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# SAND AND GRAVEL RESOURCES
# OF THE
# ST. PAUL AND BONNYVILLE AREAS
# ALBERTA

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## ABSTRACT

This report delineates areas containing sand and gravel in the St. Paul area, and describes in detail the geology of the most important deposits. Within the area there are six sites which can supply aggregate. The largest deposit, 26 km southeast of St. Paul, contains an estimated 10,000,000 $m^3$ of sandy gravel, another, 29 km east-southeast of St. Paul contains 5,000,000 $m^3$ of gravelly sand. These deposits will become the major sources of aggregate for the St. Paul area. The Bonnyville area contains an abundance of granular deposits, but most is in the form of fine sand. Three sites contain over a million cubic metres of gravel. Two of these are terraces along the Beaver River, located 13 km north and 53 km northwest of Bonnyville. The third site is a fluvial bar in the Mooselake River valley, 20 km northwest of Bonnyville. Little coarse aggregate remains in the eastern portion of the Bonnyville study area and future supplies for Medley, Grande Centre and Cold Lake will have to come from the Mooselake River valley, or outside the area studied. Bonnyville will continue to get aggregate from the La Corey pit (13 km north) but with an increasing reliance on the Mooselake River valley site.

## INTRODUCTION

This report is one of a series intended to provide information on the sand and gravel resources of Alberta. This information can provide a starting point for detailed exploration programs and can aid planners in making decisions involving land use.

This survey is concerned with delineating and describing presently exploitable deposits and identifying deposits with future potential. The deposits described, are mappable at a scale of 1:50,000, have a thickness of at least 1 m, and have a ratio of overburden to gravel and sand of no more than 1:1. Volume or tonnage figures are general estimates based on a geological interpretation of the deposits and not detailed subsurface data.

## ACKNOWLEDGMENTS

Funds for this project were supplied by Alberta Energy and Natural Resources.

I would like to thank I.J. McLaws for her help in the field; C. Carawan and J.M. Farrow for their assistance in the field and the office; P. Sham for laboratory analyses, and J. Fox, B. Peterson, M.M. Fenton, L.D. Andriashek, and E.A. Babcock for their critical reading of the manuscript.

## LOCATION OF STUDY AREAS

The study encompasses two areas located in east-central Alberta (Fig. 1); a southern area centred about the town of St. Paul and a northern area along the Beaver River north of Bonnyville.

The southern study area (St. Paul) is bounded on the north by Highway 28A, on the east by Highway 41, on the south by the North Saskatchewan River, and on the west by Highway 28 and the Range 10/11 boundary. The area includes all or part of NTS maps 73E14 and 15 and 73L 2,3, and 4 and is within Townships 55 to 60, Ranges 6

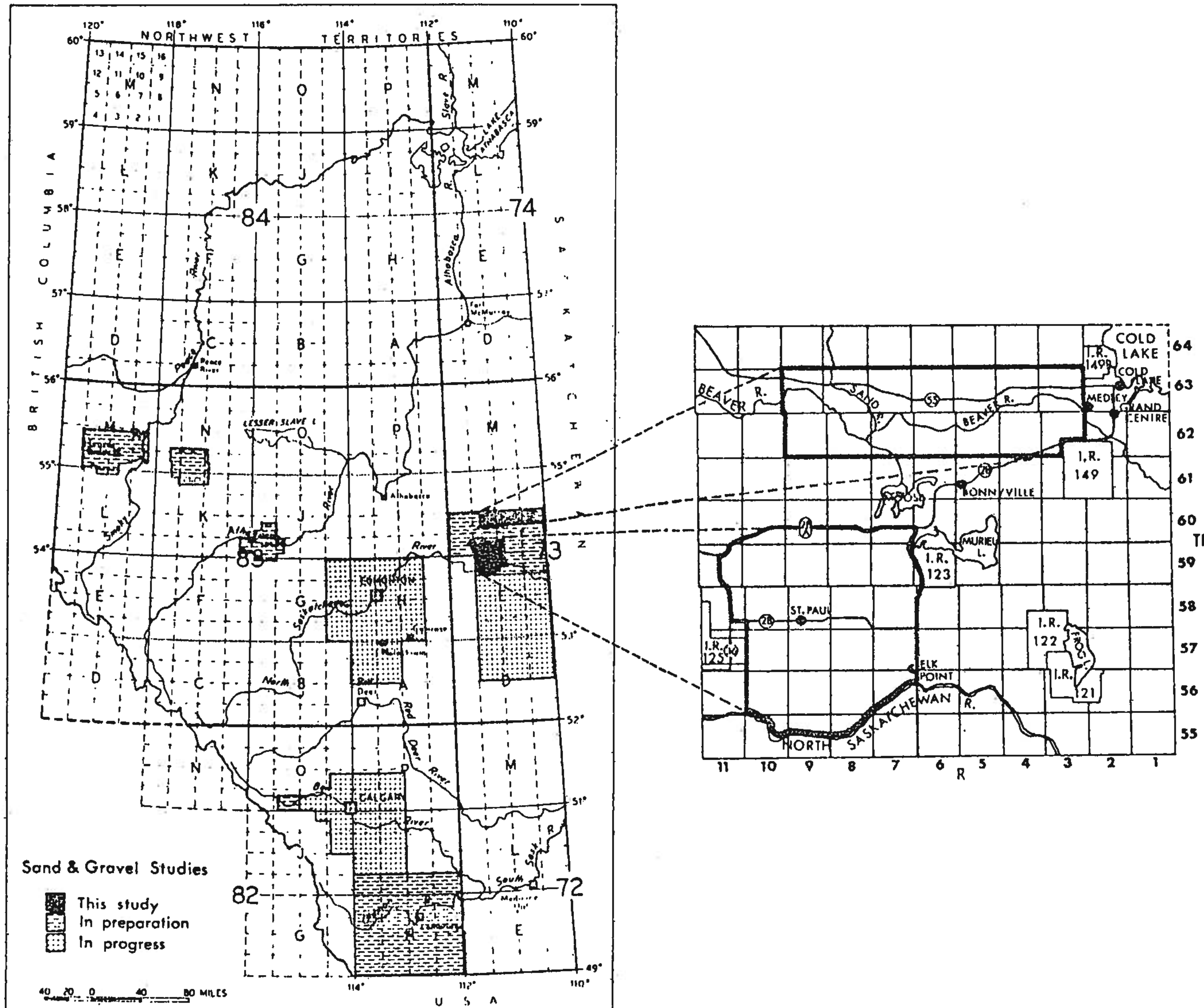



FIGURE 1. Location of this and other Sand and Gravel Inventory studies.

to 11, west of the fourth meridian. Most of the area is within the county of St. Paul with the town of St. Paul (population 4710) being the seat of county government.

The northern study area (Bonnyville) straddles the Beaver River and includes parts of NTS maps 73L, 6, 7 and 8 and is within Townships 62 and 63, Ranges 3 to 9, west of the fourth meridian. The town of Bonnyville (population 3250), located south of this area, is the headquarters for the Municipal District of Bonnyville. A large portion of the northern study area falls within this M.D. The towns of Medley (7000), Grande Centre (2829) and Cold Lake (1585) are located east of the area surveyed.

## PREVIOUS WORK

Detailed surficial geology maps were not available for the area when the survey was made. However, a map by R.B. Ellwood (1961) at a scale of 1:125,000 covering 1:50,000 scale NTS maps 73E 14 and 15 and preliminary data for NTS map 73L (Fenton and Andriashek, *in prep.*) provided useful information. Waterwell logs and soil survey information also provided useful information.

## METHOD OF STUDY

Data presented in this paper come from the following sources:

(1) fieldwork (described below) involving surface mapping, resistivity surveying, power auger drilling, and digging of test pits by backhoe,

(2) a limited amount of data was provided by aggregate producers and landowners,

(3) laboratory analyses of samples collected during this study.

Air photo interpretation and mapping were performed from June to August 1977 and during June of 1978.

Most existing pits, sections and areas having a high probability of containing gravel were field checked and sampled. Normally, 10 to 15 kg samples of granular sediments were collected and returned to the laboratory for granulometric analyses. Lithologic examination of samples and bulk sample (500 to 1000 kg) sieving was done in the field. During October and November 1977, a Mobile B-61 truck mounted power auger was used to drill 186 holes in the areas to determine the thickness of deposits, delineate deposit boundaries and to obtain samples for examination and testing. In June 1978, a Geonics EM-31 resistivity unit was used to define the geometry of the major sand and gravel bodies.

Definitions of the terms and sediment size boundaries used in this paper can be found in the appendix.

## GEOLOGY

### BEDROCK

The southern study area (St. Paul) is underlain by Cretaceous Belly River sandstone and the northern area (Bonnyville) by Lea Park shale (Currie and Zacharko, 1976; Green, 1972; and McLean, 1971).

The local bedrock is soft and easily comminuted and therefore does not form a major component of the sand and gravel in the areas. Ironstone concretions, common in both the Lea Park and Belly River Formations, are the most durable fraction of these Cretaceous formations and form a small percentage of most sand and gravel deposits.

### SURFICIAL GEOLOGY

Most granular materials in the study areas were deposited under glaciofluvial conditions at the end of the last glacial period. For this reason an understanding of the surficial (glacial) geology is important in locating gravel deposits. Figure 2 shows the surficial units mapped through air photo interpretation and fieldwork.

Most of the area (Fig. 2) is covered by moraine composed of till. Several tills have been differentiated in the region (Fenton and Andriashek, *in prep.*) but no attempt was made to map the different tills or establish the till stratigraphy during this study. A thin layer of sand, sometimes with gravel, was observed between till units south of St. Paul and intertill sand was noted at greater depths in waterwell logs from other parts of the areas. This stratified unit does not appear to contain sufficient quantity or quality of aggregate to warrant a detailed stratigraphic investigation.

The ice which deposited the surface till in the St. Paul area appears to have advanced from the northwest to the southeast. This is indicated by the orientation of the belt of fluted moraine (1b on Fig. 2) which extends from the Mann Lakes (Township 60, Range 11) to Elk Point (Township 57, Range 7) and by the position of glacial thrust blocks (1c on Fig. 2) southeast of their probable areas of excavation (for example, Upper and Lower Thérien Lakes, Township 57, Range 10). Such clear indicators of ice movement are not found in the Bonnyville area. Ice in this area probably advanced from the north and northeast.

The surficial units in figure 2 are divided into five categories: 1) glacial, 2) glaciofluvial, 3) glaciolacustrine, 4) bedrock, and 5) undifferentiated Recent deposits. The glacial deposits were subdivided on the basis of morphology and genesis as interpreted mainly from air photos. The moraine plain (1a), fluted moraine (1b) and ice-thrust moraine (1c) were probably formed under conditions of active glacial movement. The stagnant-ice moraine (1d) was probably formed by the ablation of a large mass of debris-rich stagnant ice. The glaciofluvial units include outwash and ice-contact deposits (eskers, kames and crevasse fillings). The bedrock unit includes exposed bedrock, with a thin drift cover, and slumped bedrock.

The water-modified moraine (1e) is moraine plain which has been modified slightly by later meltwaters.

Areas of moraine plain and fluted moraine are unlikely localities for gravel deposits because glacial activity tends to mix sediment rather than sort it. Minor lenses of sand and/or gravel are common in the ice-thrust areas southeast of the Therién Lakes and one deposit north of St. Paul may be a large ice-thrust block. These granular materials were plucked, carried and deposited by the ice as discrete blocks. The stagnant-ice moraine unit can also contain granular material. Complex networks of meltwater channels drained the areas of stagnant ice resulting in the transportation and deposition of the coarse grained materials. In areas of water-modified moraine the action of meltwaters altered the morphology and air photo expression of the moraine but generally did not deposit or accumulate sand and gravel.

Where the meltwater flowed off the ice a conical hill of sand and gravel (kame, 2a) was sometimes formed; where it funnelled through cracks in the ice linear ridges of aggregate (eskers, 2a) were left, and when the meltwater flowed along the channels between ice blocks or away from the ice shallow glaciofluvial bars were left (2b). Large accumulations of aggregate of glaciofluvial origin are shown as units 2a and 2b in figure 2. Deposits of granular materials are shown in figure 3 and important ones will be considered in more detail in the following chapter.

## SAND AND GRAVEL

### INTRODUCTION

Locations of sand and gravel deposits are shown in figure 3. All pit locations and descriptions, sample sites, and testhole logs are on file at the Alberta Research Council. The locations of some pits, sample sites and testholes are shown in the detailed figures in this section.

Volume figures are general estimates derived from a geological interpretation of the deposit. This interpretation is based on air photo interpretation, investigation of surface exposures and limited subsurface testing. Deposits should be tested in detail before they are developed.

## ST. PAUL STUDY AREA (Fig. 3)

There are six major sand and gravel sites within the St. Paul study area. Most of the area north of Highway 28 is composed of moraine plain, fluted moraine and stagnant-ice moraine — areas with a low potential for granular resources, and only one major aggregate deposit is found here (site 1 in Fig. 3). South of Highway 28, some small sand and gravel deposits (site 2 in Fig. 3) are found in an area of ice-thrust and stagnant-ice moraine and four large outwash and melt-water channel deposits (sites 3, 4, 5, and 6 in Fig. 3) are found which contain granular materials. A discussion of each of the six major sand and gravel sites in the St. Paul area follows.

### Site 1 (5-59-9-W4 and 31-58-9-W4)

*Description*

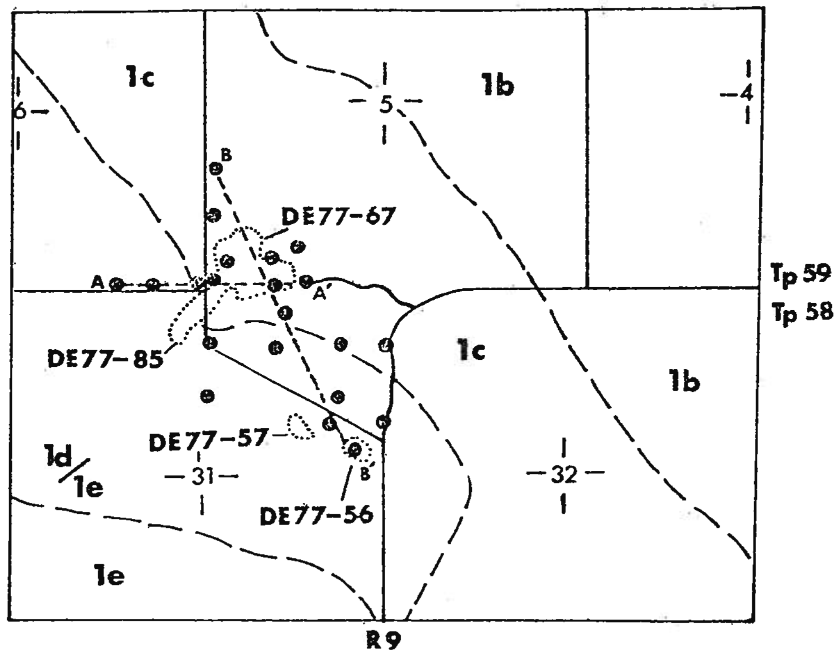
Two types of deposits are found in this small area. Stations DE77-56 and DE77-57 (Fig. 4) are in kames resting on till. Stations DE77-67 and DE77-85 are in what is interpreted to be a large ice-thrust block or, alternatively, occur between two till sheets.

