Alberta
RESEARCH COUNCIL

SAND AND GRAVEL RESOURCES OF THE ATHABASCA OIL SANDS REGION NORTHEASTERN ALBERTA

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ABSTRACT

The Athabasca Oil Sands region is located in northeastern Alberta, and encompasses approximately 29,450 km^2. Fort McMurray is central to the region. This report assesses the available information and summarizes the sand and gravel resources using this information.

The most detailed information (surface and subsurface data) available covers the central part of the study area adjacent to the Clearwater and Athabasca Rivers. Away from the central area, mapping of aggregate deposits relied mainly upon surficial geology, soil maps and a sand and gravel aerial photo interpretation study. The major deposits of sand and gravel are of meltwater channel and outwash origin. These deposits are located adjacent to the Clearwater and Athabasca Rivers from just south of Fort McMurray to just north of the proposed Alsands townsite (Tp 48, R. 9, W4th Mer). Sand and gravel is being extracted from some of these deposits. Other deposits having good potential are terraces on the lower Athabasca River and the McKay River, outwash sand and gravel on Stony Mountain and in the northern part of the study area.

Other sources of aggregate material are outwash sand which is widespread in the northeast of the map area and a stony till occurring on Stony Mountain. The suitability of this till for aggregate is unknown.

This report meets the requirements for a reconnaissance level survey for northern Alberta. Further fieldwork in such a large area will depend upon client or user requirements.

INTRODUCTION

This report is phase 2 of a project initiated at the request of Alberta Energy and Natural Resources, Resource Evaluation and Planning Division (Appendix 1). Phase 1 of the project concerned sand and gravel resources within the proposed Alsands townsite (Shetson, 1980). Phase 2 discusses the amount and detail of the available information concerning the sand and gravel resources of the Athabasca Oil Sands region; the additional work required to complete a systematic survey of the aggregate resources of the region; and gives a compilation and summary of the sand and gravel resources in the area based on the available information.

ACKNOWLEDGMENTS

Thanks are due to W.A.D. Edwards and B. Peterson of the Alberta Research Council and B. Hudson of Alberta Energy and Natural Resources for suggestions and critical reading of the report. Lawrence Buss and Brad Anderson assisted with the preparation of the report.

Funds for the project were provided by the Resource Evaluation and Planning Division of Alberta Energy and Natural Resources.

LOCATION OF THE STUDY AREA

The study area, located in northeastern Alberta, encompasses Tp 80 to 87, R 4 to 17 and Tp 88 to 104, R 4 to 15, W4th Mer, and is 29,450 km^2 in area.

Figures 1 and 2 illustrate the location and boundaries of the study area.

AMOUNT AND DETAIL OF AVAILABLE INFORMATION

Tables 1 and 2 list the information available (for complete titles see the references). The locations of the report areas and map coverage are shown in figures 3 and 4.

