peter Lake near the western margin of the area, and (3) southeast of Athelstane Lake near the eastern margin. The surfaces of these deposits generally lie between 440 and 455 m in elevation.

Extensive sandy outwash deposits with a discontinuous covering of organic material occur in the northeast corner of the map-area. These deposits lie between the Savanne River and the Dog Lake Moraine (Figure 1) which is located just beyond the northeast corner of this map-area.

In some localities, the outwash sediments are thin and rest on bedrock (GO/RP). Noteworthy examples are found southwest of Laughren Lake in the southwestern part of the area and around Far Lake in the east-central part of the area.

3.10.3 Engineering and Planning Significance:

Outwash landforms almost always have high permeability and good internal drainage, low to very low compressibility, low shrink-and-swell tendencies, and high shear strength and bearing capacity, particularly where these granular deposits are confined. Granular materials in outwash landforms form stable slopes and are seldom susceptible to frost heave. Being level and well drained, the sediments in outwash plains are not easily eroded by running water. The boulder content is generally low. A high water table can be expected beneath kettle depressions. Extensive outwash plains provide excellent sites for the construction of roads and airstrips, and are often good sources of concrete and bituminous aggregate. They are good potential sites for ground water development, particularly where the granular deposits are deep and are recharged by water from nearby lakes and rivers.

3.11 RAISED BEACH FORM (LB):

3.11.1 Description:

Raised beaches are generally thin and consist of bouldery, gravelly, and sandy wave- and current-transported materials deposited along the shores of former glacial lakes. The term "raised beach" denotes a landform

marking the position of a former rather than present-day lake margin. Generally, the wave-washed materials were eroded from coarse till and glaciofluvial deposits consisting of sand, gravel, and cobbles.

3.11.2 Occurrence:

Raised beaches (LB) are rare in the Lac des Mille Lacs map-area and only one occurrence has been mapped. It is located southwest of Reserve Bay on Lac des Mille Lacs. This poorly developed unit occurs at an elevation of approximately 455 m, which may represent the highest stage of former Glacial Lake Lac des Mille Lacs.

3.11.3 Engineering and Planning Significance:

The raised beach in this area is too thin and narrow to constitute a major source of granular construction material. Because it is nearly level, well drained, and slightly elevated above the surrounding terrain, it is a good feature to follow in route location if it happens to trend in the desired direction. The water table is generally high in this landform. Raised beaches have a high permeability, good internal drainage qualities, and low compressibility (*i.e.* small amounts of total and differential settlement of structures built upon them). They usually have high shear strength and bearing capacity. They make poor waste disposal sites because of their limited area and the possibility of leakage which can lead to contamination of nearby surface or ground waters.

3.12 GLACIOLACUSTRINE PLAIN (LP):

3.12.1 Description:

Sediments in glaciolacustrine plains consist of varved and massive, fine-grained materials deposited in glacial lake basins of varying size and depth. The proportion of clay, silt, and sand deposited at any particular location in these basins varies with depth of water in the former lake, distance from former shorelines, and the size of particles washed into the lake. Most clay, silt, and sand lacustrine deposits contain minor inclusions of till and scattered dropstones which were rafted into the lake on pieces of ice. In places,

wave and current action in former glacial lakes eroded the surface of till deposits, producing thin patches of washed sand, gravel, and boulders that rest on till or bedrock. In other areas, bedrock knobs and ridges are surrounded by pockets of glaciolacustrine sediment. Glacial lake deposits usually consist of clay and silt (cLP, cmLP, mcLP) which accumulated in deep offshore waters at a depth where the bottom was no longer affected by wave action. Closer to shore, and at points where rivers discharged sandy materials into the lake, the deposits usually consist of fine and medium sand with minor silt (sLP, smLP). Most of these sandy lacustrine deposits accumulated in deltaic environments.

3.12.2 Occurrence:

Glaciolacustrine plains (LP) occur below a cover of organic terrain (OT) along the Swamp River in the southeastern part of the map-area. They consist of red clay deposited in Glacial Lake Kaministikwia, which reached an elevation of approximately 440 m. Lacustrine deposits become silty and sandy at higher elevations, especially near and along former shorelines. Glaciolacustrine red clay is also found along the Shebandowan River east of Lower Shebandowan Lake in the southeastern part of the map-area; here, the clay deposits lie mainly below 455 m in elevation. Other fine-grained glaciolacustrine deposits are located in Duckworth and Laurie Townships in the southeast corner of the area.

Extensive sandy lacustrine deposits are located between the Savanne River and Athelstane Lake in the northeastern part of the area and north of Lac des Mille Lacs in the northern part. These are generally mantled by a thin layer of organic material (*i.e.* peat and muck).

3.12.3 Engineering and Planning Significance:

Glaciolacustrine clay deposits (cLP) have high water retention capacity, low permeability, and poor internal drainage, most of which is controlled by a network of closely spaced joints. Characteristically, these landforms possess low density, low bearing strength, and moderate to high compressibility, unless the fine-grained sediments have been consolidated by the weight of overriding glacier ice or by desiccation. The clay sediments usually provide poor foundation conditions and can be difficult to work

with heavy construction equipment during wet weather. Most clay plains in the map-area are level to gently sloping. The sides of river valleys which have been deeply incised into these fine deposits are usually highly dissected and are susceptible to rill-and-gully erosion on freshly cut ditch and highway back slopes. Higher and steeper natural and man-made slopes are subject to small failures. Where these lacustrine materials carry a high proportion of silt or very fine sand, they are susceptible to frost heave and the formation of frost boils. Subsoil permeability ranges from low to nearly impervious; as noted above, this is largely dependent on the presence of a system of closely spaced joints. In locations where glaciolacustrine clay sediments are highly plastic, they have a tendency to shrink or swell with changes in moisture content. Bearing capacity, shear strength, and compressibility vary greatly with differences in previous loading history and, therefore, the natural moisture content. Bearing capacities can be low in wet areas, particularly where plastic clay soils are normally consolidated or only slightly consolidated.

Low-lying clay plains have a high water table and are subject to local flooding during spring runoff and heavy cloudbursts. During wet weather, the glaciolacutrine clay sediments have poor workability characteristics for building roads and structures. This landform usually provides good sites for waste disposal because of its low permeability.

Lacustrine sand plains (sLP) contain mostly fine and medium sand with minor silt. Coarse sand, gravel, cobbles, boulders, and till are rare in these deposits. Sand plains are gently sloping to undulating and are well drained. A high water table may occur at sites located some distance from the ground water lowering effects of deep valleys and ravines. Sandy lacustrine materials are typically nonplastic and have high permeability, low compressibility, moderate to high bearing capacity, and high shear strength. They are generally not frost susceptible unless they contain a significant amount of silt and very fine sand. They represent fair to good terrain for most construction, especially that of roads and airstrips. They are poor for waste disposal due to the possibility of effluent seepage and ground water contamination.

3.13 ALLUVIAL PLAIN (AP):

3.13.1 Description:

Many alluvial deposits (AP) in this map-area consist of fine and medium sand at depth; these materials are commonly overlain by a silty upper stratum of variable thickness. Oxbows and abandoned channel segments occur where meandering streams cross landforms composed largely of loose silt and fine sand. Sediments beneath alluvial plains are finer textured where the material being carried by the stream was eroded from clay and silty clay glaciolacustrine deposits. The landform includes flood plains that have been eroded in till and are strewn with boulders, as well as segments of stream valleys where alluvial sediments range in texture from coarse sand to coarse gravel and cobbles. Long and complex alluvial plain systems sometimes include three constituent landforms: low alluvial terraces, alluvial flood plains, and stream channels.

3.13.2 Occurrence:

Alluvial plains (AP), many of them too small to map at the 1:100 000 scale, are scattered throughout the map-area. Examples of deposits which have been shown on the map are those (1) northeast of Bedivere Lake in the northwestern part of the area, (2) along the Wawiag River in the southwestern part, (3) along Crayfish Creek and the Kashabowie River in the central part, and (4) along the Swamp River in the eastern part. In some cases, the alluvial deposits are mantled by a thin layer of organic material (OT/AP). Examples of this occur along the Obadinaw River in the southwestern part of the area and along the Savanne River in the northeast corner.

3.13.3 Engineering and Planning Significance:

Alluvial plains are subject to flooding. The water table is usually situated at or near the surface for much of the year; organic-filled depressions are common. Although some alluvial terraces, flood plains and channel bottoms represent potential sources of sand and gravel for construction purposes, the high water table may cause problems during excavation of

such materials. This landform is generally unsuitable for transportation routes, general construction, or waste disposal sites because of the high water table and risk of flooding.