The internal structure of the largest kame (DE77-56) was well exposed and it is highly contorted. The texture of the sediment in these kames is variable but it is generally clean, medium to fine sand, or gravelly sand (Fig. 5).

The thrust feature (DE77-67 and 85) is irregular in shape and the content of coarse aggregate within the deposit is variable. Medium to fine sand (Fig. 6, station DE77-67) is found in the northern and western parts of the feature and coarse sandy gravel (Fig. 6, station DE77-85) is found in the southern and eastern sections. Overburden (till) thickness ranges from 1 to 8 m and the thickness of the deposit varies from 2 to about 10 m (Fig. 7).

*Extent*

The kames are about 0.5 to 2 ha in area and may contain about 10,000 $m^3$ of granular material. The thrust or intertill deposit is about 16 ha in area and may contain 50,000 $m^3$ to 100,000 $m^3$ of sand and gravel.




LEGEND

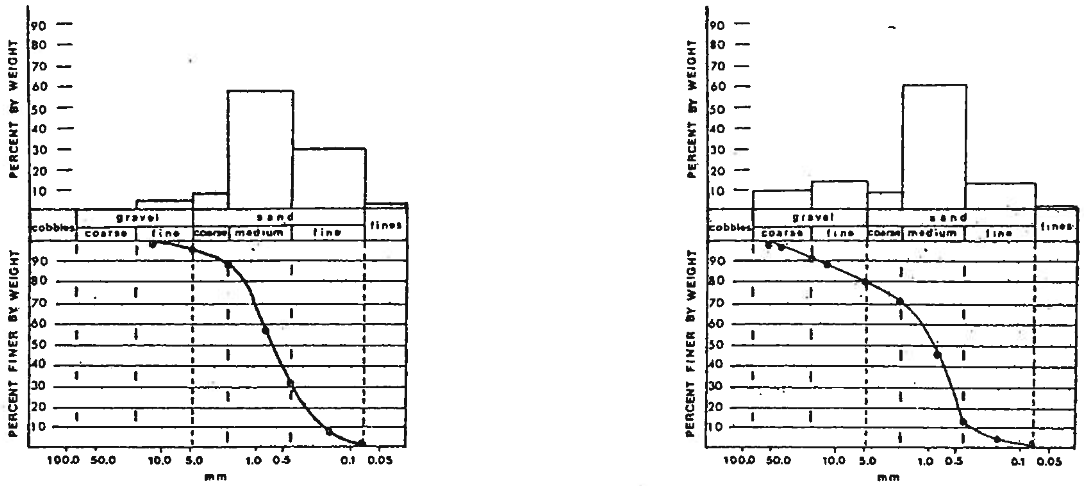
Surficial units

Fluted Moraine ..............................1b
Ice-thrust Moraine ..........................1c
Stagnant-ice Moraine ........................1d
Water-modified Moraine ......................1e

Geologic contacts ..........................
Sand and gravel exposure ...................
Station number .............................DE77-56
Roads ......................................
Line of geologic section ...................A----A'
Testhole ...................................

Geological interpretation based on airphotos.

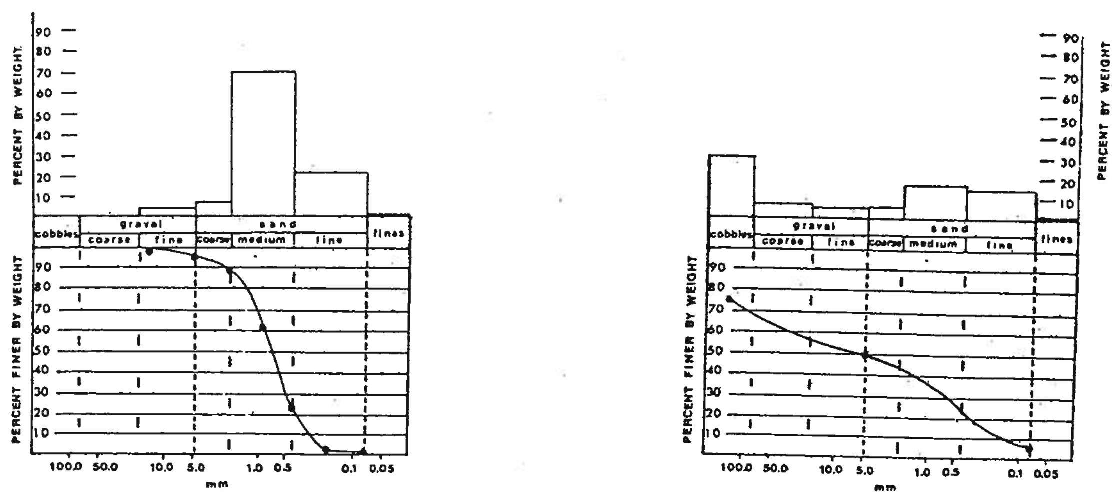
FIGURE 4. Map of site 1 showing the surficial geology, stations (DE77-56, 57, 67 and 85), testholes and cross-sections.




DE-77-56

DE77-57

FIGURE 5. Grain-size distributions of samples from kames at site 1.




DE77-67

DE77-85

FIGURE 6. Grain-size distributions of samples from the ice-thrust deposit at site 1.

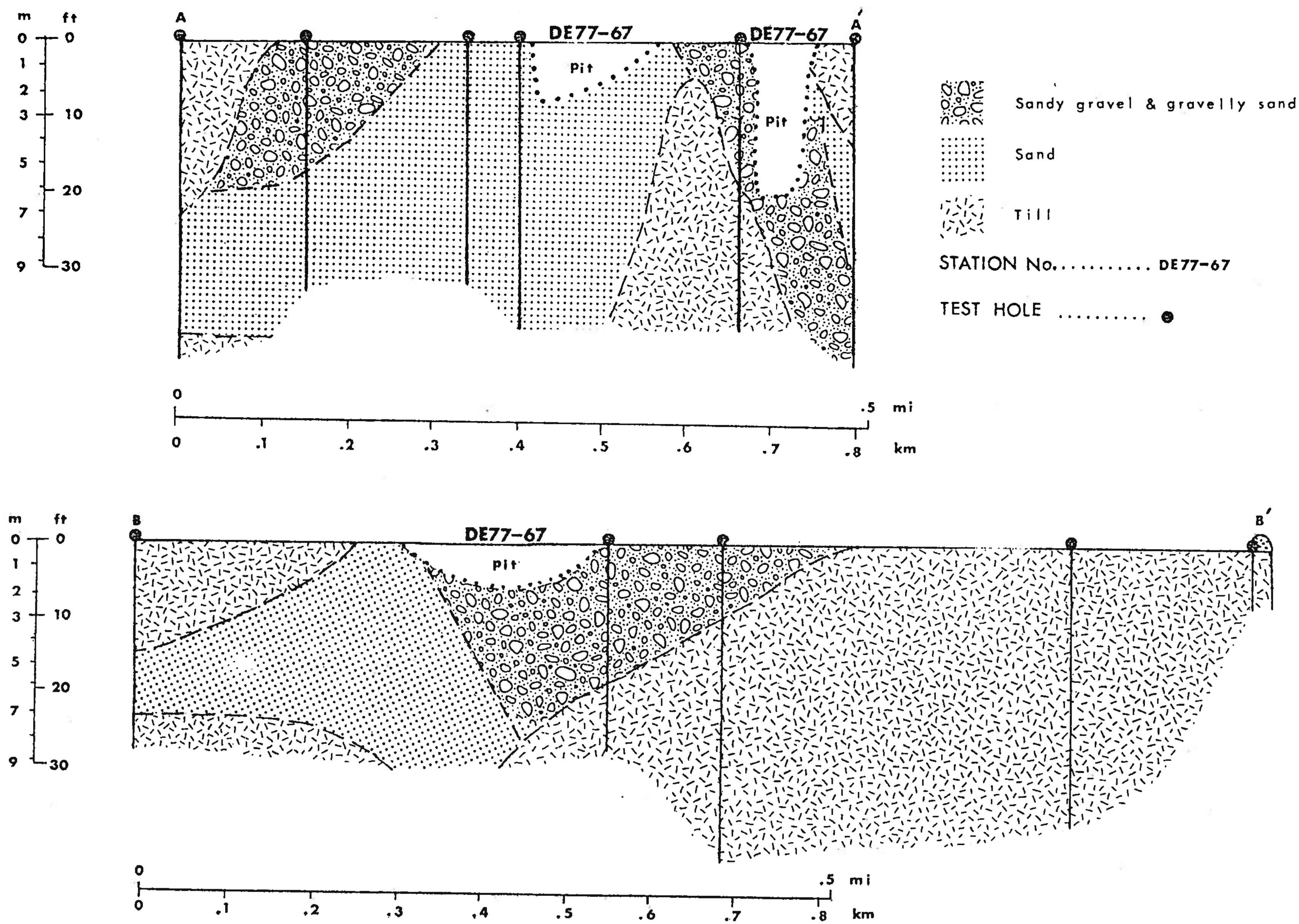



Figure 7. Geologic sections A-A' and B-B' (see Fig. 4) across site 1.

*Resource potential*

The area is only 13 km north of St. Paul and contains coarse gravel suitable for crushing. For these reasons this deposit was the major supplier of road base, concrete and paving materials to St. Paul in 1977. However, about 75 percent of the deposit has been excavated and alternative sources of aggregate are being utilized.

Site 2 (Township 57, Range 10)

*Description*

The area is mapped as stagnant-ice moraine and contains numerous hummocks interpreted as kames. The sediment in the various kames appears to be similar in texture: clean, medium to fine sand and gravelly sand. Samples from stations DE77-1, 80a, 81 and 83 show this textural similarity (Fig. 8). Some gravelly sand or sandy gravel beds are present interbedded with the sands (DE77-80b and 82a, Fig. 8).

Pebbles (12 to 36 mm) from stations DE77-34 and DE77-82 were analyzed petrographically (Table 1). The gravel is composed of about 82 percent durable rock types and 18 percent of rock types that are potentially deleterious. Minor amounts of coal particles were found in some sand beds.

*Extent*

Individual deposits range in thickness from 1 to 7 m and in area from about 0.5 to 3 ha. Numerous other knolls in the area may contain sand or gravelly sand. Most of the features contain 1000 $m^3$ to 10,000 $m^3$ while a few of the larger deposits may hold up to 100,000 $m^3$ of aggregate material.

*Resource potential*

The deposits are relatively small in size and fine textured. They may have use locally for road sanding in winter or as fine aggregate for concrete or mortar sand.

Site 3 (South half 56-10-W4)

*Description and extent*

This is an area of outwash and lag gravel with gravel thicknesses varying from 3 m [at pits DE77-23 (9-18-56-10-W4) and 31 (1-18-56-10-W4)] to a cobbly lag only

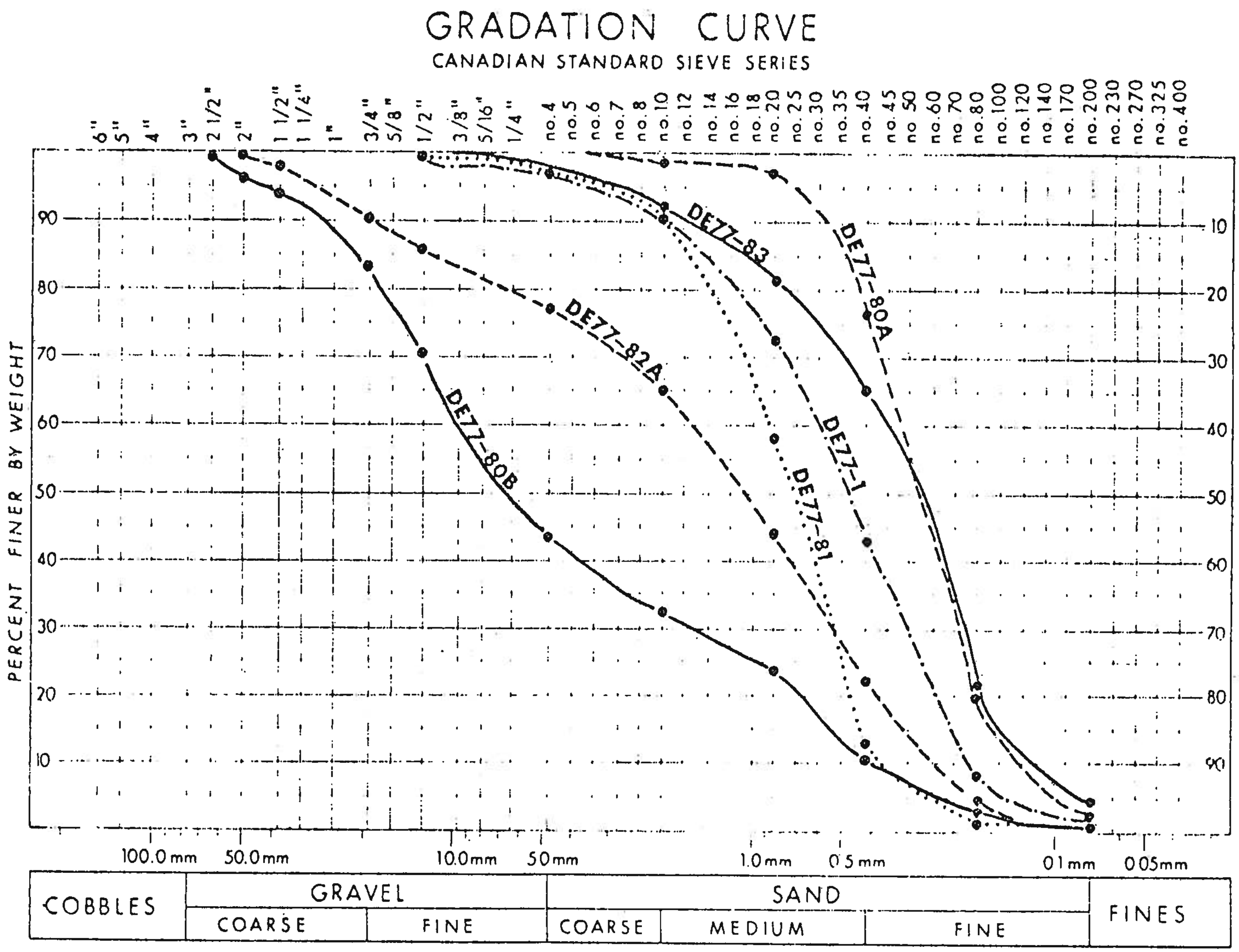



FIGURE 8. Grain-size distributions for samples taken from kames at site 2. Sample locations are: DE77-1(4-1-58-10-W4), DE77-80 A and B (11-27-57-10-W4), DE77-81(12-34-57-10-W4), DE77-82(2-3-57-10-W4) and DE77-83(16-17-57-10-W4).