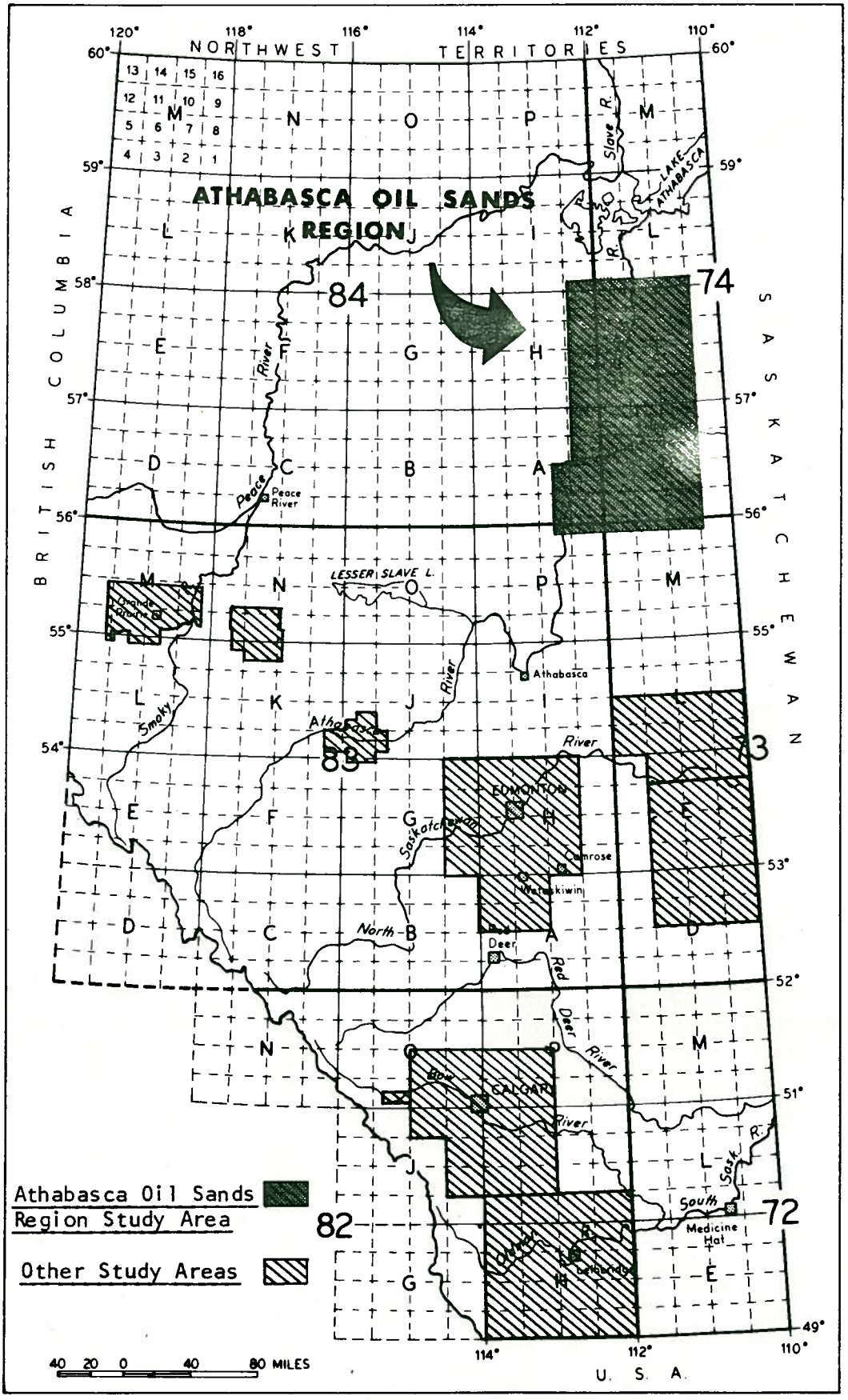


FIGURE 1. Sand and Gravel Inventory study areas.