3.14 ORGANIC TERRAIN (OT):

3.14.1 Description:

Organic terrain includes varying depths of peat and muck in marshes, swamps, fens, and bogs. No attempt was made to separate these organic landscape types during the mapping. Although peat and muck deposits usually occur as relatively thin surficial layers, in places these organic materials can be several metres thick. Moreover, the thickness of the deposits can change drastically over very short distances.

3.14.2 Occurrence:

Thin organic deposits overlie glaciolacustrine materials (OT/LP) in scattered localities throughout the southeastern part of the Lac des Mille Lacs map-area. Large areas of flat, low-lying, glaciofluvial and glaciolacustrine terrain, situated on both sides of the Savanne River and north of Lac des Mille Lacs in the northeastern part of the map-area, are covered by peat and muck deposits.

3.14.3 Engineering and Planning Significance:

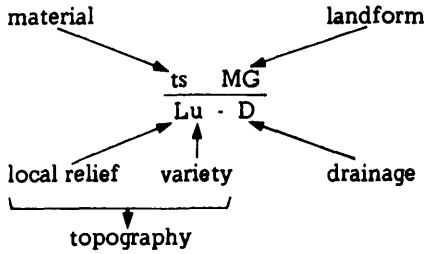
Although organic deposits are commonly thin, they are nonetheless very poor foundation and construction materials. The water table is at or near ground surface for most of the year. The locations of deeper pockets of organic material are difficult to predict reliably without extensive test-drilling. The topography of organic terrain is level or slightly depressional. Peat and muck deposits have low shear and bearing strengths and generally low permeability. They are nearly always poorly drained, highly compressible, and are subject to seasonal flooding. Consequently, they are unsuitable sites for nearly all types of engineering works and for waste disposal.

4.0 APPENDIX: EXAMPLES OF TERRAIN UNIT LETTER CODES:

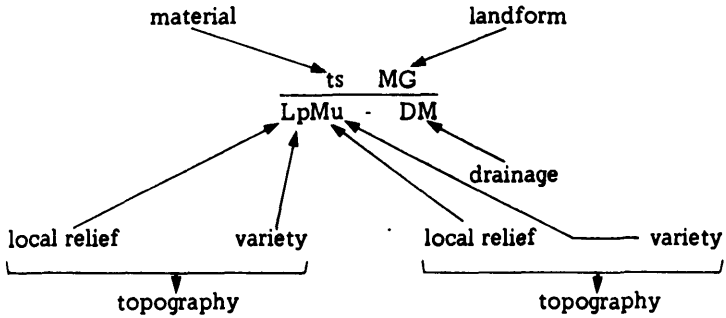
The engineering terrain unit letter codes consist of four components: surface materials, landform, topography, and drainage. The format of the letter codes used in describing the terrain units is discussed in detail in the Users' Manual (Gartner, Mollard, and Roed 1980). Some additional examples of the letter codes are as follows:

4.1 SIMPLE TERRAIN UNIT:

Example 1:



Example 2:

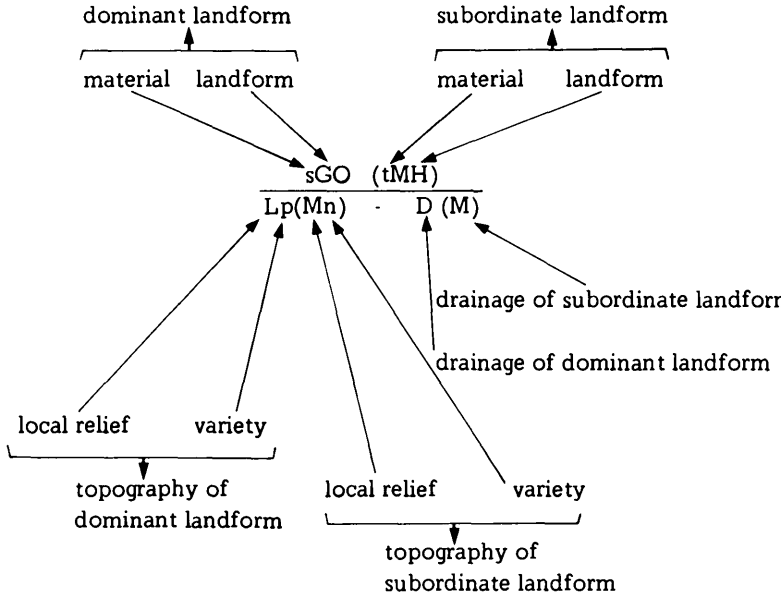


Note: The above type of letter code is used where there are two distinctly different types of topography and/or drainage in a simple terrain unit.

4.2 COMPLEX TERRAIN UNIT:

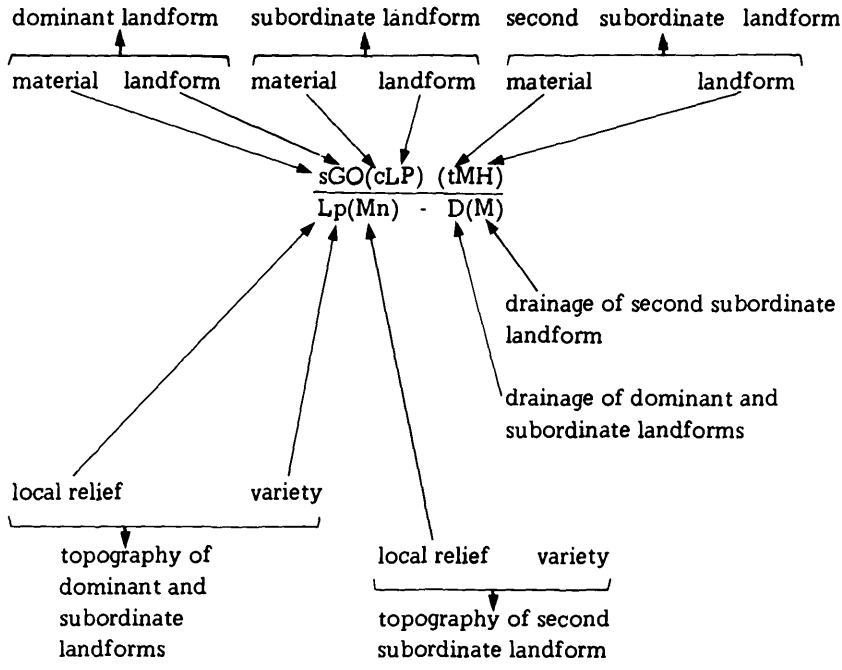
In complex areas, the dominant landform is shown first and the subordinate landform(s) appear in parentheses.

Example 1:



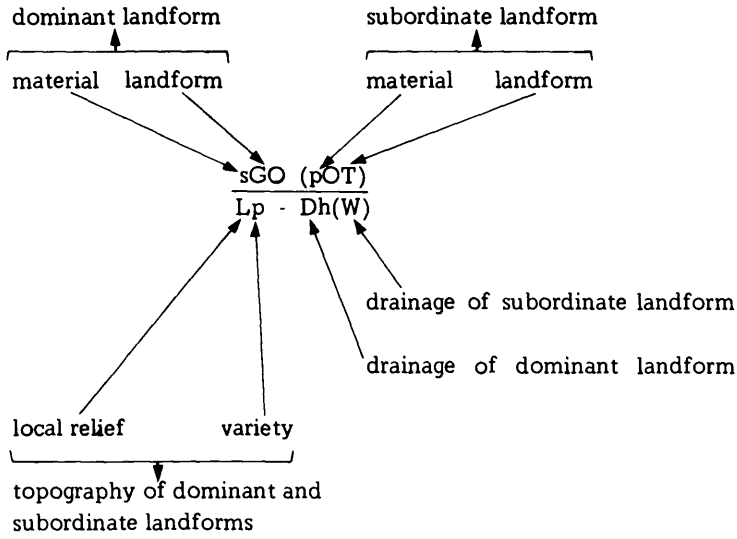
Note: The topography and drainage in parentheses refer to the landform shown in parentheses.