Table 1. Petrographic Analyses of Pebbles (12 mm to 36 mm)

| Location | Site | Station | Durable Rock Types: Granite (%) | Durable Rock Types: Quartzite (%) | Durable Rock Types: Hard Sandstone (%) | Potentially Deleterious Rock Types: Gneiss (%) | Schist (%) | Friable Sandstone (%) | Carbonate (%) | Local[1] Rock (%) | Chert (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-31-58-9-W4 | 1 | DE-77-57 | 53 | - | 24 | 7 | - | - | 4 | 12 | - |
| 1-7-57-10-W4 | 2 | DE-77-34 | 41 | 6 | 38 | 10 | - | - | - | 5 | - |
| 11-27-57-10-W4 | | DE-77-80 | 62 | 4 | 15 | 3 | 2 | - | - | 13 | 1 |
| 32-3-57-10-W4 | | DE-77-82A | 55 | 6 | 18 | 2 | 1 | - | 4 | 14 | - |
| 8-18-56-10-W4 | 3 | DE-77-32 | 49 | 13 | 20 | 17 | - | - | - | 1 | - |
| 12-17-56-10-W4 | | DE-77-35 | 57 | 4 | 19 | 7 | 1 | - | - | 12 | - |
| 15-32-55-9-W4 | 4 | DE-77-4A | 69 | 1 | 24 | 2 | - | - | - | 4 | - |
| 16-33-55-9-W4 | | DE-77-9B | 39 | 5 | 34 | 12 | - | - | - | 10 | - |
| 15-28-55-9-W4 | | R77-SP-48C | 53 | 1 | 38 | 3 | - | 1 | - | 4 | - |
| 1-20-56-7-W4 | 5 | DE-77-72C | 48 | 9 | 27 | 7 | - | - | - | 7 | 2 |
| 16-17-56-7-W4 | | DE-77-73 | 55 | 14 | 14 | 5 | 1 | 3 | - | 8 | - |
| 15-21-56-7-W4 | | DE-77-78A | 48 | 2 | 23 | 2 | 3 | 5 | - | 17 | - |
| 15-21-56-7-W4 | | R77-SP-53B | 49 | 5 | 31 | 3 | - | - | - | 12 | - |
| 5-21-56-7-W4 | | R77-SP-54A | 48 | 3 | 29 | 4 | 1 | 3 | - | 17 | - |
| 2-20-56-7-W4 | | R77-SP-71A,B | 59 | 2 | 22 | 6 | - | 2 | 1 | 7 | 1 |
| 16-34-56-7-W4 | 6 | DE-77-14B | 52 | 3 | 30 | 2 | 1 | 3 | 3 | 6 | - |
| 16-35-56-7-W4 | | DE-77-17A | 52 | 5 | 23 | 5 | 2 | 2 | 1 | 10 | - |
| 16-35-56-7-W4 | | DE-77-17C | 44 | 16 | 24 | 5 | 1 | 2 | - | 5 | 3 |
| 18-36-56-7-W4 | | DE-77-19 | 47 | 20 | 18 | 3 | - | 3 | - | 9 | - |
| 13-5-63-8-W4 | 9 | DE-77-112 | 48 | 3 | 21 | 9 | 1 | - | - | 18 | - |
| 3-30-62-5-W4 | 10 | DE-77-116B | 55 | 3 | 17 | 8 | - | 2 | - | 15 | - |
| 3-30-62-5-W4 | | DE-77-116C | 61 | 6 | 13 | 8 | 4 | - | 8 | - | - |
| 4-30-62-5-W4 | | DE-77-116E | 58 | 4 | 26 | 1 | - | - | 6 | 5 | - |
| 4-30-62-5-W4 | | DE-77-116F | 59 | 2 | 14 | 6 | 1 | - | - | 18 | - |
| 12-11-63-3-W4 | 11 | JM-77-16 | 57 | 3 | 18 | 6 | 1 | - | 3 | 12 | - |
| 13-4-62-7-W4 | 12 | DE-77-109 | 55 | 4 | 21 | 6 | - | - | 6 | 8 | - |
| 14-4-62-7-W4 | | R77-SP-149A | 52 | - | 33 | 3 | - | - | - | 12 | - |
| 10-4-62-7-W4 | | R77-SP-153B | 55 | 3 | 29 | - | - | 2 | 7 | 4 | - |

[1] Local rock types: shale, siltstone, ironstone, sandstone (see friable sandstone) and coal.

centimetres thick. The composition of the outwash is consistent over the area: sandy gravel to gravelly sand composed --incipally of medium sand and fine gravel (Fig. 9). The pebble fraction (12 to 36 mm) contains an average of 81 percent of durable clasts and 19 percent deleterious rock types (Table 1). Site 3 covers about 1400 ha. However, this figure includes low marshy areas as well as the more prospective highs.

*Resource potential*

The irregular occurrence of relatively shallow deposits over a large aerial extent limits the usefulness of this area as a source of aggregate. Although the overall quantity could be several million cubic metres the likelihood is that exploitable deposits do not exceed several hundreds of thousands of cubic metres. Deposits here should continue to be of interest for local roa maintenance but could not satisfy the demands of a large project.

Site 4 (Sections 22, 23, 24, 27, 32, 33 and 34, Township 55, Range 9)

*Description and extent*

Small deposits of sand and gravel occur in a linear trend through an area of stagnant and ice-thrust moraine. They are probably outwash sediments filling in a meltwater channel. Individual deposits are relatively small (less than 4 ha), thin (less than 4 m) and variable in thickness and generally contain less than 10,000 cubic metres. The material is moderately well sorted to poorly sorted and varies from dirty to clean sandy gravel or sand. The pebble fraction (12 to 36 mm) contains about 88 percent hard, durable rock types and 12 percent deleterious rock types which could disintegrate easily (Table 1).

*Resource potential*

As in site 3, this area may be of local interest for road maintenance but could not supply the needs of a major building project.

Site 5 (Sections 16, 17, 20 and 21, Township 56, Range 7)

*Description*

This is a large area of pitted outwash dissected by meltwater channels (Figs. 10 and 11). The deposit rests on till or bedrock. The north and northwest part of

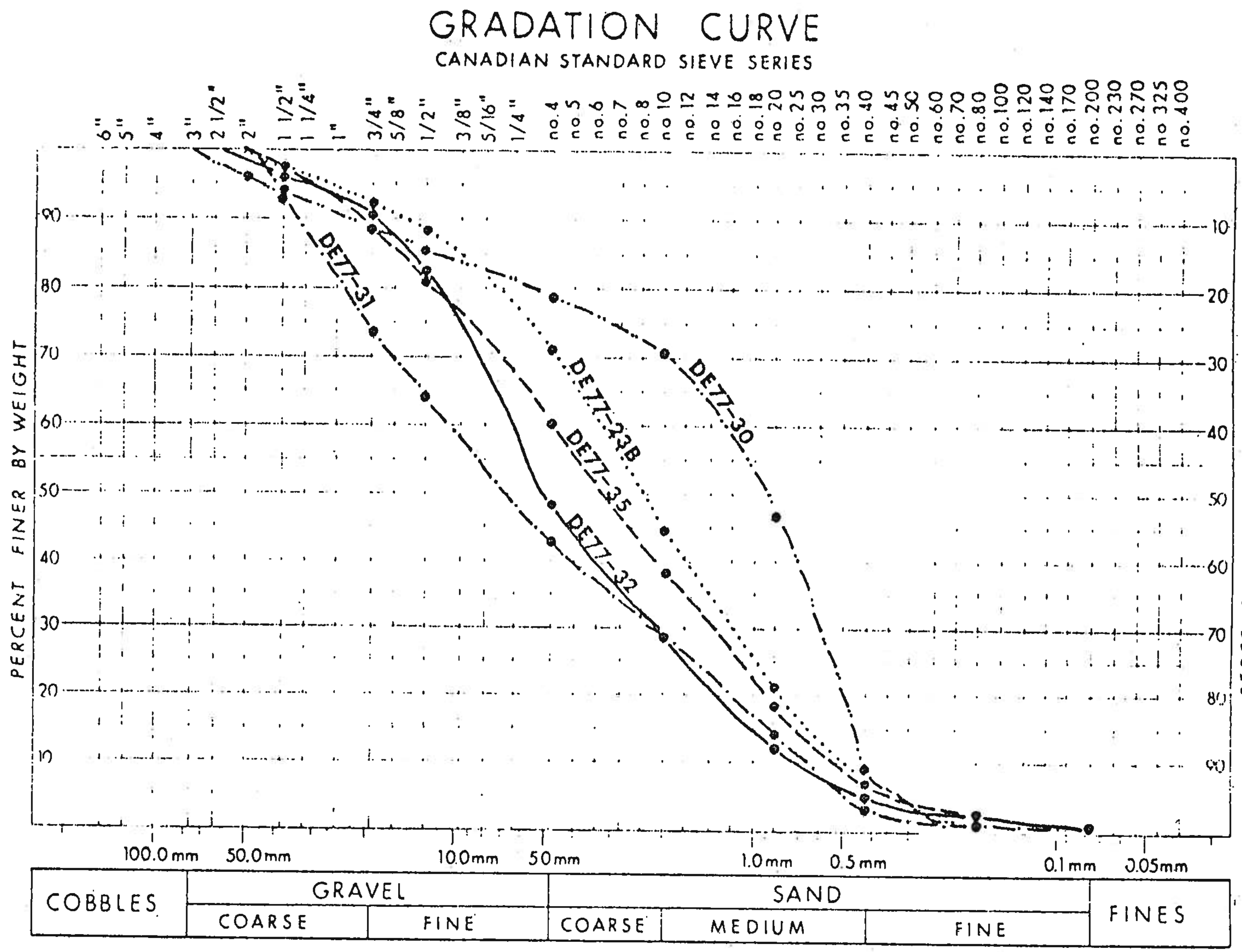
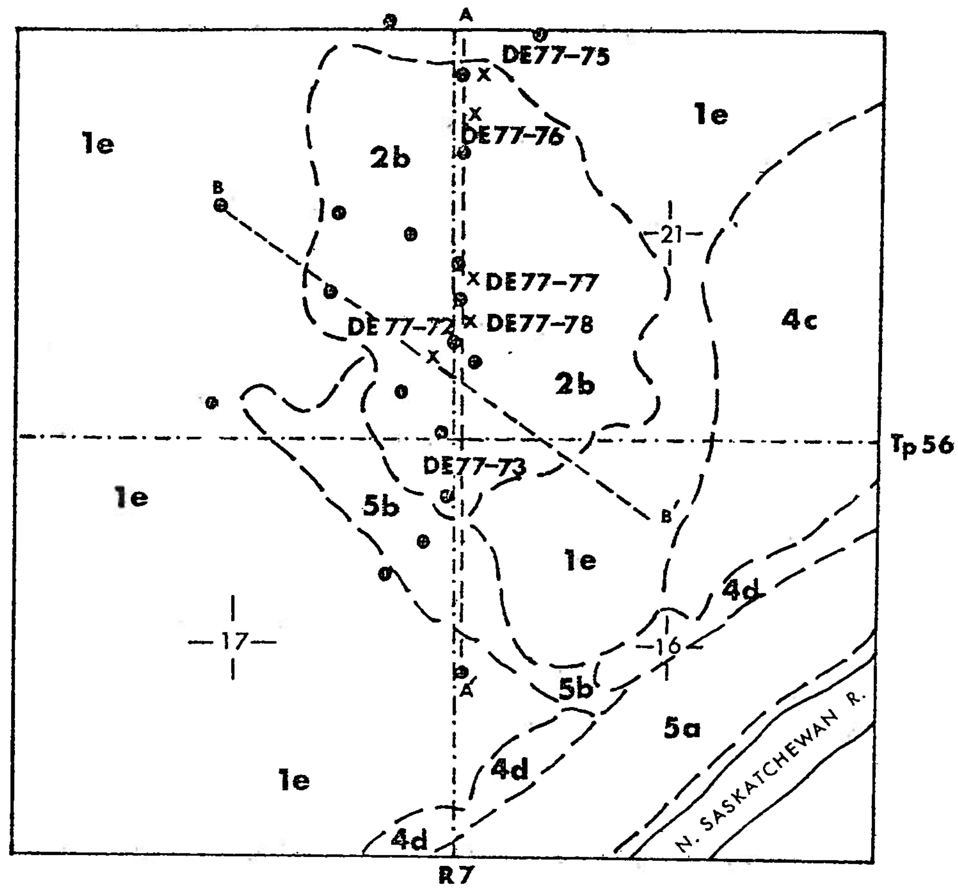



FIGURE 9. Grain-size distribution for samples taken at site 3 (outwash). Sample locations are: DE77-23B(9-18-56-10-W4), DE77-30(15-9-56-10-W4), DE77-31(1-18-56-10-W4), DE77-32 (8-18-56-10-W4) and DE77-35(12-17-56-10-W4).




LEGEND

Surficial

Water-modified Moraine ............................. 1e
Outwash(pitted) .................................... 2b
Thinly covered bedrock ............................. 4c
Slumped bedrock .................................... 4d
Terrace (erosional in bedrock) ..................... 5a
Bog ................................................ 5b

Geologic contacts ..................
Sand and gravel pit ................ X
Station number ..................... DE77-78
Testhole ........................... ⊖
Line of geologic section ........... A — — — — — — A'

Geological interpretation based on airphotos.