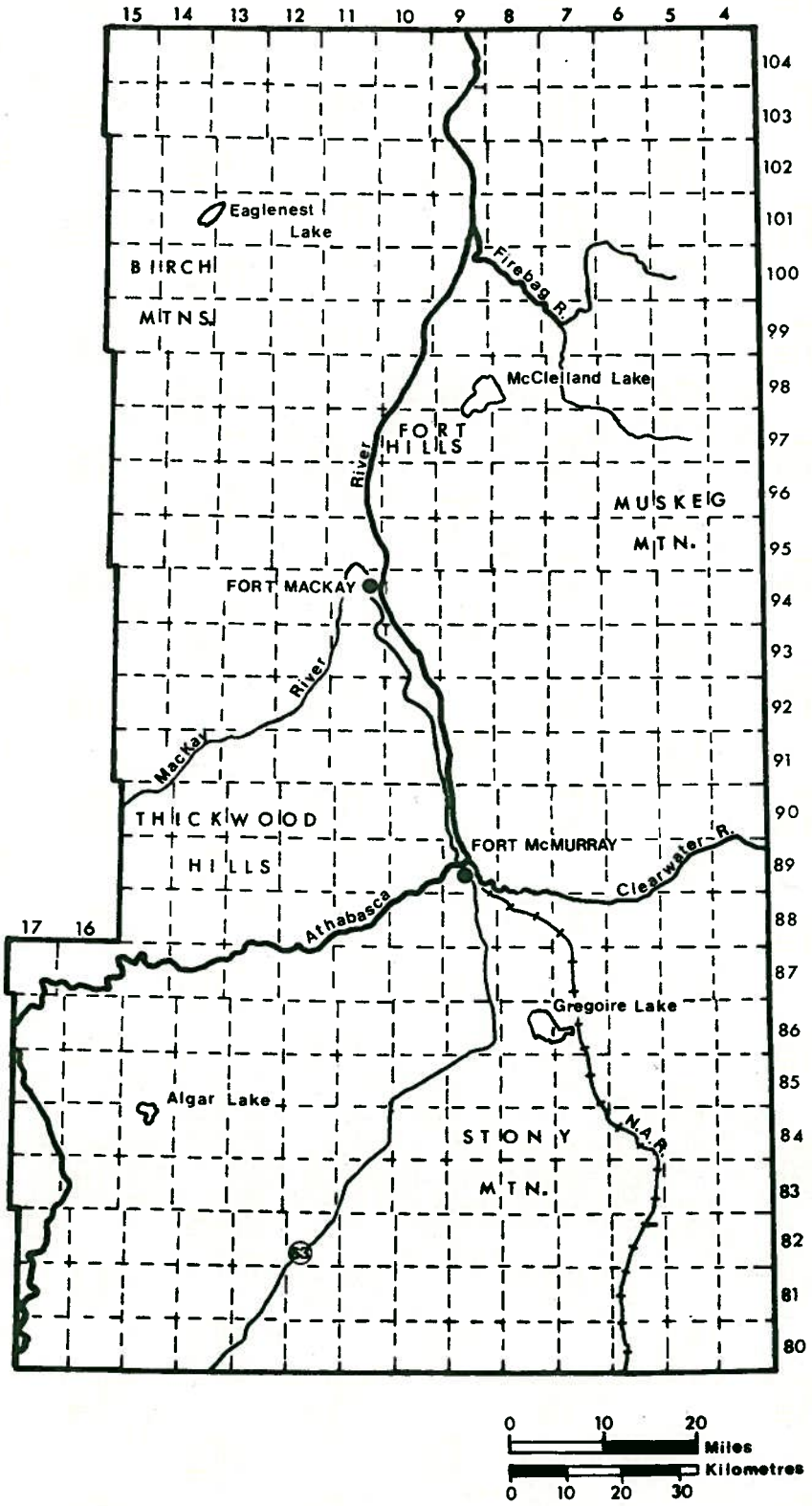


FIGURE 2. Athabasca oil sands region study area.

Table 1. Report Contents and Level of Detail

Report	Areal Coverage (Tp) (see Fig. 3)	Surficial Geology	Sand and Gravel Information	Testhole Log	Grain Size Analysis	Level of Detail* (see Fig. 6)	Comments
Quaternary Geosciences, 1977	50	yes	yes	no	yes	3	very useful
Quaternary Geosciences, 1976a	12	yes	yes	yes	yes	3	very useful, small area
Quaternary Geosciences, 1976b	54	no	no	yes	yes	3	very useful
Quaternary Geosciences, 1975	65	no	no	no	yes	2	very useful
Mollard, 1974	268	no	yes	no	no	1a	very useful, large area
Klohn Leonoff, 1978	1.5	no	yes	yes	yes	3	very useful, small area
Athabasca Realty, 1974	1.5	no	yes	yes	yes	2	useful, small area
Biophysical analysis, 1974	17	yes	no	no	no	1	not used
Biophysical analysis, 1973	11	yes	no	no	no	1	not used
Thurber, 1975	-	no	yes	no	no	1	general summary
Thurber, 1974	-	no	no	no	no	1	general summary

*Level 3 detail - greatest detail (surface and subsurface information)
Level 2 detail - intermediate detail (surface information)
Level 1 detail - least detailed (aerial photo interpretation - limited field checking)

Table 2. Maps and Level of Detail

Maps	Scale (see Fig. 4 for areal coverage)	Surficial Geology	Sand and Gravel Information	Level of Detail* (see Fig. 6)	Comments
Surficial Geology Waterways NTS 74D	1:250,000 map sheet	yes	yes	1	very useful
Surficial Geology Bitumount NTS 74E	1:250,000 map sheet	yes	yes	1	very useful
Surficial Geology Lake Claire NTS 84I	1:250,000 map sheet	yes	yes	1	very useful
Surficial Geology Fort Chipewyan NTS 74I	1:250,000 map sheet	yes	yes	1	very useful
Alberta Land Inventory	1:63,000 map sheets - total area	yes	no	1	of limited value - generalized
A.O.S.E.R.P. Surficial Geology	1:50,000	yes	no	1	of limited value
A.O.S.E.R.P. Soils	1:50,000	yes	no	1	of limited value

*Level 1 detail - least detail (aerial photo interpretation - limited field checking)

LEGEND

1. Burry, A.F., Athabasca Realty Co. Ltd., 1975.
2. Klohn Leonoff Consultants Ltd., 1978.
3. Quaternary Geosciences Ltd., 1976a.
4. Quaternary Geosciences Ltd., 1976b, 1977.(---)
5. Quaternary Geosciences Ltd., 1975.(× × ×)
6. Mollard and Associates Ltd., 1974.