Example 2:



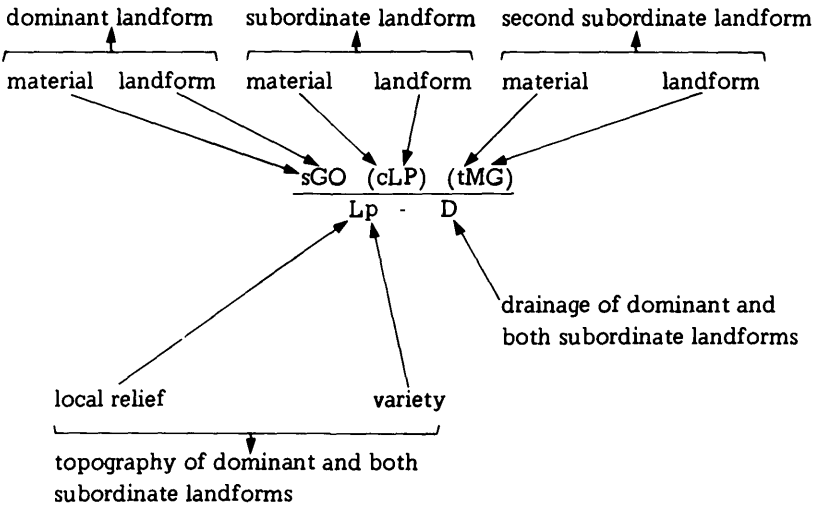
Note: The topography and/or drainage in parentheses refer to the second subordinate landform (in parentheses).

Example 3:



Note: If topography or drainage is similar in the dominant and subordinate landforms, then no topography or drainage symbol is shown in parentheses and the symbol shown applies to both landforms. If topography or drainage conditions are different in one of the landforms, a topography or drainage symbol is shown in parentheses to indicate this difference.

Example 4:



Note: Where topography and drainage conditions are similar in all of the landforms shown, no topography or drainage symbols are placed in parentheses.

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Ontario Geological Survey

Northern Ontario
Engineering Geology Terrain Study 56

LAC DES MILLE LACS AREA

(NTS 52B/NE)

Districts of Rainy River and Thunder Bay

by

D.G. Mollard and J.D. Mollard

1980

Ontario

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CONTENTS

		Page
1.0	Introduction	1
2.0	Physiography and Geological Setting	2
3.0	Engineering Terrain Units	3
3.1	Bedrock Knob (RN)	4
3.1.1	Description	4
3.1.2	Occurrence	4
3.1.3	Engineering and Planning Significance	4
3.2	Bedrock Plain (RP)	4
3.2.1	Description	4
3.2.2	Occurrence	5
3.2.3	Engineering and Planning Significance	5
3.3	Bedrock Ridge (RR)	5
3.3.1	Description	5
3.3.2	Occurrence	6
3.3.3	Engineering and Planning Significance	6
3.4	End Moraine (ME)	6
3.4.1	Description	6
3.4.2	Occurrence	8
3.4.3	Engineering and Planning Significance	8
3.5	Ground Moraine (MG)	8
3.5.1	Description	8
3.5.2	Occurrence	9
3.5.3	Engineering and Planning Significance	9
3.6	Hummocky Moraine (MH)	10
3.6.1	Description	10
3.6.2	Occurrence	10
3.6.3	Engineering and Planning Significance	10
3.7	Ice-Contact Delta (GD)	11
3.7.1	Description	11
3.7.2	Occurrence	11
3.7.3	Engineering and Planning Significance	11
3.8	Esker (GE)	12
3.8.1	Description	12
3.8.2	Occurrence	12
3.8.3	Engineering and Planning Significance	12

3.9 Kame (GK) 13
3.9.1 Description 13
3.9.2 Occurrence 13
3.9.3 Engineering and Planning Significance 14
3.10 Outwash Plain (GO) 14
3.10.1 Description 14
3.10.2 Occurrence 14
3.10.3 Engineering and Planning Significance 15
3.11 Raised Beach Form (LB) 15
3.11.1 Description 15
3.11.2 Occurrence 16
3.11.3 Engineering and Planning Significance 16
3.12 Glaciolacustrine Plain (LP) 16
3.12.1 Description 16
3.12.2 Occurrence 17
3.12.3 Engineering and Planning Significance 17
3.13 Alluvial Plain (AP) 19
3.13.1 Description 19
3.13.2 Occurrence 19
3.13.3 Engineering and Planning Significance 19
3.14 Organic Terrain (OT) 20
3.14.1 Description 20
3.14.2 Occurrence 20
3.14.3 Engineering and Planning Significance 20
4.0 Appendix: Examples of Terrain Unit Letter Codes 21
4.1 Simple Terrain Unit 21
4.2 Complex Terrain Unit 22
5.0 References 26

FIGURE

1 - Map of the Quetico - Nipigon area showing moraines and orientation of glacial features. 7

MAP
(accompanying report)

Map 5074 (coloured) - Northern Ontario Engineering Geology Terrain Study, Data Base Map, Lac des Mille Lacs (NTS 52B/NE). Scale 1:100 000.

Northern Ontario
Engineering and Geology Terrain Study 56

LAC DES MILLE LACS AREA

(NTS 52B/NE)

Districts of Rainy River and Thunder Bay

by

D.G. Mollard[1] and J.D. Mollard[2]

1.0 INTRODUCTION:

This report contains an inventory of regional engineering terrain conditions in the Lac des Mille Lacs map-area, Districts of Rainy River and Thunder Bay. The area, which covers NTS block 52B/NE, lies between Latitudes 48°30'N and 49°00'N and Longitudes 90°00'W and 91°00'W. The report forms part of a series of publications that provide similar terrain data for some 370 000 km^2 of northern Ontario.

The purpose of the inventory is to assist regional engineering and resource planning studies at a level of detail consistent with a scale of 1:100 000. The terrain information is contained on the Data Base Map (OGS Map 5074, accompanying this report).

---

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Interpretation of black and white aerial photographs, at a scale of approximately 1:50 000, formed the basis of the terrain mapping process. The interpretation was checked against published and unpublished maps and reports which documented previous field visits and observations. During the fall of 1978, roads in the map-area were traversed and observed terrain conditions recorded as further verification of the office studies. Thus, the Data Base Map represents a reconnaissance overview of the engineering conditions of the terrain.

An engineering terrain legend was developed to facilitate the mapping and to provide a common information base for the entire map series. This legend is shown on the accompanying Data Base Map. Further discussion on the mapping techniques, legend format, and possible uses of this engineering geology information is available in the Ontario Engineering Geology Terrain Study Users' Manual (Gartner, Mollard, and Roed 1980), a companion publication to this series of maps and reports.

2.0 PHYSIOGRAPHY AND GEOLOGICAL SETTING:

Maximum local relief in the Lac des Mille Lacs map-area is 90 m; however, much of the area has local relief of less than 60 m. The relief is greatest in the south half of the area, particularly around the Shebandowan Lakes, Greenwater Lake, Burchell Lake, and Windigoostigwan Lake. Athelstane Lake, Lac des Mille Lacs, and Bedivere Lake are large lakes in the north half of the map-area, where relief is generally much less than in the south.

The glacial overburden is thicker in the eastern part of the map-area. Thick drift also occurs near Greenwater Lake in the south-central part, where till in hummocky moraine and sand and gravel in glaciofluvial landforms have been mapped. A few narrow end moraine ridges occur, and glaciofluvial deposits are widely spaced. Landforms composed of surface and near-surface bedrock are the most common terrain types.

Two east-trending belts of metavolcanics, metasediments, and minor mafic to ultramafic intrusive rocks occur in the map-area. The larger of these occupies most of the southern third of the area, while the other cuts through the central part, south of Lac des Mille Lacs. The remainder of the area is underlain by felsic igneous and metamorphic rocks (granites, gneisses, and allied lithologies).

3.0 ENGINEERING TERRAIN UNITS:

The engineering terrain units mapped are identified in terms of four components: surface material, landform, topography, and drainage. Format of the legend used in the terrain mapping is described in detail in the Users' Manual (Gartner, Mollard, and Roed 1980). Landform is a very important component because surface and near-surface materials, topographic expression, and the surface and internal drainage conditions are all related to it. Consequently, the engineering terrain units are grouped, for descriptive purposes, according to the dominant landform.

A particular landform can occur as the only component in a simple terrain unit, or as a dominant or subordinate component in a complex terrain unit. The dominant landform usually occupies more than half of a complex terrain unit. Where only one subordinate landform is shown, it usually occupies between 10 and 50 percent of the complex unit. Where two subordinate landforms are shown, the first covers the larger area. Landforms that occupy less than 10 percent of the terrain in a complex unit are rarely indicated in the terrain unit letter code. Where two or three landforms in a complex terrain unit consist of the same material, the landform letter symbols are connected by a dash. Examples of terrain unit letter codes which may occur in this map-area, and an explanation of each, are given in the Appendix.

A large number of complex terrain units has been mapped due to the widespread occurrence of irregular topography. Bedrock, which is situated at or near the ground surface throughout much of the map-area, controls the topography and therefore the surface drainage conditions. Resource development and engineering planning considerations are complicated by these complex conditions.

Noteworthy occurrences of important landforms are described with respect to location, typical materials, topography, and drainage; their significance in geotechnical investigations, regional engineering planning, and resource development is summarized.