FIGURE 10. Map of site 5 showing the surficial geology, stations, testholes and cross-sections.

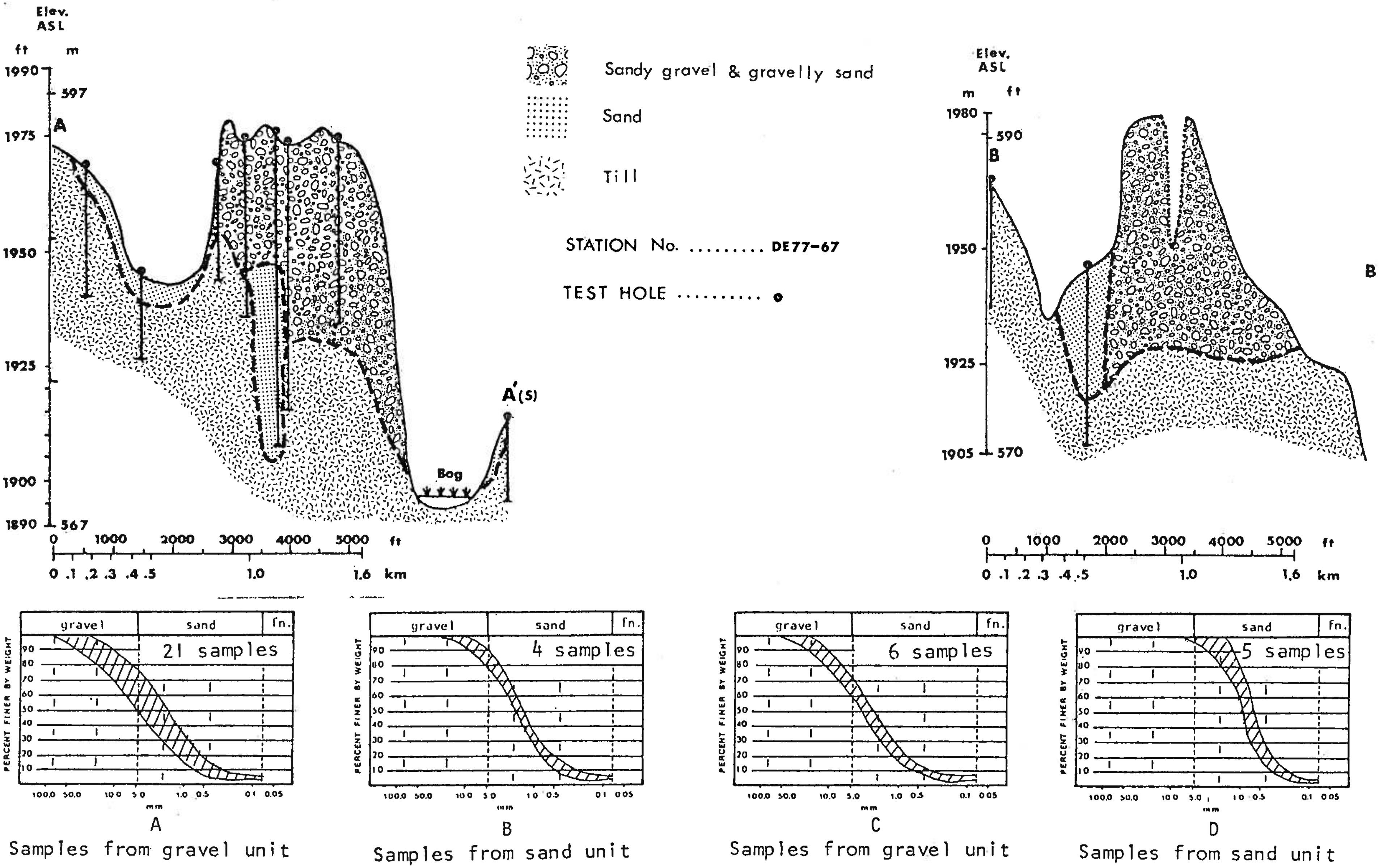



Figure 11. Geologic sections (A-A' and B-B') across site 5 showing topography and testholes on or near the line of section. Samples A and B are from stations on section A-A', C and D from stations on section B-B'.

the deposit is composed of coarse to medium-grained sand (Figs. 11B and 11D). The thick, central part of the deposit is composed of well sorted, clean gravelly sand and sandy gravel (Figs. 11A and 11C). Drilling in the central part of the deposit indicates that the thickness may exceed 15 m. The gravel fraction contains 81 percent durable rock types and a significant portion of soft, locally derived clasts and friable gneiss (Table 1).

*Extent*

The area underlain by sand or gravel is about 215 ha in size of which only about 5 percent has been exploited (1977). The thickness of the deposit exceeds 15 m in places and the overall volume probably exceeds 10,000,000 $m^3$. About 3,000,000 $m^3$ of this is gravel.

*Resource potential*

The deposit has a high potential for development: the quantity is large, the quality is good (40 to 60 percent gravel in much of the deposit), the overburden is negligible, and the area is relatively undeveloped. Care should be taken, however, to examine the aggregate for deleterious rock types so that material specifications can be met. This is the closest deposit to St. Paul (30 km) containing a large volume of gravel. It was quarried to a limited extent in 1976, and in 1977 a new pit was opened and the existing county pit was expanded. This area will become one of the major producers in the region in the near future.

Site 6 (Sections 34, 35 and 36, Township 56, Range 7;
Sections 4, 5, 7, 8, 18 and 19, Townhip 57, Range 7)

*Description*

The origin of this elongate deposit varies along its length. The northern part (4, 5, 7, 8, 18, 19-57-7-W4) is a low, flat, valley train deposit confined to the Atimoswe Creek valley (Fig. 12). At station DE77-14 (34, 35-56-7-W4), the deposit forms a ridge. The feature at this point is an esker. At stations DE77-17 and 19 (35, 36-56-7-W4) the deposit is flat and covers the upland area above the Atimoswe Creek valley. The deposit here is probably of outwash origin.

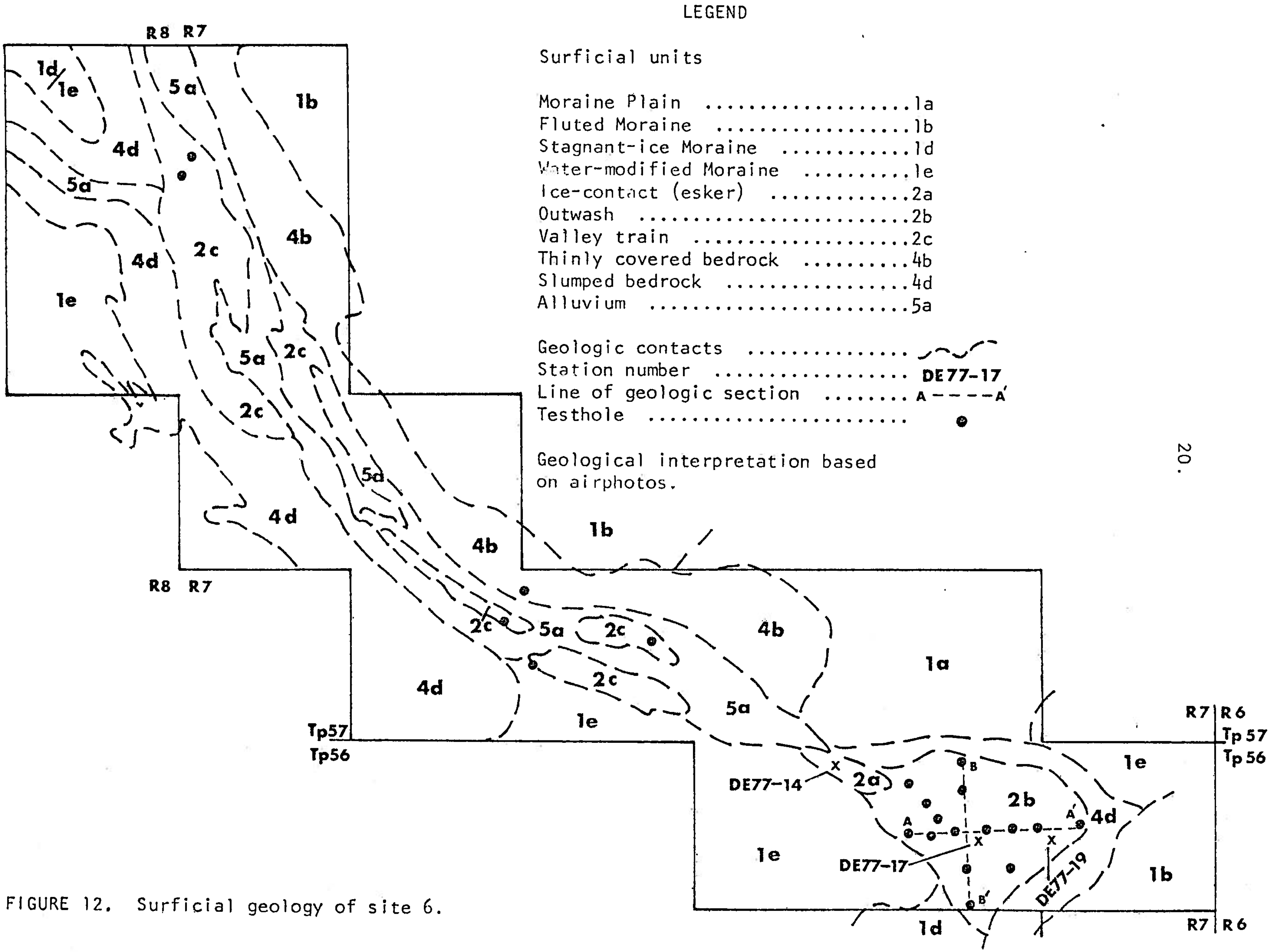



FIGURE 12. Surficial geology of site 6.

The thickness of granular material in the deposit varies: in parts of the valley train portion 1 to 3 m of sandy gravel to gravelly sand can be found; in the esker up to 9 m of gravelly sand occurs and in the outwash deposit 2 to 3 m of sandy gravel or gravelly sand rest on medium to fine sand (see cross-sections, Fig. 13).

Petrographic analysis of pebbles (12 to 36 mm) indicates that the deposit is relatively high in deleterious rock types (siltstone, soft sandstone and ironstone concretions) and care should be exercised in the use of the material.

*Extent and resource potential*

The deposit covers approximately 260 ha and contains over 5,000,000 $m^3$ of aggregate. About 10 percent of the deposit has been exploited. The deposit is elongate in form and crosses the property owned by a number of individuals. The valley train portion of the deposit occurs in a topographic low and high water table conditions could restrict development. Part of the outwash segment is used as a golf course and cemetery. These factors prevent utilization of the deposit under a single development scheme but do not preclude exploitation of most of it. This site and site 5 should satisfy future requirements of the St. Paul area.

BONNYVILLE STUDY AREA (Fig. 3)

This area can be divided into five general zones based on the occurrence of granular materials.

(1) A number of major deposits occur along the Beaver River valley as terraces or fluvial bars. This zone is the most important gravel source.

(2) The Mooselake River valley contains several high level fluvial bars with significant volumes of aggregate.

(3) A large area of outwash and washed or modified till occurs north of the Beaver River in the vicinity of the Sand River (parts of Townships 62 and 63, Ranges 7 and 8, west of the 4th meridian). Most of the large volume of granular material which occurs in this zone is fine sand.

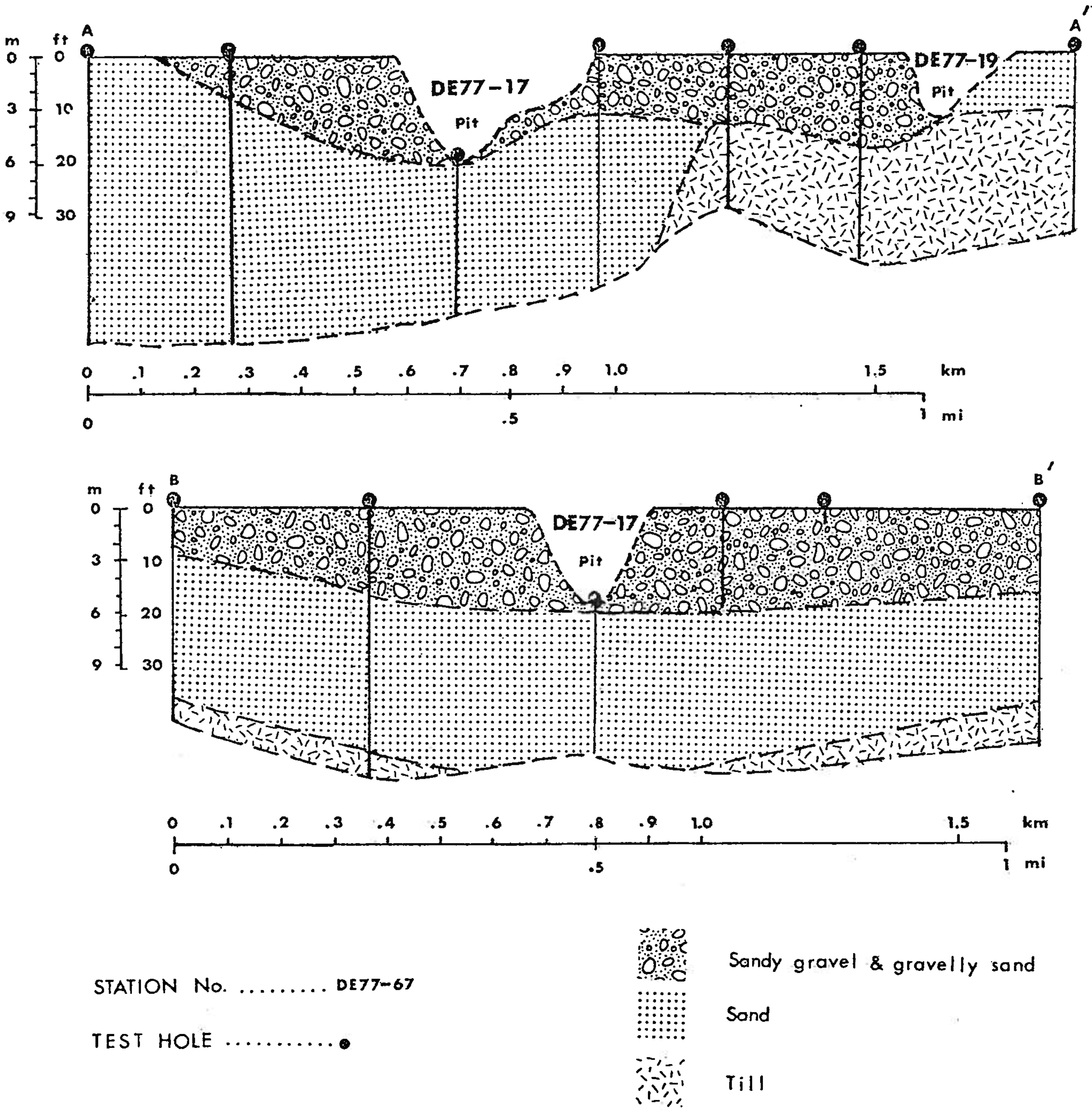



Figure 13. Geologic sections A-A' and B-B' (see Fig. 12) across the outwash of site 6.