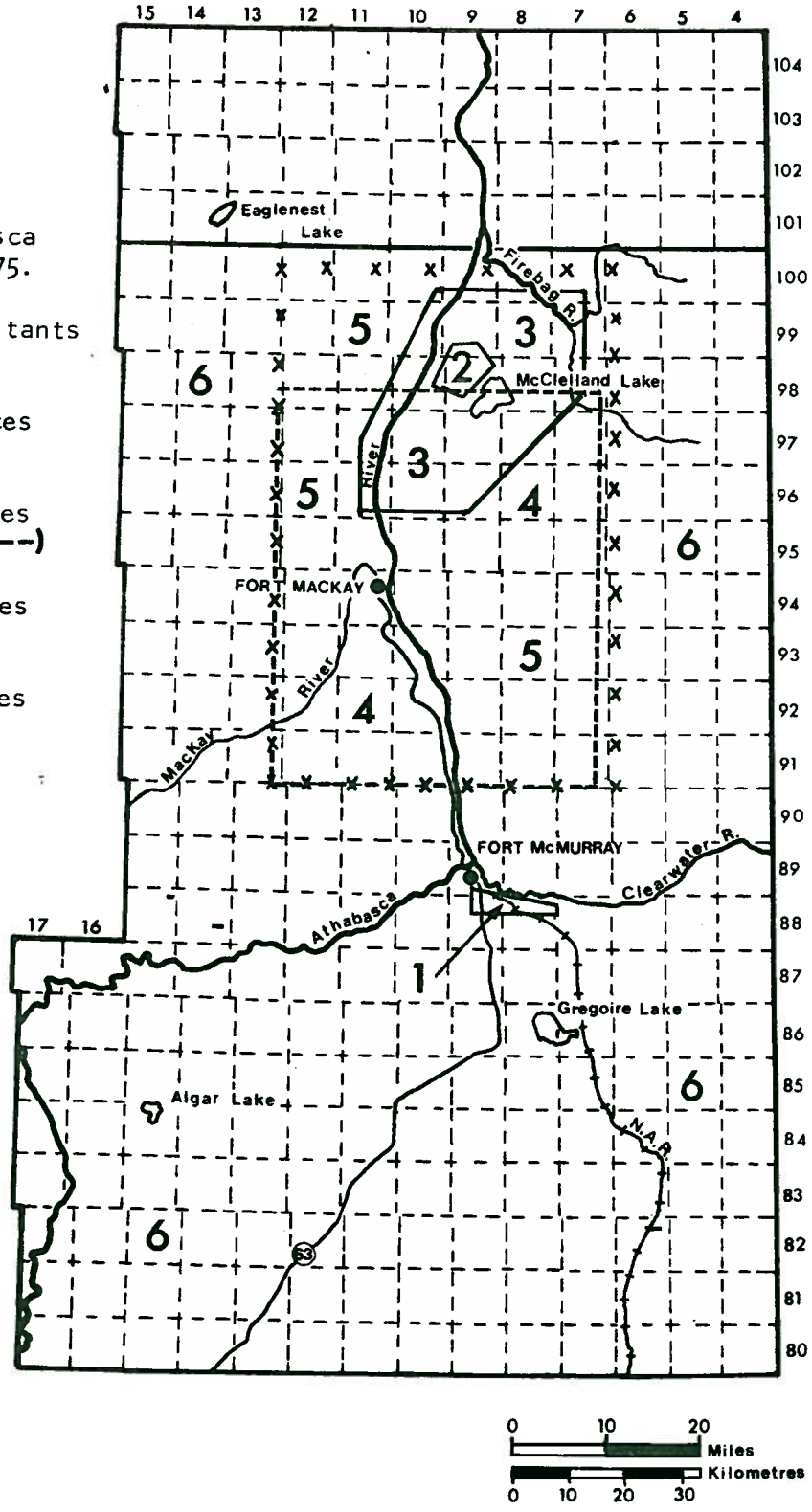


FIGURE 3. Areal coverage of available reports.

LEGEND

●●● ARC Surficial Geology (1:250,000)

△△△ A.O.S.E.R.P. - Soils (1:50,000)

■■■ A.O.S.E.R.P. - Surficial Geology (1:50,000)

ALI maps cover total study area.