3.1 BEDROCK KNOB (RN):

3.1.1 Description:

Bedrock knob landscape (RN) is characterized by an irregular bedrock surface having complex multiple slopes of varying steepness. The cover of glacial deposits overlying the bedrock knobs is generally thin and discontinuous. Much of the glacial overburden consists of bouldery, sand-rich till that was transported only a short distance by the ice.

3.1.2 Occurrence:

Occurrences of knobby bedrock (RN) are less common in the Lac des Mille Lacs area than in neighboring map-areas. Rock knobs are the dominant bedrock landform throughout the southeastern part and most of the western third. In these areas, an irregular bedrock surface is commonly covered by a thin mantle of bouldery till. Bedrock knob terrain is underlain mainly by felsic igneous and metamorphic rocks (granites, gneisses, and allied lithologies).

3.1.3 Engineering and Planning Significance:

Two principal engineering considerations are the large volumes of rock that must be excavated during construction and the generally uniform and solid foundation conditions at shallow depths. However, due to difficult topography and the existence of rock fractures, bedrock knob terrain is considered poor for most types of light construction and for waste disposal. Drilling and blasting are required during the construction of almost all types of engineering works.

3.2 BEDROCK PLAIN (RP):

3.2.1 Description:

The bedrock plain unit (RP) has a low-lying, undulating to rolling surface. The bedrock is generally mantled by a thin and variable cover of glacial

material, consisting mainly of boulder-rich sandy till. The rock plains display considerable local variation. They may consist of bare bedrock or may be covered by till or fine-grained water-laid deposits.

3.2.2 Occurrence:

Bedrock plains (RP) occur only in a few isolated areas, specifically around Tilly Lake in the western part of the area and in the southeast corner of the area. In the latter instance, the bedrock surface is covered by a discontinuous mantle of bouldery till.

3.2.3 Engineering and Planning Significance:

Engineering and construction problems relate mainly to the cost of bedrock excavation. Foundation materials are strong, have a low compressibility, and a permeability that is controlled almost entirely by rock fractures. Bedrock plains are poor construction and waste disposal sites, but are still considered better than areas mapped as bedrock plateau (RL), bedrock knob (RN), or bedrock ridge (RR). Drainage courses tend to follow eroded zones of weakness in the underlying bedrock. Many of these depressions occupy preglacial channels that were enlarged by glacial erosion. A large proportion of the ground water in this landform is confined to fractures in the upper 45 to 60 m of bedrock. Permeability varies from impervious to highly pervious, depending on the spacing, depth, and width of fissures in the bedrock. Rock materials have high compressive, shearing, and bearing strengths. Position of the water table varies with topography, being closer to the surface beneath depressions. By careful route selection and proper design of vertical alignment, rock cuts on lower class roads can be avoided or at least the volume of rock to be blasted can be minimized. This is possible because of the low relief surfaces of the bedrock plains.

3.3 BEDROCK RIDGE (RR):

3.3.1 Description:

The bedrock ridge unit (RR) consists of long, narrow, subparallel and intersecting bedrock ridges of varying height. Thickness of drift over the

masked bedrock surface varies substantially over short distances. In general, it is relatively thin (1 to 2 m) on ridge tops and thicker on the lower slopes and in the depressions between rock ridges.

3.3.2 Occurrence:

Small areas of rock ridges (RR) are located west and south of Burchell Lake in the southwestern part of the map-area and northeast of Greenwater Lake in the southeast-central part. Rock ridges have generally formed on volcanic rock types. Ridge crests are probably bare bedrock. Where rock ridges are the dominant landform, they can occur alone (RR) or with subordinate amounts of rock knobs (RR(RN)). Isolated pockets of organic material can occur between rock ridges (RR(OT)).

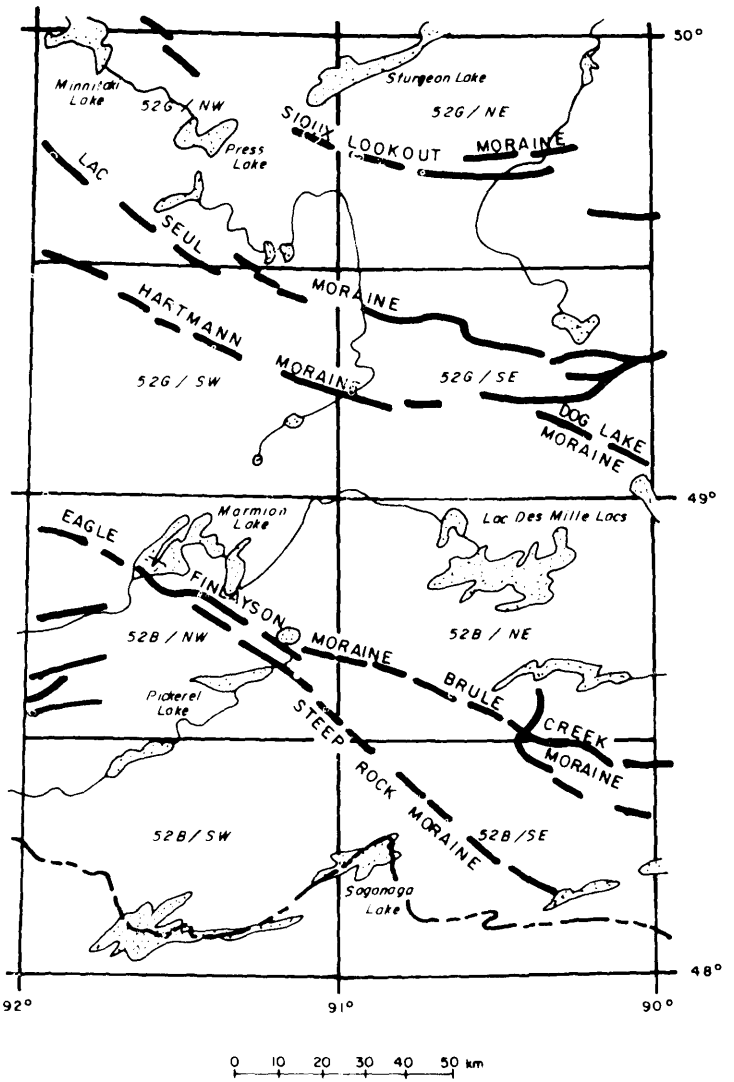
3.3.3 Engineering and Planning Significance:

The main construction problem is the large quantities of very hard rock that often must be excavated during construction. Drilling and blasting costs can be very high. Bedrock ridge terrain is considered poor for most types of engineering, construction, and resource development. It also has a low rating for waste disposal due to irregular relief, the presence of rock fractures near the ground surface, and the high cost of earthwork construction.

3.4 END MORAINE (ME):

3.4.1 Description:

End moraine (ME), which forms either prominent or inconspicuous till ridges, was deposited along the margin of the glacier. Although the ridges are usually lone and narrow, they can be hummocky in places. End moraine consists largely of ice-deposited till and boulders, with minor inclusions of water-laid silt, sand, and gravel. Segments of end moraine, composed mainly of till, occur with hummocky moraine (MH), kames (GK), and ice-contact deltas (GD) and in large moraine complexes which are identified by name in Figure 1. The bedrock surface is nearly always buried in areas of end moraine; there are exceptions, however, and in a few places end moraine ridges have a core of solid rock.



NOTE: Moraine segments shown in the figure do not necessarily all occur on the Data Base Map accompanying this report.

FIGURE 1 - MAP SHOWING MAJOR MORAINES IN NTS 52B AND 52G (MODIFIED FROM ZOLTAI 1965, FIGURE 3)

3.4.2 Occurrence:

Large segments of the Brule Creek Moraine occur between Greenwater Lake and the Shebandowan Lakes in the southeastern part of the map-area (Figure 1). Elevations of 500 to 520 m are common along these end moraine segments. Smaller end moraines occur south of Greenwater Lake near the southern margin of the area. An end moraine on the east shore of Greenwater Lake probably has a core of bedrock in places.

Other end moraines are situated in the southwest-central part of Lac des Mille Lacs map-area, south of Crayfish Lake and south of the settlement of Huronian. An end moraine ridge has been mapped along the south shore of Athelstane Lake, in the east-central part of the map-area. This ridge is approximately 18 km long and occurs in association with knobby stratified deposits (ME(GK)).

3.4.3 Engineering and Planning Significance:

An important characteristic of end moraines is their variability. Layers of unsorted and unstratified material of varying sizes can both underlie and overlie sequences of layered silt, sand, and gravel. In general, the boulder content of this landform is high. End moraines in the map-area commonly exhibit variable permeability and internal drainage, low compressibility, and high bearing strength. The water table is low in end moraine ridges. Where the unit consists of till that is high in sand- and gravel-sized material, and where sources of stratified sand and gravel are scarce, the coarse till may sometimes be crushed and used as a source of road-surfacing material. End moraines may present excavation dificulties during the building of roads and structures due to the abundance of small and large boulders.