(4) Sand is also the major component of a complex area of meltwater channels and outwash south of the Beaver River west of Medley.

(5) The remaining and largest part of the Bonnyville area is essentially devoid of major sand and gravel deposits. Most of this zone is moraine plain, stagnant-ice moraine (usually "doughnut moraine") and water-modified moraine. Meltwater channels are numerous in the moraine plain and stagnant-ice moraine, but the granular deposits within them are usually thin and sandy.

The major deposits in the area are discussed in more detail below and are shown in figure 3.

Site 7 (17 to 20-63-9-W4)

*Description*

This deposit consists of low and high level terraces. The deposits appear to contain bodies of clean gravelly sand and sandy gravel in a larger mass of sand.

*Extent and resource potential*

The area covers approximately 49 ha and probably contains 1 000,000 $m^3$ of granular materials — most in the form of sand. The area has been tested (persons unknown) but not exploited (1978). The large volume makes this a choice area for further study.

Site 8 (14, 15, 22 and 23-63-9-W4)

*Description*

This deposit, like site 7, consists of high and low level terraces. The high terrace appears to be composed of up to two metres of clean, fine sand. The lower terrace may contain gravelly sand. Access to this area is poor and subsurface testing was not done.

*Extent and resource potential*

The area is 20 to 30 ha in size and may contain over 100,000 $m^3$ of granular material, likely as medium and fine sand. Further testing is necessary to determine if gravel is buried beneath the sand.

Site 9 (5 to 8-63-8-W4)

*Description*

This deposit (Fig. 14) is a clean, coarse, sandy gravel that exceeds 10 m in depth in some places. The coarse aggregate occurs as a terrace, probably deposited by the ancestral Beaver River. The highest concentration of gravel and greatest thickness occurs in the central part of the deposit (Fig. 15). Underlying the gravel and sand of the terrace is a clean, fine sand which probably was deposited in an old valley that may extend from 19-63-8-W4 to 36-60-8-W4. The valley is filled with fine sand and silt except where it has been eroded by the present Beaver River.

The gravel at this deposit contains about 72 percent durable rock types and 28 percent siltstone, shale, minor ironstone, schist and gneiss in various states of disintegration (Table 1).

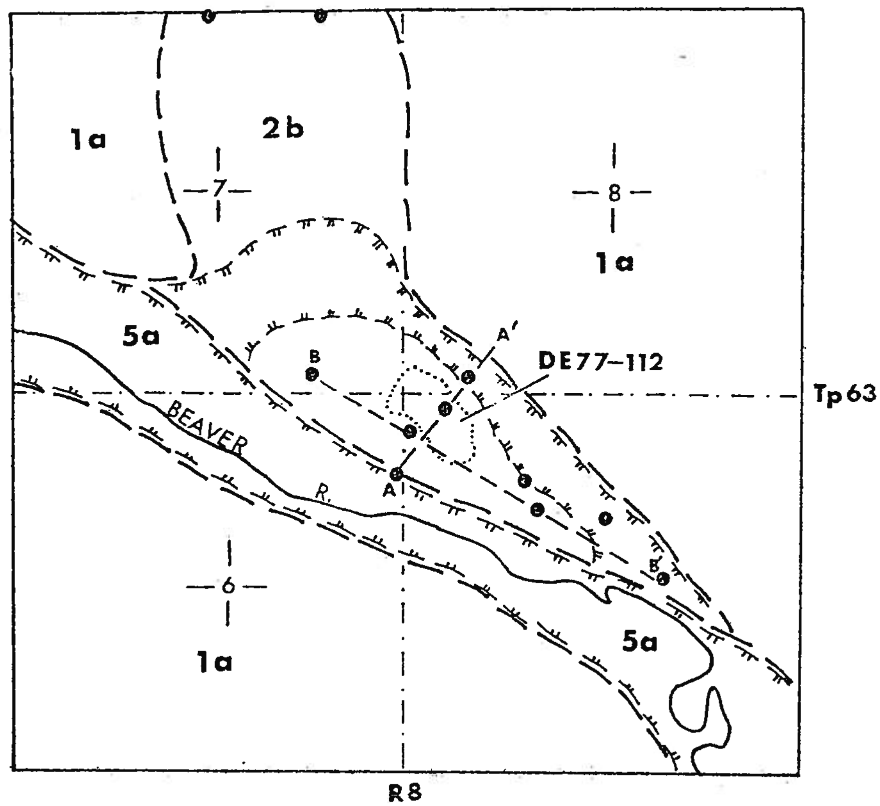
*Extent and resource potential*

The deposit is about 70 ha in size. About 20 percent of the deposit has been stripped of overburden or excavated, and between 2,000,000 $m^3$ and 3,000,000 $m^3$ of granular material probably remains in the deposit. The quality of the deposit is fair to poor for concrete aggregate purposes based on petrographic analyses and Los Angeles Abrasion testing (R.M. Hardy and Associates, 1979) but is valuable for road gravel. This deposit has been active for a number of years and is still one of the most useful deposits in the northwest portion of the Bonnyville area.

Site 10 (19, 30-62-5-W4 and 24, 25-62-6-W4)

*Description*

This deposit, the La Corey pit (Fig. 16) is in the form of a high level bar in the Beaver River valley. The central part of the deposit contains up to 12 m of coarse to very coarse gravel (Fig. 17). A bulk sample at a section in the pit shown in figure 17 indicated that 38 percent of the material was over 70 mm in size and 11 percent was greater than 150 mm. The coarse gravel is composed of durable granite and quartzite. The finer gravel may contain up to 24 percent siltstone,




LEGEND

Surficial units

Moraine Plain ................................ 1a
Outwash and terrace .......................... 2b
Alluvium ..................................... 5a

Geologic contacts ............................
Sand and gravel pit ..........................
Testhole .....................................
Line of geologic section ..................... A———A'
Station number ............................... DE77-112
Steep slope ..................................

Geologic interpretation based on airphotos

FIGURE 14. Surficial geology of site 9.

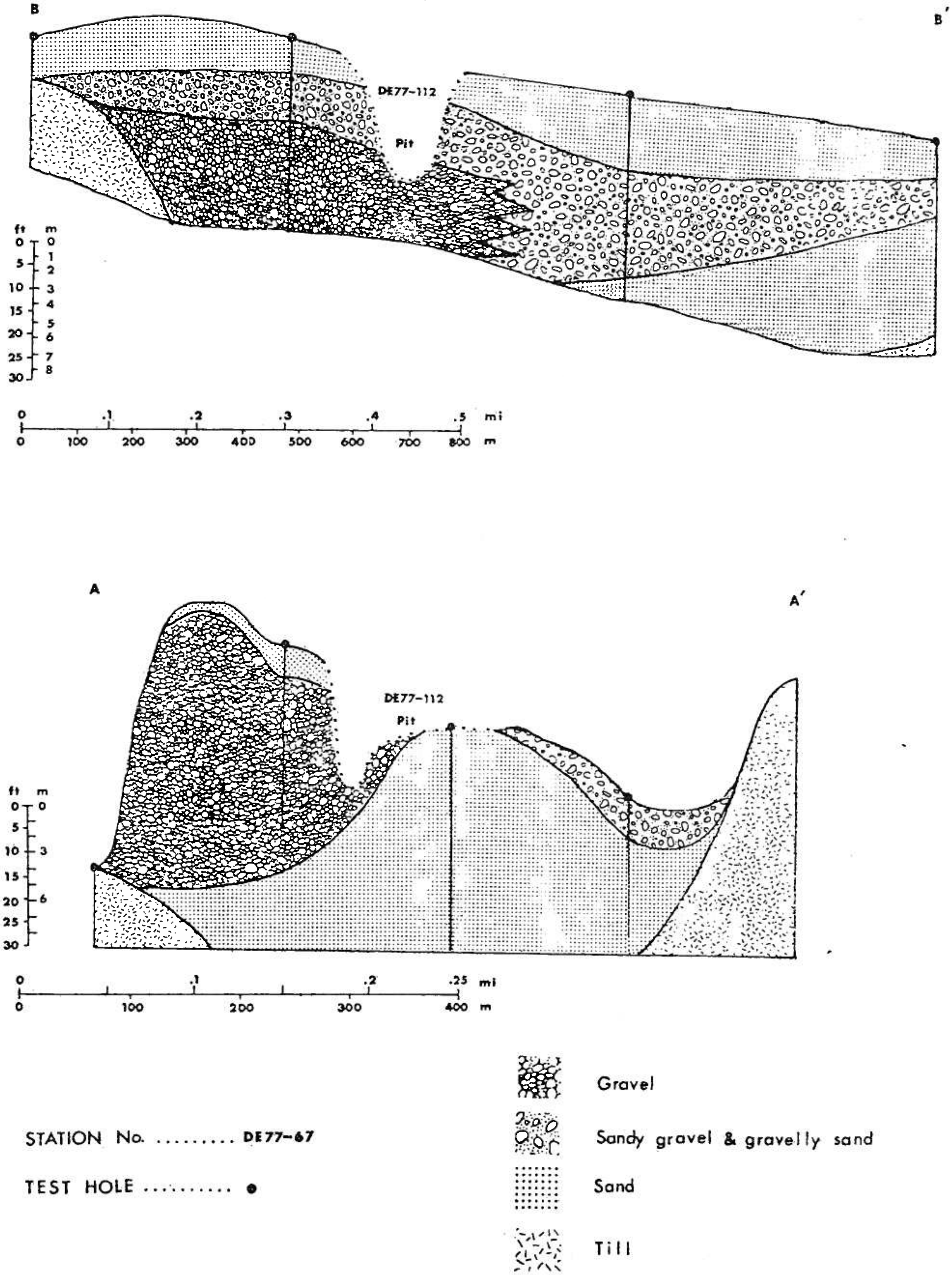
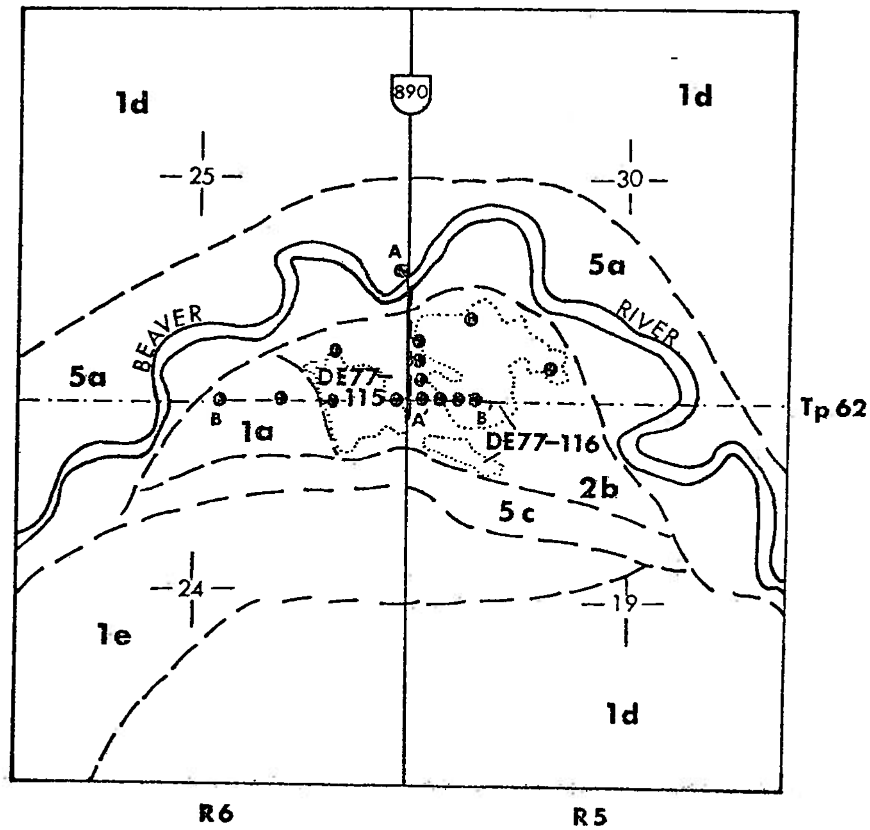



Figure 15. Geologic sections A-A' and B-B' (see Fig. 14) across site 9.




LEGEND

Surficial units

Moraine Plain ..................................1a
Stagnant-ice Moraine ...........................1d
Water-modified Moraine .........................1e
Terrace ........................................2b
Alluvium .......................................5a
Marsh ..........................................5c

Geological contacts ...........................
Sand and gravel pit ........................... x
Station number ................................DE77-115
Testhole ......................................
Line of geologic section ......................A — — — A'
Highway ....................................... 890

Geological interpretation based on airphotos.

FIGURE 16. Surficial geology of site 10.