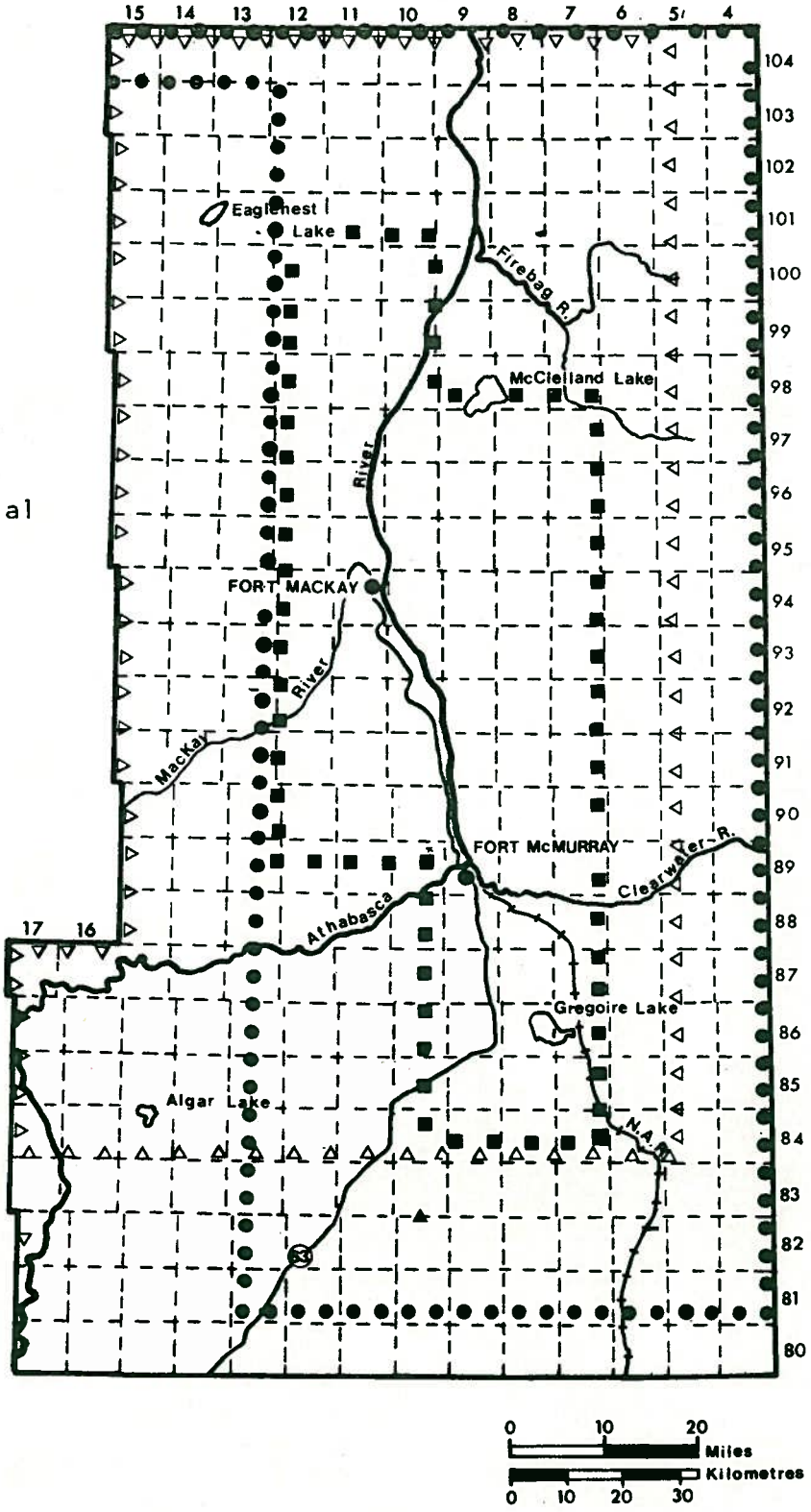


FIGURE 4. Map coverage.

Lithologic logs of wells available from the files of the Groundwater Department of the Alberta Research Council provided information for a few limited areas around Fort McMurray, Gregoire Lake (Fig. 2), Tar Island-Mildred Lake (Tp 92 and 93, R 10, W4th Mer) and Bohn Lake (Tp 80, R 5, W4th Mer).

The number and type of data points used in this study are shown in figure 5.

The reports and maps used in this study have been divided into three levels of detail (Fig. 6).