3.5 GROUND MORAINE (MG):

3.5.1 Description:

The term ground moraine (MG) refers to an extensive deposit of till forming an undulating to rolling plain. Although till is generally composed of an assortment of particle sizes (including clay, silt, sand, gravel, cobbles, and boulders), till deposits in this map-area have a high sand and boulder

content. The thickness of till in ground moraine varies from less than 1 m to many tens of metres. The landform is mapped as MG where the till is thick enough to mask the topographic effect of underlying bedrock. In general the till layer forms a mantle less than 3 m thick over the bedrock and is mapped as MG/R. Till in ground moraine tends to be thicker in bedrock depressions and thinner over bedrock ridges and knobs.

3.5.2 Occurrence:

Ground moraine (MG) deposits are common in the Lac des Mille Lacs map-area. The thickness of till overlying the bedrock increases across the map-area toward the northeast. Most ground moraine, however, forms only a thin veneer over the bedrock. Such a situation is widespread across the northern part of the area and in the southeastern part. The unit (MG/R) is commonly found in association with such subordinate landforms as rock knobs (RN), glaciolacustrine plains (LP), and organic terrain (OT). Ground moraine occurs extensively in the western half of the map-area as the subordinate landform in the complex terrain unit RN(MG/R). The relief on ground moraine units in this vicinity is generally undulating and is less irregular than in the southern part of the map-area due to a greater thickness of till.

3.5.3 Engineering and Planning Significance:

The till in ground moraine is coarse and bouldery, and has moderate permeability and internal drainage, low compressibility, and high bearing strength. Water table position varies with relief, being lower beneath knolls and low ridges and higher beneath depressions. The till in many of the depressions is covered by thin deposits of peat and muck.

The suitability of ground moraine for road and other light foundation construction is fair to good. The fact that the till often forms only a thin mantle over the bedrock (MG/R) has a great deal of significance in road building. Road construction through this type of terrain is difficult owing to the bouldery nature of the till and the probability of encountering bedrock in cuts. The suitability of ground moraine for waste disposal varies from poor to fair.

3.6 HUMMOCKY MORAINE (MH):

3.6.1 Description:

Although some hummocky moraine deposits formed along an active ice front, most of the sediments which make up this landform accumulated on the surface of stagnant glacial ice. In time, the buried ice melted and deposited a layer of unsorted till and, in places, washed glacial debris. Most hummocky moraine consists of steep-sided knobs and short ridges separated by undulating to flat areas and swampy kettle hole basins. Soil materials in hummocky moraine include till, usually as the dominant constituent, and subordinate amounts of stratified silt, sand, and gravel in pockets or lenses. Hummocky moraine can be very bouldery. Scattered kames (GK) are a common subordinate landform.

3.6.2 Occurrence:

Areas of hummocky moraine (MH) are commonly located on the north side of major moraine complexes (Figure 1). A large expanse of this landform occurs southeast of Lac des Mille Lacs in the central part of the map-area. Other smaller occurrences are located south and southeast of Athelstane Lake in the east-central part of the area, east of the settlement of Huronian in the west-central part, and south and northeast of Greenwater Lake in the southern part. Hummocky moraine commonly occurs in association with kames (MH(GK)).

3.6.3 Engineering and Planning Significance:

Engineering considerations include the large quantities of material that may have to be excavated during construction, a high content of boulders, and rapid changes in the nature of the materials. Pockets of sand and gravel constitute small sources of construction material of variable quality.

Although variable, most areas of hummocky moraine have moderate permeability and internal drainage, low compressibility, high bearing strength, and low shrink-and-swell potential. In depressions, the till deposits are commonly covered by thin, water-laid silt and clay, which in turn are overlain by peat and muck deposits. Hummocky moraine is considered fair to poor for general construction purposes and for waste disposal.

3.7 ICE-CONTACT DELTA (GD):

3.7.1 Description:

Esker deltas, kame deltas, and delta moraines are all varieties of the ice-contact delta. Some of them are quite large in area and important in terms of the volume of recoverable sand and gravel which they contain. Individual beds, consisting mainly of sand or gravel, are usually better sorted, cleaner, and less variable than stratified deposits in esker (GE) and kame (GK) landforms. The beds in this unit are also typically less folded and faulted and are more continuous. It is worth noting that materials in many ice-contact deltas are coarse (*i.e.* gravelly) on the north and northeast sides and finer (*i.e.* sandy) on the south and southwest sides. These conditions indicate the parts of the delta which were, respectively, closest to and farthest from the glacial front against which the delta was built.

3.7.2 Occurrence:

The most conspicuous ice-contact delta (GD) in the map-area is located south and west of Greenwater Lake. Here, sand and gravel were deposited in glacial lake waters that reached elevations of 470 to 490 m. These deposits, which are sometimes associated with end moraine (ME), extend from the eastern shore of Greenwater Lake as far west as Burchell Lake. Small glaciofluvial deltas, whose surfaces are at elevations of 470 to 490 m, occur south of Crayfish Lake in Ames Township and west of Athelstane Lake in the central part of the map-area.

3.7.3 Engineering and Planning Significance:

Ice-contact deltas are good potential sources of concrete and blacktop aggregate. They are also favorable sites for the construction of airstrips, roads, and other types of engineering works. Because the subsoils are highly permeable, deltaic landforms are relatively poor areas for waste disposal. Larger deposits, however, are generally good ground water prospects, especially where sand and gravel horizons are thick and extend below the water table. Ice-contact deltas possess high bearing strength and good workability in wet weather. Slopes are stable and subsoils are well drained. Away from the steeply sloping margins of this landform,

earthwork volumes and excavation costs are normally low. Reservoirs and sewage lagoons in ice-contact deltas must be lined to prevent excessive leakage.

3.8 ESKER (GE):

3.8.1 Description:

The ridged landform represented by the esker symbol (GE, >>>) also includes crevasse fillings. Both occur as long, narrow, sand and gravel ridges that can be winding or straight and may widen in places. Some of these elongate ice-contact stratified drift ridges include braided, branching, beaded, and kettled segments. Most of the ridges trend roughly parallel to the last direction of glacial flow. The cores of many eskers and crevasse fillings contain complexly layered units, consisting of sandy gravel and gravelly sand, that exhibit collapse structures (*i.e.* folds, faults, and pinch-outs of strata). Some silt and fine sand units (water-laid), boulders, and till pockets may occur within the central parts of eskers and crevasse fillings, as well as along their flanks.

3.8.2 Occurrence:

Most of the eskers in the Lac des Mille Lacs map-area occur in association with other glaciofluvial landforms, such as outwash plains and kames. Eskers form part of two outwash-esker-kame complexes in the central part of the map-area, while an esker is associated with an outwash deposit west of Edar Lake in the western part of the area. Eskers occur in other terrain units throughout the map-area, but are generally of minor significance and have little effect on the engineering conditions or resource potential of the unit in which they are found.

3.8.3 Engineering and Planning Significance:

Eskers and crevasse fillings are relatively small and isolated landforms in this map-area, and are generally inferior to ice-contact delta and glacial outwash deposits as sources of good quality granular construction materials.

Typically, the unit possesses high permeability and good internal drainage, low compressibility, high bearing strength, low frost susceptibility, and low shrink-and-swell potential. Where esker ridges are steep-sided, narrow, and winding, they may be unsuitable for use as transportation routes. They may trend in the wrong direction for route location purposes, but in regions that are dominated by large expanses of swamp and bedrock, eskers are frequently considered as good route location possibilities. Where the sand and gravel in large eskers extends many metres below the water table, the unit represents a potential source of ground water for domestic and, possibly, municipal and industrial use.

3.9 KAME (GK):

3.9.1 Description:

Kames occur either as steep-sided single knobs or as clusters of several knobs in kame fields and kame moraine. The larger, steep-sided kames usually have an irregular surface; in a few places, they contain deep kettle hole depressions. Most are composed of complexly interbedded sand and gravel strata which regularly exhibit fold, fault, and pinch-out structures. Kames also contain variable but usually minor amounts of silt, till, and boulders. Large kame deltas are discussed in Section 3.7; kame terraces are rare.