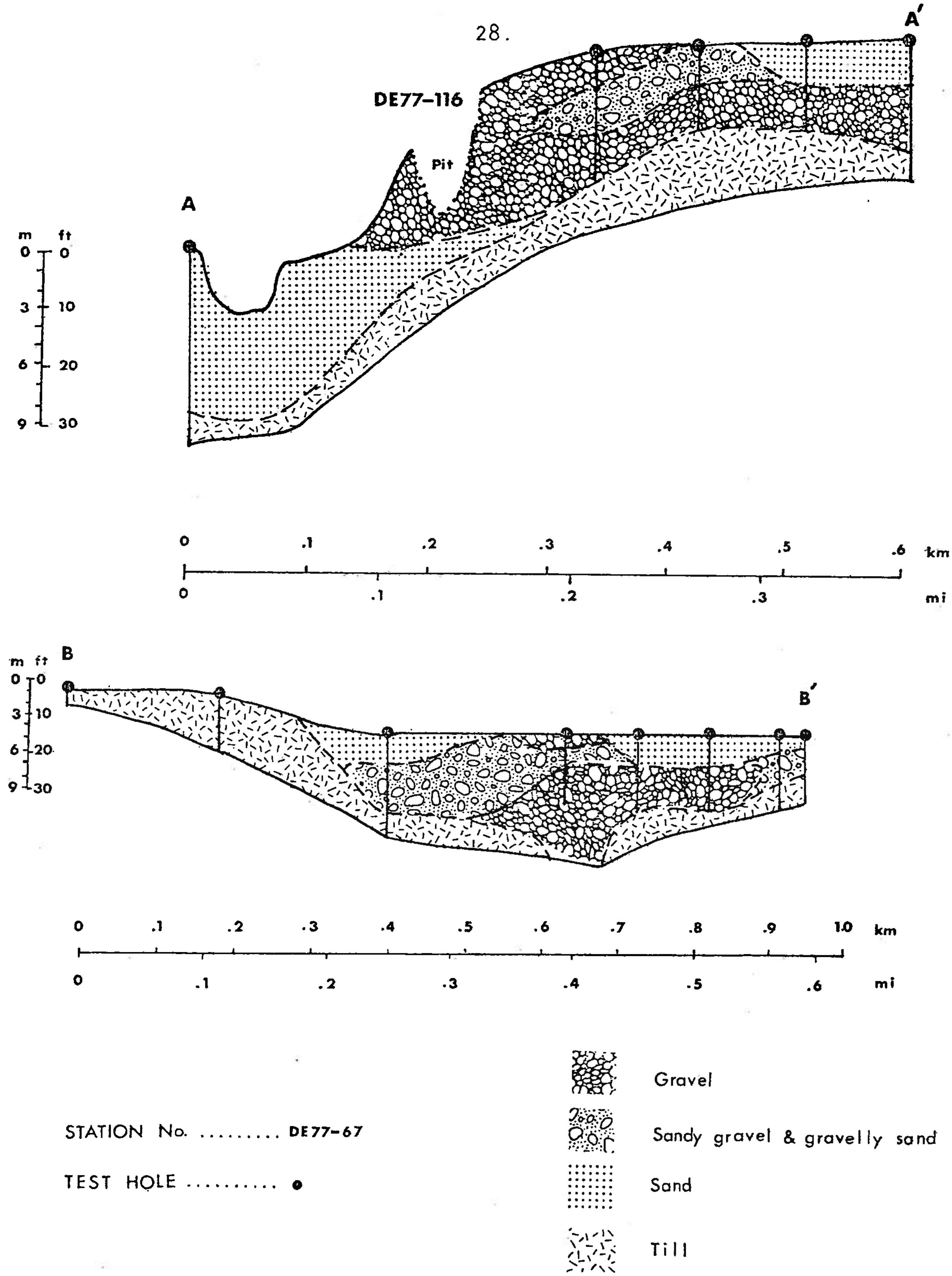



Figure 17. Geologic sections A-A' and B-B' (see Fig. 16) across site 10.

carbonate and gneiss (Table 1). The deposit gets thinner and finer (medium sand) to the south. The deposit also gets finer to the east and decreases in elevation (Fig. 17) resulting in a decrease in the amount of aggregate above the water table.

*Extent and resource potential*

This deposit has been the main supply for the town of Bonnyville and the surrounding region for a number of years. There is a wide range in the size of material in the deposit — from coarse gravel suitable for crushing, to sand. The deposit originally covered an area approximately 90 ha in size. About 50 ha now remains, containing about 1,800,000 $m^3$ of granular material. Of this, a major portion will be sand or lies beneath Highway 890 and is therefore unavailable.

This deposit could continue to supply large volumes of gravel and sand for several years. Because the deposit is ideally situated to supply Bonnyville and contains concrete quality aggregate, alternative sources of granular material of lower quality should be utilized now, if possible, to conserve the La Corey deposit.

Site 11 (10, 11-63-3-W4)

*Description*

This area occurs as a low and high level terrace or bar. The lower level contains an upper layer of sandy gravel to gravelly sand several metres thick. On the west end of the terrace the gravel overlies till while on the east end it rests on about 3 m of medium sand. The upper terrace has up to 2 m of gravelly sand resting on sand or silty sand. This sand increases in thickness from west to southeast from about 6 to 15 m and rests on a clay till.

*Extent and resource potential*

This deposit was originally about 90 ha in size. The better parts of the deposit have been utilized and only about 15 ha on the fringes of the deposit are not developed. Over 500,000 $m^3$ of granular material remains, a major proportion of which is found in previously worked parts of the deposit.

Site 12 (4, 5 and 8-62-7-W4)

*Description, extent and resource potential*

This site is found within the Mooselake River valley and occurs as fluvial bars above the level of the present stream. Three bars (A, B and C) are identified in figure 18 and described below. The central (A) deposit (4 and 5-62-7-W4) is composed of clean, cobbly, sandy gravel to gravelly sand. The gravel rests on a flat till surface so that the thickest gravel (approximately 6 m) occurs in the topographically highest areas (sections A-A' and B-B', Fig. 19). The deposit averages about 4.5 m in thickness over an area of about 30 ha and contains over 1,000,000 $m^3$ of good quality material.

The geological setting of the southern (B) deposit (4 and 5-62-7-W4) is very similar (section C-C' and D-D', Fig. 19) to that of the 'A' deposit. It contains clean, coarse, gravelly sand to sandy gravel. This deposit is about 80 ha in size but is thinner overall than the 'A' deposit. This deposit contains about 3,500,000 $m^3$ of granular material and an estimated 1,000,000 $m^3$ of coarse gravel.

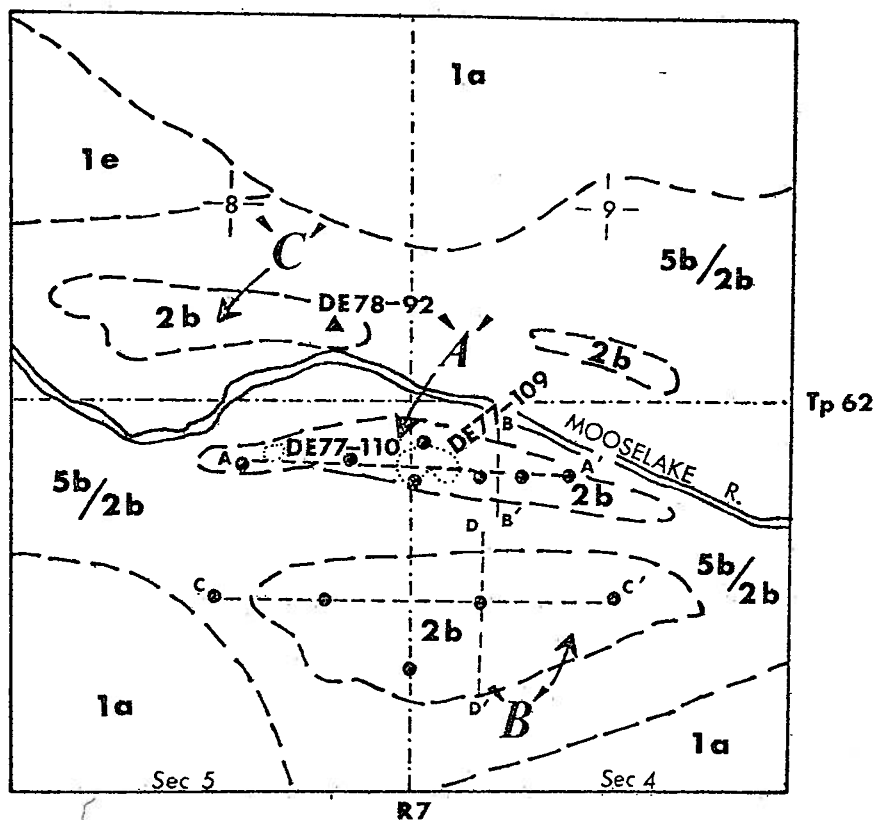
The northern (C) deposit (8-62-7-W4) is lower in elevation and contains about 30 ha of sandy gravel, 1 m to 1.5 m thick. The material sampled was sandy gravel with 5 to 10 percent of the material over 70 mm in size. This deposit may contain 30,000 $m^3$ of aggregate.

At present, one pit of limited extent is operating in deposit 'A'. However, the high quality (clean, coarse grain size and high percentage of durable rock types) and large reserves (5,000,000 $m^3$) should make this area the most important future supply for the Bonnyville region.

Site 13 (Parts of Townships 62 and 63, Ranges 7 and 8, west of the 4th meridian)

*Description, extent and resource potential*

A large area (greater than 400 ha) containing granular material occurs between the Beaver and Sand Rivers and east of the Sand River. The deposit includes high level terraces on the east side of the Beaver River and the west side of the Sand River




LEGEND

Surficial units

Moraine Plain ................................1a
Water-modified Moraine ....................1e
Outwash ......................................2b
Bog ..........................................5b

Geologic contact ..........................
Sand and gravel pit ........................ x
Station number ............................ DE77-92
Testhole ..................................
Line of geologic section .................. A----A′
Deposit number at site 12 ................. A′

Geologic interpretation based on airphotos.

FIGURE 18. Surficial geology of site 12.

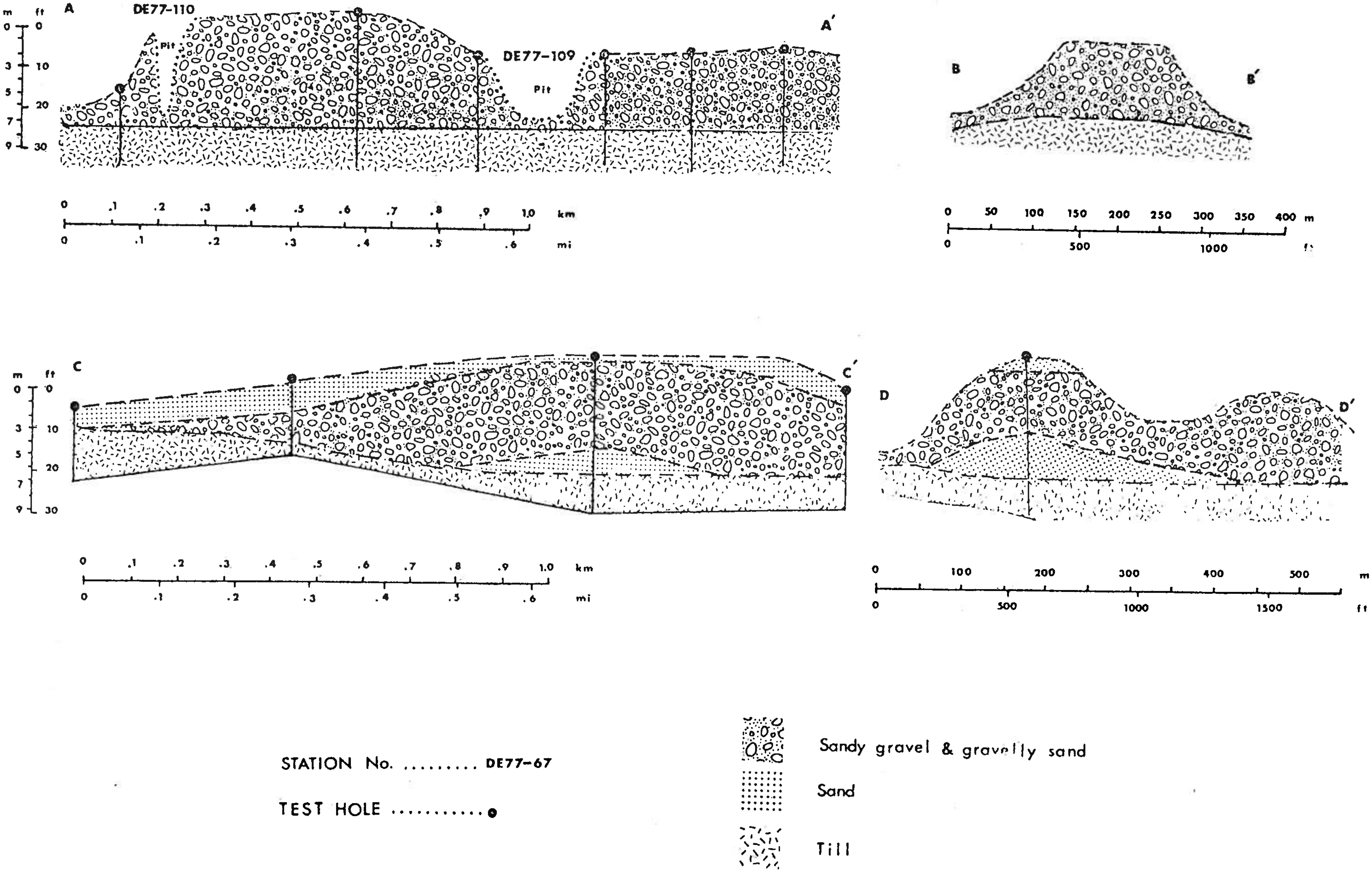



FIGURE 19. Geologic sections A-A' and B-B' (see Fig. 18, deposit number 'A'), C-C' and D-D' (see Fig. 18, deposit number 'B') in site 12.

as well as outwash in the area between them. The outwash is probably quite variable in thickness and composed primarily of fine sand. No subsurface data is available. At least one of the Sand River terraces contains sand to 1.5 m (hand dug test pit). The outwash east of the Sand River appears to be fine sand based on testhole information.

Millions of cubic metres of granular material are contained in this deposit but detailed exploration will be necessary to locate areas containing coarse aggregate.