The Quaternary Geosciences Ltd. studies (1976a, 1976b and 1977) and a study by Klohn Leonoff Consultants Ltd. (1978), located in the north-central part of the study area (Fig. 3) contain surface and subsurface data. These reports are the most useful available in the region and are of level 3 detail.

Two slightly less useful reports containing only surface data from shallow test pit sampling (Quaternary Geosciences Ltd., 1975, Athabasca Realty Co. Ltd., 1975), are called level 2 detail (Fig. 3).

Level 2 and level 3 detail cover 17 percent of the total study area of 29,450 km^2. The remainder of the study area (83 percent of the total area) is covered by either surficial geology, soil or biophysical maps (Fig. 4). These maps were compiled from aerial photo interpretation with very little or no fieldwork. Subsurface and surface data is absent so quality and quantity assessments of individual deposits cannot be made from this source. This information is the lowest level of precision considered in this report and is termed level 1 detail. Of these reports, Mollard's 1974 sand and gravel study was the most specific. These level 1 detail maps, although general, form a good base for further exploration. A low level of detail does not preclude a good deposit being present but merely indicates that the information available is not sufficient to adequately judge the characteristics of the deposit.

LEGEND

Number of data points and type per township.

TESTHOLES

(Quaternary Geosciences Ltd., 1976a, 1976b; Klohn Leonoff Consultants Ltd., 1978).

SURFACE SAMPLES

(Quaternary Geosciences Ltd., 1975; Athabasca Realty Co. Ltd., 1975).

WELL LOGS

(Alberta Research Council-Groundwater files).