3.9.2 Occurrence:

Kames (GK), which are common in the Lac des Mille Lacs map-area, are usually found in association with hummocky moraine (GK(MH)), outwash (GO(GK), GO-GK), and eskers (GK-GE). In this area, many of the kames have a bouldery surface, similar to that of hummocky moraine. The complexly layered materials in kames can be highly variable and include isolated pockets of silt, till, and boulders, as well as clean strata of sand and gravel. Kames are common on the north side of prominent end moraines. The symbol (GK) designates individual kames as well as large clusters of kames in kame moraine. Individual kames and kame fields may occur as part of a major moraine complex (Figure 1) or may be located far beyond its boundaries. Kames occur in the central part of the map-area as part of several outwash-esker-kame complexes (GO-GK, GK-GE, GO).

3.9.3 Engineering and Planning Significance:

In general, kames have high permeability and good internal drainage, low compressibility, high shear strength, and good bearing capacity. Position of the water table varies with relief, being nearer the surface beneath kettle depressions and deeper beneath ridges and knobs. Although the granular materials in kames provide good foundations for buildings and small engineering works, the quantities of material that must be excavated during construction can be moderately high. Waste disposal sites require special design procedures and costly construction in order to function properly. Kames should be avoided as waste disposal sites. They vary from poor to good as sources of sand and gravel aggregate, depending upon their size and compositional variability.

3.10 OUTWASH PLAIN (GO):

3.10.1 Description:

Outwash deposits include plains, fans, deltas, and valley trains of varying sizes, all consisting mainly of sand and gravel. Most outwash sediments were drained from the front of a melting glacier and accumulated in flooded lowlands and valley bottoms. Although most outwash deposits were formed in proglacial positions, some accumulated over masses of stagnant glacier ice, resulting in pitted or kettled surfaces. Outwash landscapes that show abandoned channel scars, braid bars, or deep kettle holes are commonly coarse in texture (*i.e.* gravelly and cobbly rather than sandy).

3.10.2 Occurrence:

Small to moderately sized outwash deposits (GO) occur in many locations within the Lac des Mille Lacs map-area. The greatest concentration is found in the south-central, central, and eastern parts of the area. These largely proglacial sediments occur on both sides of the Brule Creek Moraine (Figure 1). Examples occur east of Kashabowie Lake in the central part of the area and north of Laughren Lake in the southwest-central part. The surfaces of these deposits lie between 470 and 490 m in elevation. Occurrences of outwash not associated with major moraines are found (1) southwest of Laughren Lake in the southwestern part of the area, (2) west of

Chief Peter Lake near the western margin of the area, and (3) southeast of Athelstane Lake near the eastern margin. The surfaces of these deposits generally lie between 440 and 455 m in elevation.

Extensive sandy outwash deposits with a discontinuous covering of organic material occur in the northeast corner of the map-area. These deposits lie between the Savanne River and the Dog Lake Moraine (Figure 1) which is located just beyond the northeast corner of this map-area.

In some localities, the outwash sediments are thin and rest on bedrock (GO/RP). Noteworthy examples are found southwest of Laughren Lake in the southwestern part of the area and around Far Lake in the east-central part of the area.

3.10.3 Engineering and Planning Significance:

Outwash landforms almost always have high permeability and good internal drainage, low to very low compressibility, low shrink-and-swell tendencies, and high shear strength and bearing capacity, particularly where these granular deposits are confined. Granular materials in outwash landforms form stable slopes and are seldom susceptible to frost heave. Being level and well drained, the sediments in outwash plains are not easily eroded by running water. The boulder content is generally low. A high water table can be expected beneath kettle depressions. Extensive outwash plains provide excellent sites for the construction of roads and airstrips, and are often good sources of concrete and bituminous aggregate. They are good potential sites for ground water development, particularly where the granular deposits are deep and are recharged by water from nearby lakes and rivers.

3.11 RAISED BEACH FORM (LB):

3.11.1 Description:

Raised beaches are generally thin and consist of bouldery, gravelly, and sandy wave- and current-transported materials deposited along the shores of former glacial lakes. The term "raised beach" denotes a landform

marking the position of a former rather than present-day lake margin. Generally, the wave-washed materials were eroded from coarse till and glaciofluvial deposits consisting of sand, gravel, and cobbles.

3.11.2 Occurrence:

Raised beaches (LB) are rare in the Lac des Mille Lacs map-area and only one occurrence has been mapped. It is located southwest of Reserve Bay on Lac des Mille Lacs. This poorly developed unit occurs at an elevation of approximately 455 m, which may represent the highest stage of former Glacial Lake Lac des Mille Lacs.

3.11.3 Engineering and Planning Significance:

The raised beach in this area is too thin and narrow to constitute a major source of granular construction material. Because it is nearly level, well drained, and slightly elevated above the surrounding terrain, it is a good feature to follow in route location if it happens to trend in the desired direction. The water table is generally high in this landform. Raised beaches have a high permeability, good internal drainage qualities, and low compressibility (*i.e.* small amounts of total and differential settlement of structures built upon them). They usually have high shear strength and bearing capacity. They make poor waste disposal sites because of their limited area and the possibility of leakage which can lead to contamination of nearby surface or ground waters.

3.12 GLACIOLACUSTRINE PLAIN (LP):

3.12.1 Description:

Sediments in glaciolacustrine plains consist of varved and massive, fine-grained materials deposited in glacial lake basins of varying size and depth. The proportion of clay, silt, and sand deposited at any particular location in these basins varies with depth of water in the former lake, distance from former shorelines, and the size of particles washed into the lake. Most clay, silt, and sand lacustrine deposits contain minor inclusions of till and scattered dropstones which were rafted into the lake on pieces of ice. In places,

wave and current action in former glacial lakes eroded the surface of till deposits, producing thin patches of washed sand, gravel, and boulders that rest on till or bedrock. In other areas, bedrock knobs and ridges are surrounded by pockets of glaciolacustrine sediment. Glacial lake deposits usually consist of clay and silt (cLP, cmLP, mcLP) which accumulated in deep offshore waters at a depth where the bottom was no longer affected by wave action. Closer to shore, and at points where rivers discharged sandy materials into the lake, the deposits usually consist of fine and medium sand with minor silt (sLP, smLP). Most of these sandy lacustrine deposits accumulated in deltaic environments.

3.12.2 Occurrence:

Glaciolacustrine plains (LP) occur below a cover of organic terrain (OT) along the Swamp River in the southeastern part of the map-area. They consist of red clay deposited in Glacial Lake Kaministikwia, which reached an elevation of approximately 440 m. Lacustrine deposits become silty and sandy at higher elevations, especially near and along former shorelines. Glaciolacustrine red clay is also found along the Shebandowan River east of Lower Shebandowan Lake in the southeastern part of the map-area; here, the clay deposits lie mainly below 455 m in elevation. Other fine-grained glaciolacustrine deposits are located in Duckworth and Laurie Townships in the southeast corner of the area.

Extensive sandy lacustrine deposits are located between the Savanne River and Athelstane Lake in the northeastern part of the area and north of Lac des Mille Lacs in the northern part. These are generally mantled by a thin layer of organic material (*i.e.* peat and muck).

3.12.3 Engineering and Planning Significance:

Glaciolacustrine clay deposits (cLP) have high water retention capacity, low permeability, and poor internal drainage, most of which is controlled by a network of closely spaced joints. Characteristically, these landforms possess low density, low bearing strength, and moderate to high compressibility, unless the fine-grained sediments have been consolidated by the weight of overriding glacier ice or by desiccation. The clay sediments usually provide poor foundation conditions and can be difficult to work

with heavy construction equipment during wet weather. Most clay plains in the map-area are level to gently sloping. The sides of river valleys which have been deeply incised into these fine deposits are usually highly dissected and are susceptible to rill-and-gully erosion on freshly cut ditch and highway back slopes. Higher and steeper natural and man-made slopes are subject to small failures. Where these lacustrine materials carry a high proportion of silt or very fine sand, they are susceptible to frost heave and the formation of frost boils. Subsoil permeability ranges from low to nearly impervious; as noted above, this is largely dependent on the presence of a system of closely spaced joints. In locations where glaciolacustrine clay sediments are highly plastic, they have a tendency to shrink or swell with changes in moisture content. Bearing capacity, shear strength, and compressibility vary greatly with differences in previous loading history and, therefore, the natural moisture content. Bearing capacities can be low in wet areas, particularly where plastic clay soils are normally consolidated or only slightly consolidated.

Low-lying clay plains have a high water table and are subject to local flooding during spring runoff and heavy cloudbursts. During wet weather, the glaciolacutrine clay sediments have poor workability characteristics for building roads and structures. This landform usually provides good sites for waste disposal because of its low permeability.