## SUMMARY AND CONCLUSION

Aggregate was used in 1978 within the St. Paul study area by the county of St. Paul, Alberta Transportation, the town of St. Paul, a concrete and a concrete block plant. There are six sites containing exploitable aggregate in the area to supply these users needs. Thin outwash deposits (sites 3 and 4, Fig. 3) to the south and southwest of town are useful as a source of gravelly sand for road maintenance by the county but could not supply large volumes of gravel. Sandy kame deposits (site 2, Fig. 3) southwest of St. Paul can supply aggregate for road maintenance as well as fine aggregate for the concrete and concrete block industries. A major supply area of coarse aggregate in the past was site 1 (Fig. 3), 13 km north of St. Paul. Material was used by Alberta Transportation, the county, the town and local industry. However, this area is nearing depletion, and more distant sources must be used. Two outwash areas (sites 5 and 6, Fig. 3) near Elk Point (southeast of St. Paul) contain large volumes of gravel and are likely to become the main suppliers of concrete aggregate for St. Paul in the future. These deposits should also satisfy the needs of the county and Alberta Transportation for road construction and maintenance materials in this part of the study area. The town of St. Paul and the southern part of the St. Paul study area have supplies of both coarse and fine aggregate to meet their needs well into the future. The northern part of the area contains no major deposits and aggregate for use here must be transported from the Elk Point (sites 5 and 6, Fig. 3) or Mooselake River (site 12, Fig. 3) areas.

Aggregate from the Bonnyville study area was used by the Municipal District of Bonnyville, Alberta Transportation (for provincial highways and Improvement Distri roads), the towns of Bonnyville, Medley and Grande Centre and industry in both Bonnyville and Grand Centre. The eastern half of the study area contains the three major towns, the Canadian Forces Air Base and several provincial highways, and as a result, deposits have been greatly exploited in this area. Four terrace deposits (site 11, Fig. 3 and deposits located at 15-63-3-W4; 17-63-3-W4, and 12-63-4-W4) along the Beaver River west of Medley are essentially depleted. The La Corey pit (site 10, Fig. 3), north of Bonnyville, now contains less than 2,000,000 $m^3$ of granular materials. Future supplies of coarse aggregate for the eastern part of the study area will probably come from the Mooselake River site (site 12, Fig. 3) where deposits containing millions of cubic metres of gravel are as yet relatively undeveloped. The western part of the study area is well endowed with sand and gravel with three terrace deposits (sites 7, 8 and 9, Fig. 3) along the Beaver River as well as the Mooselake River deposits.

The area as a whole contains only five deposits over one million cubic metres with known, significant proportions (above 30 percent) of gravel (see chart on Fig. 3). These deposits are concentrated in the southeastern part of the St. Paul area and the western part of the Bonnyville area — away from the centres of population. Care should be taken to use small and partially depleted deposits efficiently in areas of short supply and to manage the larger deposits under a long range plan.

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# APPENDIX

## CLASSIFICATION OF SEDIMENTS

A number of different systems are presently used in classifying rock fragments according to size. Fragments described by geologists are most commonly classified according to the Wentworth scale (Wentworth, 1922) (Fig. A-1). Fragments used industrially (aggregate) are often classified according to the Industrial Classification shown in figure A-1. Terms used in this report correspond to the industrial classification unless otherwise indicated.

Sediments are classified according to the abundance of fragments of different sizes. In this study all coarse-grained sediments (more than 50 percent, by weight, of the sediment having particle diameters in excess of .075 millimetres) are classified according to figure A-2.

Sand and gravel is a general term used for any coarse-grained sediment. Sand, gravelly sand, sandy gravel and gravel are specific terms defined in figure A-2. The amount of fines in a coarse-grained sediment is indicated by the use of the appropriate modifier - clean, dirty or very dirty (Fig. A-2) (for example, clean gravelly sand or very dirty gravel). If no modifier is used the sediment is assumed to be clean.

In this study the grain-size distribution, by weight, of a sample was determined by sieving the sample through a stack of sieves (Canadian Standard Sieve Series) of the following sizes: 75 mm (3 in), 63 mm (2.5 in), 15 mm (2 in), 37.5 mm (1.5 in), 19 mm (0.75 in), 12.5 mm (0.5 in), 4.75 mm (No. 4 mesh), 2.00 mm (No. 10 mesh), 0.85 mm (No. 20 mesh), 0.425 mm (No. 40 mesh), 0.18 mm (No. 80 mesh) and 0.075 mm (No. 200 mesh). The weight retained on each sieve was calculated as a percentage of the total weight of the sample and plotted on a graph. An attempt was made to take samples which exceeded the minimum mass as specified by ASTM standard designation D75-71. This was not always possible, especially when samples were taken from power auger testholes.

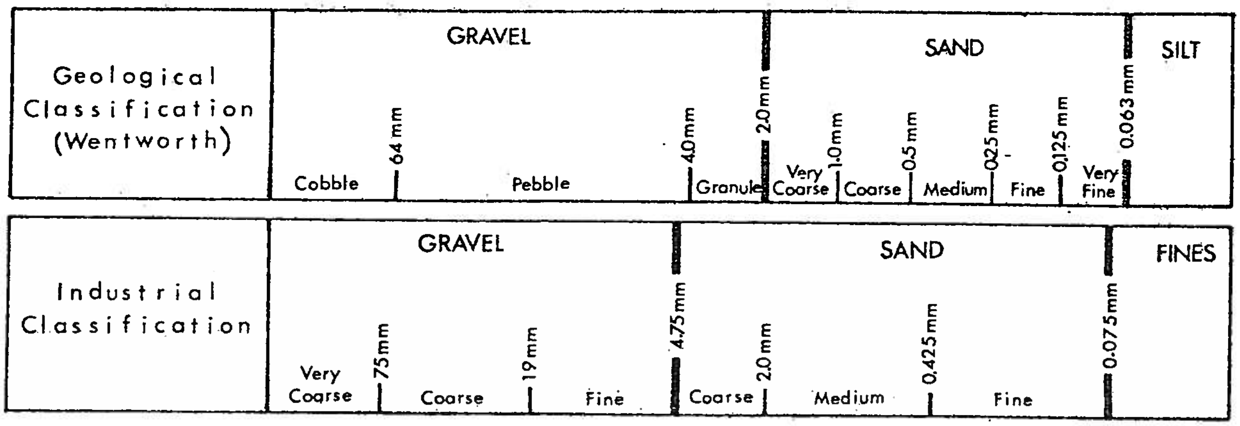



FIGURE A-1. Geological and Industrial grain-size classifications.

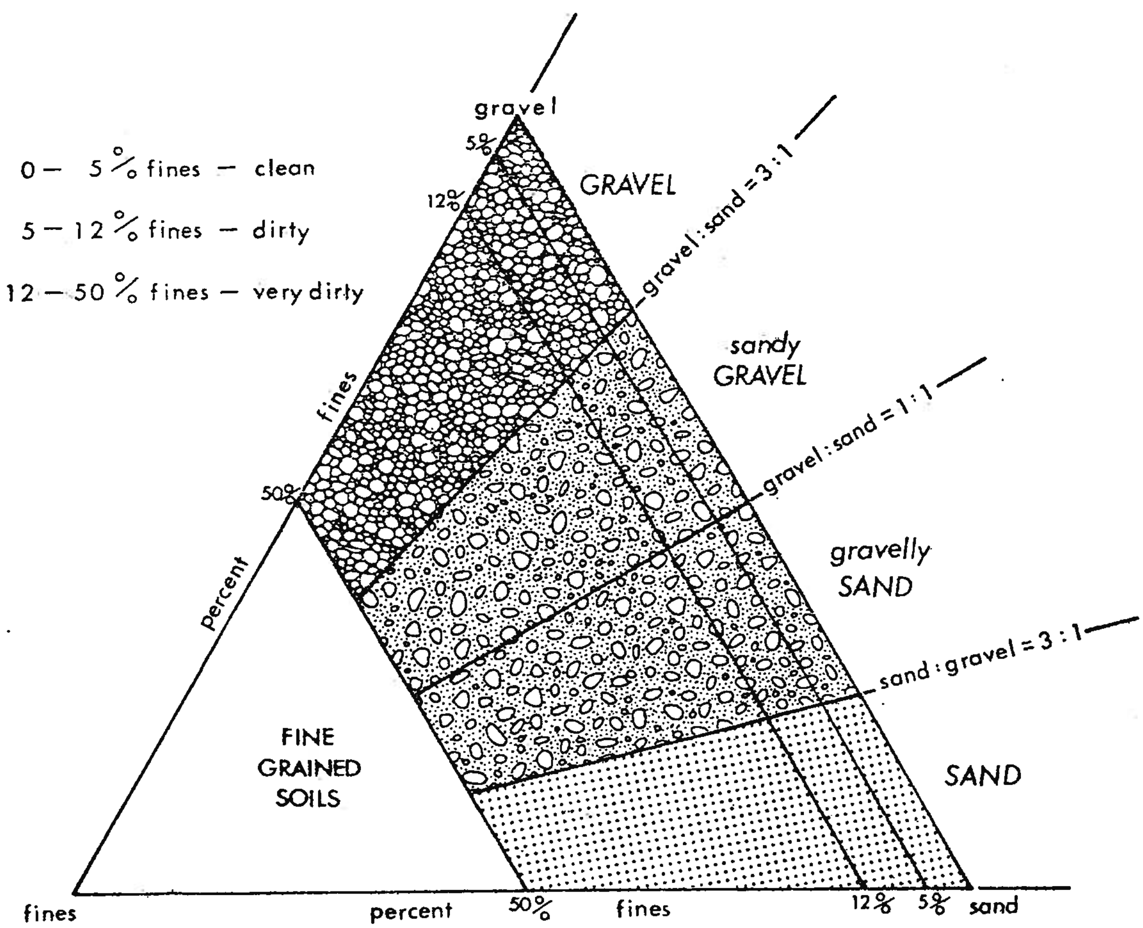



FIGURE A-2. Classification of unconsolidated, coarse-grained sediments (after the Unified Soil Classification System).

# GLOSSARY

aggregate - any of several hard, inert, construction materials (such as sand, gravel, crushed stone, slag, or other mineral material), or combinations thereof, used for mixing in various-sized fragments with a cementing or bituminous material to form concrete, mortar, plaster, etc., or used alone as in railroad ballast or in various manufacturing processes (such as fluxing). Syn: mineral aggregate; coarse aggregate - the portion of an aggregate with diameters greater than 4.75 mm; fine aggregate - the portion of an aggregate in which the particle diameters are smaller than 4.75 mm and larger than 0.075 mm.

bedrock - in-place pre-Quaternary material exposed at the surface or underlying the surficial material.

boulder - a detached rock mass having a diameter greater than 250 mm. Syn: very coarse gravel.

clay - a rock or mineral fragment or detrital particle of any composition having a diameter less than 1/256 mm (Wentworth scale).

clean - said of sand and/or gravel than contains less than 5 percent fines.

cobble - gravel having a diameter in the range of 75 to 250 mm. Syn: very coarse gravel.

Cretaceous - the final period of the Mesozoic era, thought to have covered the span of time between 136 and 65 million years ago.

crevasse filling - a short, straight ridge of stratified sand and gravel and till believed to have been deposited in a crevasse of a wasting glacier and left standing after the ice melted; a variety of kame.

deleterious rock (type) - a rock fragment which when used as aggregate will break or crumble into smaller sized fragments or react with the cementing agent or fluids within the mix to expand, shrink or break-down to weaken the mixture (such as soft sandstone, weathered gneiss, and some chert).

deposit (sand, gravel, aggregate) - an accumulation of sand and/or gravel left by a natural process or agent, usually wind, water or gravity.

dirty gravel - said of gravel that contains between 5 and 12 percent fines (Fig. A-2).

dirty sand - said of sand that contains between 5 and 12 percent fines (Fig. A-2).

doughnut (moraine) - a small, well developed circular closed ridge composed of till, glaciolacustrine or rarely glaciofluvial sediments and believed to have been formed as a result of stagnant-ice conditions.

durable rock (type) - a rock fragment which is hard and inert and can be used as aggregate without breaking, crumbling or reacting with the cementing material (such as quartzite, fresh granite or limestone).

esker - a narrow ridge, often long and sinuous, composed of sand and/or gravel deposited by a meltwater stream flowing in or on glacier ice.

fines - sediment with particle diameters less than .075 mm (Fig. A-1).

fluvial - pertaining to rivers or streams.

fluvial bar - a ridge-like accumulation of sand, gravel or other alluvial material formed in the channel (or former channel) of a stream where a decrease in velocity induces deposition.

friable - a rock or mineral that crumbles naturally or is easily broken, pulverized, or reduced to powder, such as a soft or poorly cemented sandstone.

glacial - pertaining to distinctive features and materials produced by or derived from glaciers and ice sheets.

glaciofluvial (deposits) - material deposited by streams flowing from, on or within melting glacier ice, generally composed of sorted, stratified sand and gravel; includes outwash, kame, esker, etc.

glaciolacustrine - material deposited in lakes affected by glacier ice or by melt-water flowing directly from glaciers; composed of well-sorted clay, silt, or sand.

gneiss - a foliated rock formed by regional metamorphism in which bands of granular minerals (often feldspar and quartz) alternate with bands of flaky or elongate minerals (often hornblende and biotite); the rock may break or crumble easily when used as aggregate especially when the rock has been weathered deeply.

granite - a coarse grained, plutonic rock composed principally of quartz and alkali feldspar; forms a good aggregate material unless deeply weathered when it may crumble.

granular material - natural occurring mineral sediment in which more than 50 percent of the sediment is greater than .075 mm in size. Syn: sand and gravel.

gravel - naturally occurring rock or mineral fragments larger than 4.75 mm in diameter; an unconsolidated, natural accumulation of granular material which contains more than 3 parts gravel for every part sand (Figs. A-1 and A-2).

gravelly sand - an unconsolidated, naturally occurring granular material which contains a ratio of sand to gravel between 3:1 and 1:1 (50 to 75 percent sand) (Fig. A-2).

ice-contact (deposit) - material deposited in contact with glacier ice by melt-water; includes kames, eskers, and kame terraces.

ice-molded - a surface composed of streamlined landforms (such as drumlins, grooves or flutes) formed by active ice movement.

ice-thrust moraine - a ridge or block of material (usually arcuate) formed by the thrusting or pushing of ice.

ironstone - a hard, banded sedimentary rock of ferruginous composition, often found as a compact, rounded, subspherical mass (concretion); although hard ironstone tends to fracture and break when used as aggregate (deleterious).

kame - a steep-sided hill, knob, hummock or short irregular ridge composed chiefly of poorly sorted and stratified sand and gravel deposited by a subglacial or supraglacial stream as an alluvial fan or delta against or upon a glacier or ice sheet.

lacustrine (deposit) - material deposited in a lake.

lag (gravel) - a residual accumulation of coarse, usually hard rock fragments left behind after currents have winnowed or washed away the finer material.

limestone - a sedimentary rock containing more than 95 percent of the mineral calcite and less than 5 percent dolomite; usually forms a good aggregate material, often used to make crushed stone.