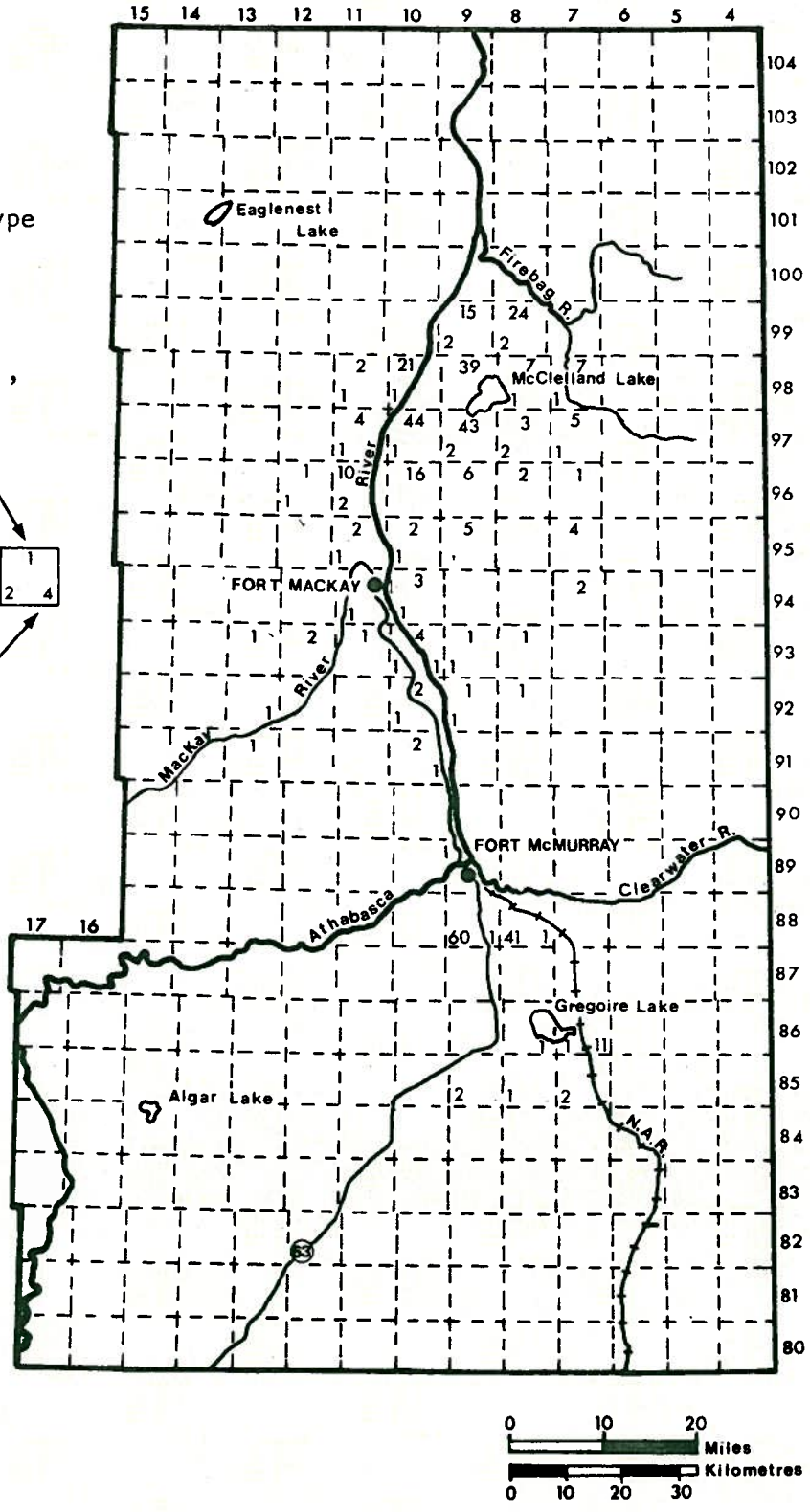


FIGURE 5. Sand and gravel data points - surface and subsurface.

LEGEND

1 Aerial photo interpretation.

major information source -

a) Mollard, 1974
ARC - Surficial Geology
b) ARC - Surficial Geology
c) A.O.S.E.R.P. - Soils

2 Aerial photo interpretation with some field checking.

3 Aerial photo interpretation, field mapping and drilling.

Total area - 29,450 sq km.