Lacustrine sand plains (sLP) contain mostly fine and medium sand with minor silt. Coarse sand, gravel, cobbles, boulders, and till are rare in these deposits. Sand plains are gently sloping to undulating and are well drained. A high water table may occur at sites located some distance from the ground water lowering effects of deep valleys and ravines. Sandy lacustrine materials are typically nonplastic and have high permeability, low compressibility, moderate to high bearing capacity, and high shear strength. They are generally not frost susceptible unless they contain a significant amount of silt and very fine sand. They represent fair to good terrain for most construction, especially that of roads and airstrips. They are poor for waste disposal due to the possibility of effluent seepage and ground water contamination.

3.13 ALLUVIAL PLAIN (AP):

3.13.1 Description:

Many alluvial deposits (AP) in this map-area consist of fine and medium sand at depth; these materials are commonly overlain by a silty upper stratum of variable thickness. Oxbows and abandoned channel segments occur where meandering streams cross landforms composed largely of loose silt and fine sand. Sediments beneath alluvial plains are finer textured where the material being carried by the stream was eroded from clay and silty clay glaciolacustrine deposits. The landform includes flood plains that have been eroded in till and are strewn with boulders, as well as segments of stream valleys where alluvial sediments range in texture from coarse sand to coarse gravel and cobbles. Long and complex alluvial plain systems sometimes include three constituent landforms: low alluvial terraces, alluvial flood plains, and stream channels.

3.13.2 Occurrence:

Alluvial plains (AP), many of them too small to map at the 1:100 000 scale, are scattered throughout the map-area. Examples of deposits which have been shown on the map are those (1) northeast of Bedivere Lake in the northwestern part of the area, (2) along the Wawiag River in the southwestern part, (3) along Crayfish Creek and the Kashabowie River in the central part, and (4) along the Swamp River in the eastern part. In some cases, the alluvial deposits are mantled by a thin layer of organic material (OT/AP). Examples of this occur along the Obadinaw River in the southwestern part of the area and along the Savanne River in the northeast corner.

3.13.3 Engineering and Planning Significance:

Alluvial plains are subject to flooding. The water table is usually situated at or near the surface for much of the year; organic-filled depressions are common. Although some alluvial terraces, flood plains and channel bottoms represent potential sources of sand and gravel for construction purposes, the high water table may cause problems during excavation of

such materials. This landform is generally unsuitable for transportation routes, general construction, or waste disposal sites because of the high water table and risk of flooding.

3.14 ORGANIC TERRAIN (OT):

3.14.1 Description:

Organic terrain includes varying depths of peat and muck in marshes, swamps, fens, and bogs. No attempt was made to separate these organic landscape types during the mapping. Although peat and muck deposits usually occur as relatively thin surficial layers, in places these organic materials can be several metres thick. Moreover, the thickness of the deposits can change drastically over very short distances.

3.14.2 Occurrence:

Thin organic deposits overlie glaciolacustrine materials (OT/LP) in scattered localities throughout the southeastern part of the Lac des Mille Lacs map-area. Large areas of flat, low-lying, glaciofluvial and glaciolacustrine terrain, situated on both sides of the Savanne River and north of Lac des Mille Lacs in the northeastern part of the map-area, are covered by peat and muck deposits.

3.14.3 Engineering and Planning Significance:

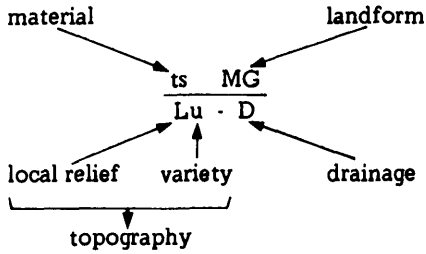
Although organic deposits are commonly thin, they are nonetheless very poor foundation and construction materials. The water table is at or near ground surface for most of the year. The locations of deeper pockets of organic material are difficult to predict reliably without extensive test-drilling. The topography of organic terrain is level or slightly depressional. Peat and muck deposits have low shear and bearing strengths and generally low permeability. They are nearly always poorly drained, highly compressible, and are subject to seasonal flooding. Consequently, they are unsuitable sites for nearly all types of engineering works and for waste disposal.

4.0 APPENDIX: EXAMPLES OF TERRAIN UNIT LETTER CODES:

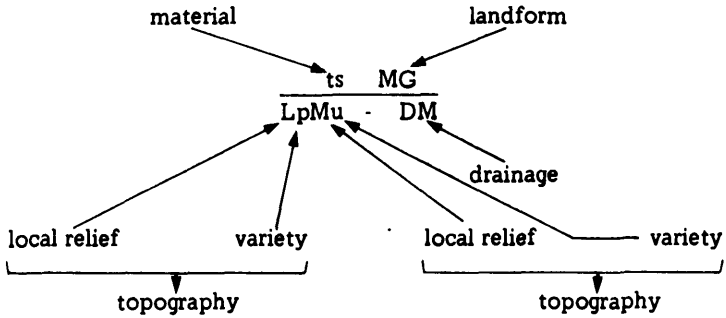
The engineering terrain unit letter codes consist of four components: surface materials, landform, topography, and drainage. The format of the letter codes used in describing the terrain units is discussed in detail in the Users' Manual (Gartner, Mollard, and Roed 1980). Some additional examples of the letter codes are as follows:

4.1 SIMPLE TERRAIN UNIT:

Example 1:



Example 2:

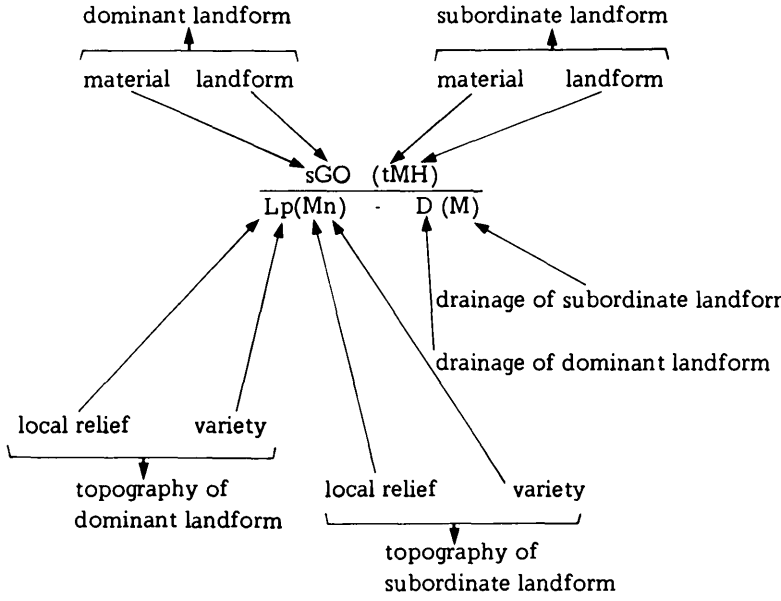


Note: The above type of letter code is used where there are two distinctly different types of topography and/or drainage in a simple terrain unit.

4.2 COMPLEX TERRAIN UNIT:

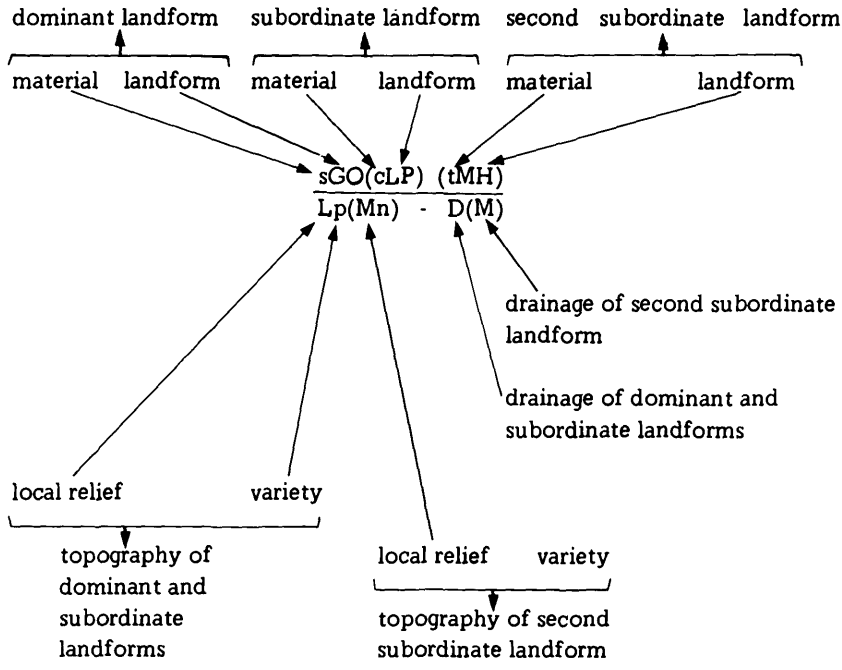
In complex areas, the dominant landform is shown first and the subordinate landform(s) appear in parentheses.