meltwater channel - a watercourse or abandoned watercourse used by water derived from melting glacier ice and often marked by accumulations of gravel and sand derived from the ice.

moraine plain - a flat to gently undulating surface composed primarily of till.

outwash - a glaciofluvial deposit formed in front of the margin of glacier ice; a pitted outwash deposit is a deposit whose otherwise flat surface is marked by many irregular shallow depressions.

overburden - the soil, silt, till or other unconsolidated material overlying a gravel or sand deposit which must be removed prior to mining.

pebble - a small, roundish rock fragment having a diameter in the range of 4 to 64 mm (Wentworth scale) (Fig. A-1). Syn: gravel.

petrographic analysis - the description and systematic classification of rock fragments (esp. gravel) by unaided eye or microscopic examination for the purpose of determining the origin of the fragments and their quality (durability) when used as aggregate. Syn: pebble count.

quartzite - a sedimentary or metamorphic rock consisting of quartz grains or crystals cemented with secondary silica such that the rock breaks across or through the grains rather than around them; an excellent aggregate material, highly resistant to weathering and very hard.

sand - naturally occurring rock or mineral fragments larger than 0.75 mm in diameter and smaller than 4.75 mm; an unconsolidated, natural accumulation of granular material which contains more than 3 parts sand for every part gravel (Fig. A-2).

sand and gravel - see granular material.

sandstone - a clastic sedimentary rock composed principally of fragments of sand size (usually quartz) united by a cementing material (commonly silica, iron oxide, or calcium carbonate); an excellent to poor aggregate material depending on the strength of the cementing bond, and the amount of weathering it has been subjected to, and the reaction of the rock to weathering.

sandy gravel - an unconsolidated naturally occurring granular material which contains a ratio of gravel to sand between 3:1 and 1:1 (50 to 75 percent gravel) (Fig. A-2).

schist - a strongly foliated metamorphic rock which can be readily split into thin flakes or slabs due to the well developed parallelism of more than 50 percent of the minerals present (e.g. mica, hornblende); a poor aggregate material because of its tendency to split and weather easily into crumbly masses.

shale - a fine-grained sedimentary rock formed by the consolidation of clay, silt or mud and characterized by a finely stratified structure, shale is generally soft but sufficiently indurated so that it will not fall apart on wetting; a poor aggregate material because of its softness and fissility.

silt - a rock or mineral fragment or detrital particle having a diameter in the range of 1/256 to 1/16 mm (Wentworth scale) (Fig. A-1).

siltstone - an indurated or somewhat indurated silt having the texture and composition but lacking the fine lamination or fissility of shale; a poor to fair aggregate depending on the hardness of the rock.

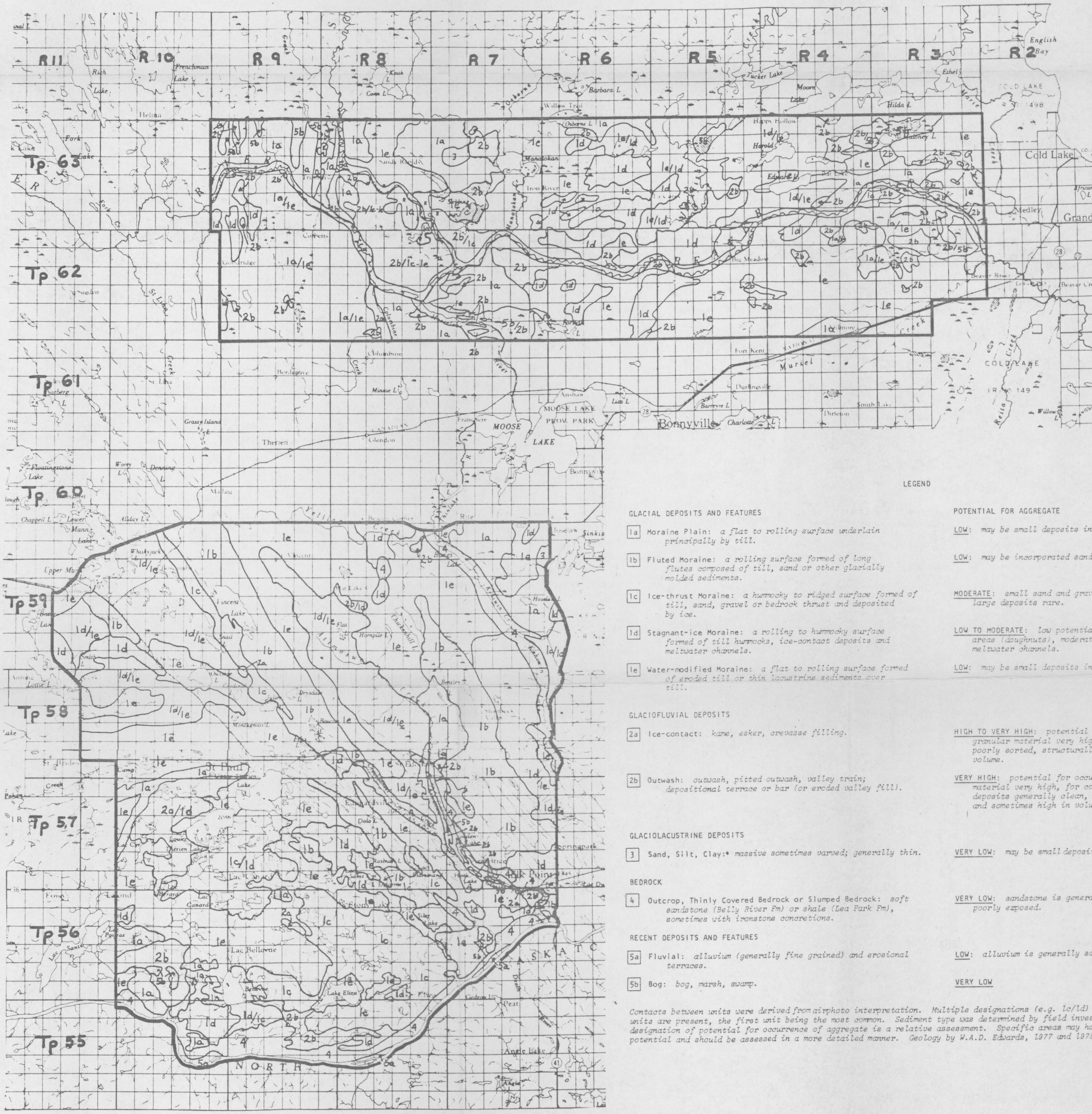
stagnant ice (moraine) - the landform formed by ablating ice that is no longer flowing forward; characterized by hummocky topography (mounds or hummocks) formed of till or glaciolacustrine sediments, doughnuts, ice-contact deposits and meltwater channels.

terrace - a large bench or step-like ledge breaking the continuity of a slope and marking a former water level; terrace commonly denotes an aggradational form contained in a valley and composed of unconsolidated material, often sand and gravel.

till - unsorted and unstratified sediment deposited directly by glacier ice.

valley train - outwash confined within a valley.

well-sorted - said of a sorted sediment that consists of particles all having approximately the same size.




LEGEND

| GLACIAL DEPOSITS AND FEATURES | POTENTIAL FOR AGGREGATE |
| --- | --- |
| 1a Moraine Plain: *a flat to rolling surface underlain principally by till.* | LOW: *may be small deposits in meltwater channels.* |
| 1b Fluted Moraine: *a rolling surface formed of long flutes composed of till, sand or other glacially molded sediments.* | LOW: *may be incorporated sand or gravel lenses.* |
| 1c Ice-thrust Moraine: *a hummocky to ridged surface formed of till, sand, gravel or bedrock thrust and deposited by ice.* | MODERATE: *small sand and gravel lenses common; large deposits rare.* |
| 1d Stagnant-ice Moraine: *a rolling to hummocky surface formed of till hummocks, ice-contact deposits and meltwater channels.* | LOW TO MODERATE: *low potential in primarily till areas (doughnuts), moderate in areas with meltwater channels.* |
| 1e Water-modified Moraine: *a flat to rolling surface formed of eroded till or thin lacustrine sediments over till.* | LOW: *may be small deposits in meltwater channels.* |
| **GLACIOFLUVIAL DEPOSITS** | |
| 2a Ice-contact: *kame, esker, crevasse filling.* | HIGH TO VERY HIGH: *potential for occurrence of granular material very high; deposits may be poorly sorted, structurally deformed, low in volume.* |
| 2b Outwash: *outwash, pitted outwash, valley train; depositional terrace or bar (or eroded valley fill).* | VERY HIGH: *potential for occurrence of granular material very high, for coarse aggregate high; deposits generally clean, well-sorted, uniform and sometimes high in volume.* |
| **GLACIOLACUSTRINE DEPOSITS** | |
| 3 Sand, Silt, Clay:• *massive sometimes varved; generally thin.* | VERY LOW: *may be small deposits in meltwater channels.* |
| **BEDROCK** | |
| 4 Outcrop, Thinly Covered Bedrock or Slumped Bedrock: *soft sandstone (Belly River Fm) or shale (Lea Park Fm), sometimes with ironstone concretions.* | VERY LOW: *sandstone is generally fine grained, poorly exposed.* |
| **RECENT DEPOSITS AND FEATURES** | |
| 5a Fluvial: *alluvium (generally fine grained) and erosional terraces.* | LOW: *alluvium is generally sandy or muddy.* |
| 5b Bog: *bog, marsh, swamp.* | VERY LOW |

*Contacts between units were derived from airphoto interpretation. Multiple designations (e.g. 1c/1d) indicate that both units are present, the first unit being the most common. Sediment type was determined by field investigation. The designation of potential for occurrence of aggregate is a relative assessment. Specific areas may have a lower or higher potential and should be assessed in a more detailed manner. Geology by W.A.D. Edwards, 1977 and 1978.*

FIGURE 2. Surficial geology in the St. Paul and Bonnyville areas.



1/2

1980-3


LEGEND

| SITE NO. | LOCATION | TYPE OF DEPOSIT | MATERIAL | ESTIMATED VOL. ($M^3$) | ASSESSMENT (1) QUALITY FN AGG | QUALITY CRS AGG | QUANTITY FN AGG | QUANTITY CRS AGG |
|---|---|---|---|---|---|---|---|---|
| 1 | 31-58-9-W4 | kame | sand | 10,000 | G | P | 4 | 4 |
| | 5-59-9-W4 | ice-thrust (?) | sand to sdy gvl | 100,000 | G | E | 2 | 3 |
| 2 (2) | 57-10-W4 | kame | sand | 100,000 | G | P | 3 | 4 |
| 3 (2) | 56(S 1/2)-10-W4 | outwash | gvlly sd | 100,000 (+) | G | F | 3 | 3 |
| 4 (2) | 55(N 1/2)-9-W4 | outwash | sdy gvl | 10,000 (+) | P | P | 4 | 4 |
| 5 | 16,17,20,21-56-7-W4 | pitted outwash | sdy gvl | 10,000,000 | G | G | 1 | 1 |
| 6 | 56(NE)-7-W4<br>57(SW)-7-W4 | outwash, esker | gvlly sd | 5,000,000 | F | F | 1 | 1 |
| 7 (3) | 17 to 20-63-9-W4 | terrace | sand, gvlly sd | 1,000,000 | F | ? | 2 | ? |
| 8 (3) | 14,15,22,23-63-9-W4 | terrace | sand, gvlly sd(?) | 100,000 | P | ? | 3 | ? |
| 9 | 5 to 8-63-8-W4 | terrace | sdy gvl | 3,000,000 | F | F | 1 | 2 |
| 10 | 19,30-62-5-W4<br>24,25-62-6-W4 | terrace | sand to gravel | 1,800,000 | G | E | 2 | 1 |
| 11 | 10,11-63-3-W4 | terrace | sand, gvlly sd | 700,000 | G | F | 2 | 2 |
| 12 A | 4,5-62-7-W4 | bar | gvlly sd, sdy gvl | 1,500,000 | G | F | 2 | 2 |
| B | 4,5-62-7-W4 | bar | gvlly sd, sdy gvl | 3,500,00 | G | E | 1 | 1 |
| C | 8-62-7-W4 | bar | gvlly sd | 300,000 | F | G | 3 | 3 |
| 13 (2) | parts of Tp's 62 and 63,R's 7 and 8, W-4 | outwash terrace | sand | 1,000,000 (+) | P | ? | 1 | ? |

(1) The quality and quantity assessment is a relative assessment for the study area. Fine aggregate (Fn Agg) is material 4.75 mm to 0.075 mm in size. Coarse aggregate (Crs Agg) is greater than 4.75 mm. The quality of the aggregate was judged by the amount of fines (less than 0.075 mm), and deleterious rock types present and the grain-size distribution. Aggregate of excellent quality generally had a low percentage of fines (less than 2%) and was composed of hard, durable rock types. This excellent type can meet the specifications for most aggregate uses with relatively minor processing. Poor quality aggregate generally had an excess of fines (greater than 5%) and/or contained a significant proportion of deleterious rock types. This type of aggregate has very limited use. The good and fair categories provide a range between the excellent and poor end members. E = excellent quality; G = good quality; F = fair quality; P = poor quality. The quantity assessment was determined by estimating the volume of fine and coarse aggregate present and classifying these estimates as follows: 1 = very large, greater than 1,000,000 cubic metres; 2 = large, 100,000 to 1,000,000 cubic metres; 3 = medium, 10,000 to 100,000 cubic metres; 4 = small, less than 10,000 cubic metres.

(2) The area shown on the map is an area of high potential for aggregate and contains several deposits or former deposits. The volume estimate refers to one (usually the largest) of these deposits.

(3) No subsurface data was available - material, volume and quality estimates are based on surface investigation only.

Geological Units (see Fig. 2 for more complete descriptions)

- 1a Moraine Plain
- 1c Ice-thrust Moraine
- 1d Stagnant-ice Moraine
- 1e Water-modified Moraine
- 2a Ice-contact: kame, esker, crevasse filling
- 2b Outwash: outwash, pitted outwash, meltwater channel, terrace
- 5b Bog

The boundaries of the deposits shown on this map were derived from airphoto interpretation. The quantity estimates and quality determinations are based on limited subsurface data and sample analyses. Multiple designations (e.g. 2a/1d) indicate that both units are present, the first unit being the most common. Geology by W.A.D. Edwards, 1977 and 1978.

FIGURE 3. Sand and gravel occurrences in the St. Paul and Bonnyville areas.

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