Example 1:



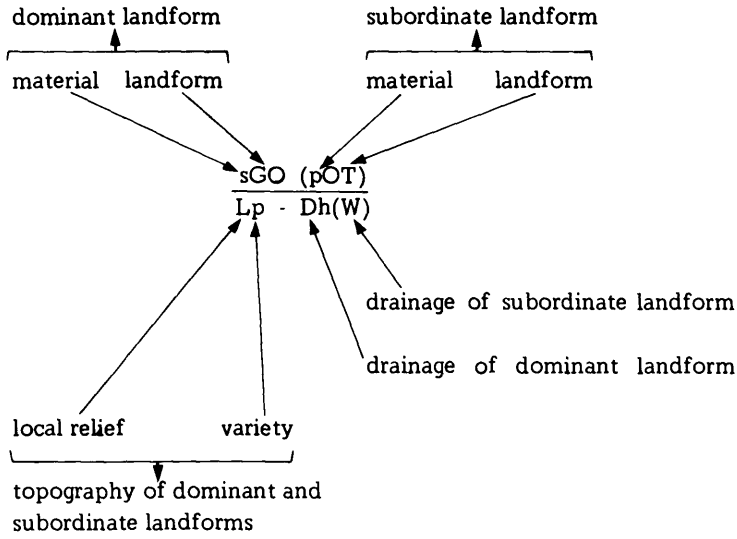
Note: The topography and drainage in parentheses refer to the landform shown in parentheses.

Example 2:



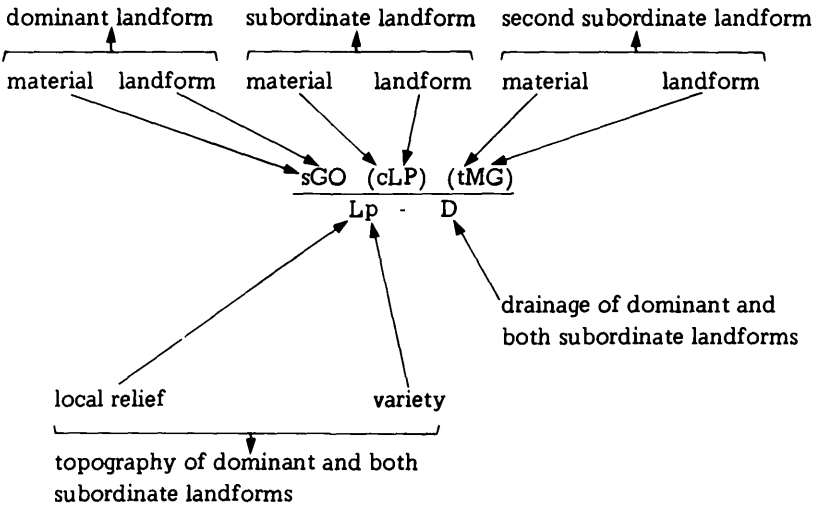
Note: The topography and/or drainage in parentheses refer to the second subordinate landform (in parentheses).

Example 3:



Note: If topography or drainage is similar in the dominant and subordinate landforms, then no topography or drainage symbol is shown in parentheses and the symbol shown applies to both landforms. If topography or drainage conditions are different in one of the landforms, a topography or drainage symbol is shown in parentheses to indicate this difference.

Example 4:



Note: Where topography and drainage conditions are similar in all of the landforms shown, no topography or drainage symbols are placed in parentheses.

5.0 REFERENCES:

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Ontario Ministry of Natural Resources

Hon. James A. C. Auld
Minister

Dr. J. K. Reynolds
Deputy Minister

Ontario Geological Survey

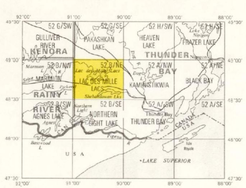
Map 5074

LAC DES MILLE LACS

NTS 52 B/NE

Data Base Map

Northern Ontario Engineering
Geology Terrain Study



INDEX TO ADJOINING SHEETS

1:100 000

2 1 0 2 4 6

One centimetre represents one kilometre

LEGEND

LANDFORM

MORAINAL
- ME *End moraine*
- MG *Ground moraine*
- MH *Hummocky moraine*

GLACIOFLUVIAL
- GD *Ice contact delta, esker delta, kame delta, delta moraine*
- GE *Esker, esker complex, crevasse filling*
- GK *Kame, kame field, kame terrace, kame moraine*
- GO *Outwash plain, valley train*

GLACIOLACUSTRINE
- LB *Raised (abandoned) beach ridge*
- LD *Glaciolacustrine delta*
- LP *Glaciolacustrine plain*

ALLUVIAL
- AP *Alluvial plain*

COLLUVIAL
- CS *Slope failure*
- CT *Talus pile*
- CW *Slopewash and debris creep sheet; minor talus*

EOLIAN
- ED *Sand dunes*

ORGANIC
- OT *Organic terrain*

BEDROCK
- RL *Bedrock plateau*
- RN *Bedrock knob*
- RP *Bedrock plain*
- RR *Bedrock ridge*
- /R *Bedrock below a drift veneer*

MATERIAL

- b *boulders, bouldery*
- c *clay, clayey*
- g *gravel, gravelly*
- p *peat, muck*
- r *rubble*
- s *sand, sandy*
- m *silt, silty*
- t *till*

TOPOGRAPHY

LOCAL RELIEF
- H *Mainly high local relief*
- M *Mainly moderate local relief*
- L *Mainly low local relief*

VARIETY
- c *channelled*
- d *dissected, gullied*
- j *jagged, rugged, cliffed*
- j* *cliffed volcanic rock signature*
- k *kettles, pitted*
- n *knobby, hummocky*
- p *plain*
- r *ridged*
- s *sloping*
- t *terraced*
- u *undulating to rolling*
- w *washed, reworked*

DRAINAGE

SURFACE CONDITION
- W *Wet*
- D *Dry*
- M *Mixed wet and dry*
- h *Suspected high water table*

The letter codes describing the terrain units are made up of four components arranged as follows:—

MATERIAL	LANDFORM
TOPOGRAPHY	DRAINAGE

Examples:

1. dominant landform
   - material: IMG(RN)
   - subordinate landform
   - drainage: Mu(Hj)-D
   - local relief
   - topographic variety of dominant landform
2. slash indicates a veneer of one landform overlying a second landform: pOT/sGO / Lp-W

SYMBOLS

- *Significant end moraine or linear moraine-like feature*
- *Well expressed drumlins and drumlinoid ridges*
- *All other linear ice-flow features*
- *Esker ridge (continuous, discontinuous; the symbol does not indicate direction of flow)*
- *Abandoned shoreline (continuous, discontinuous)*
- *Local dune area (type and location of individual dunes not indicated)*
- *Abandoned river channel, spillway, or ice marginal channels*
- *Escarpment*
- ●10 *Sample location*
- *Small landslide scar*
- *Sand or gravel pit*
- *Quarry or mine workings evident from airphotos or field observation (crossed picks are shown in the area of open excavation)*
- *Other man-made features (rock dumps, tailings, lagoons, landfills, etc.; type of feature mentioned where identifiable)*
- *Steep-walled valleys, often bedrock-controlled features*
- *Talus (defined, inferred; base of talus triangle indicates downslope side of escarpment)*
- *Line joining two same terrain units*

NOTE 1:

This map is a landform inventory, as determined largely by airphoto interpretation, that provides base data for engineering and resource planning. Accuracy of terrain unit boundaries is consistent with map scale. Detailed investigations are required to obtain site specific geotechnical information. Refer to accompanying report for more detailed terrain descriptions and engineering significance.

NOTE 2:

Colour is used to highlight only glaciolacustrine, glaciofluvial, morainal and organic landforms. In the case of layered or complex terrain units, colour is used only if one of the above noted landforms is dominant from an engineering viewpoint in the terrain unit.

NOTE 3:

Not all letter and graphic symbols shown in the legend necessarily appear on this map sheet.

Information from this publication may be quoted if appropriate credit is given. Reference to this map is recommended as follows:

Mollard, D. G.
1980: Northern Ontario Engineering Geology Terrain Study,
Data Base Map, Lac Des Mille Lacs
Ontario Geological Survey, Map 5074, Scale 1:100 000

Published 1980. Base Map derived from 1 inch to 2 miles Provincial Series, Surveys and Mapping Branch, Ministry of Natural Resources.

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THIS PROJECT WAS FUNDED BY THE ONTARIO MINISTRY OF NORTHERN AFFAIRS