Level of detail	% area	sq km
1	11	3240
2	7	2060
3	82	24150

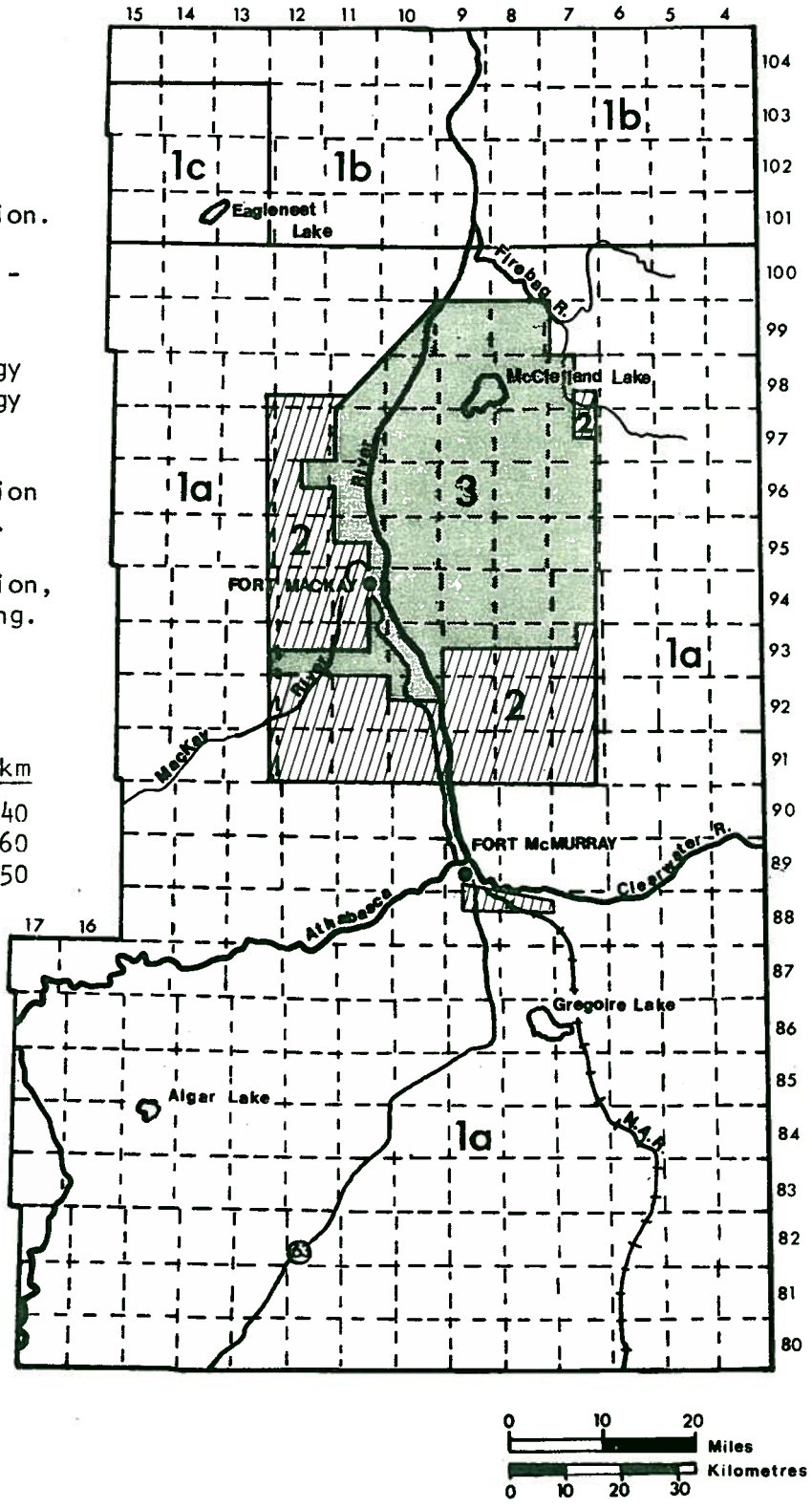


FIGURE 6. Level of detail - areal coverage.

SUMMARY OF SAND AND GRAVEL RESOURCES

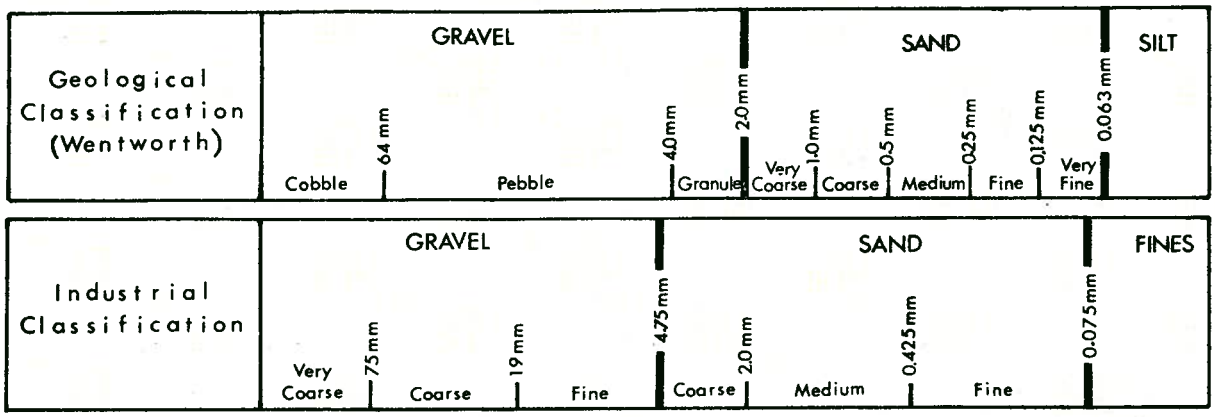
This section of the report summarizes the sand and gravel resources of the study area, based on the available information (see Tables 1 and 2). Additional fieldwork was not undertaken. The number and type of data points used in this summation are shown in figure 5 and the terminology used is explained in figure 7 and the glossary.

GEOLOGY

Lowlands form the central part of the study area grading into the Birch Mountains to the northwest and Muskeg Mountain to the east. The northern flanks of Stony Mountain occur within the southern edge of the area. The surficial geology maps (Bayrock, 1971, 1972a, 1972b; Bayrock and Reimchen, 1974) show that the predominant surficial materials of the lowlands are: a) extensive outwash sands mostly east of the Athabasca River north of Tp 93; b) extensive glaciolacustrine silts and clays south of Tp 93; c) outwash, including meltwater channel sediments, composed of sand and varying amounts of gravel; d) ice-contact deposits composed of silt and silty sand (kames and kame moraine) occurring immediately south of McClelland Lake (Fort Hills) and in a broad east-west band in Tp 102 and 103; and e) terrace and channel deposits composed of gravel, sand, silt and clay in the modern river valleys.

The surficial materials of the lowlands are underlain by the important Cretaceous oil bearing sediments and Devonian carbonates. To the northeast of McClelland Lake outcrops of the Canadian Shield are present.

The uplands are formed of Cretaceous shales and sandstones overlain by glacial drift, mainly tills. The flanks of the uplands have been modified, in places, by a glacial lake or lakes (Quaternary Geosciences Ltd., 1977) resulting in beach deposits at various elevations below 510 m a.s.l.



Geological and industrial grain size classifications

Classification of unconsolidated granular material.

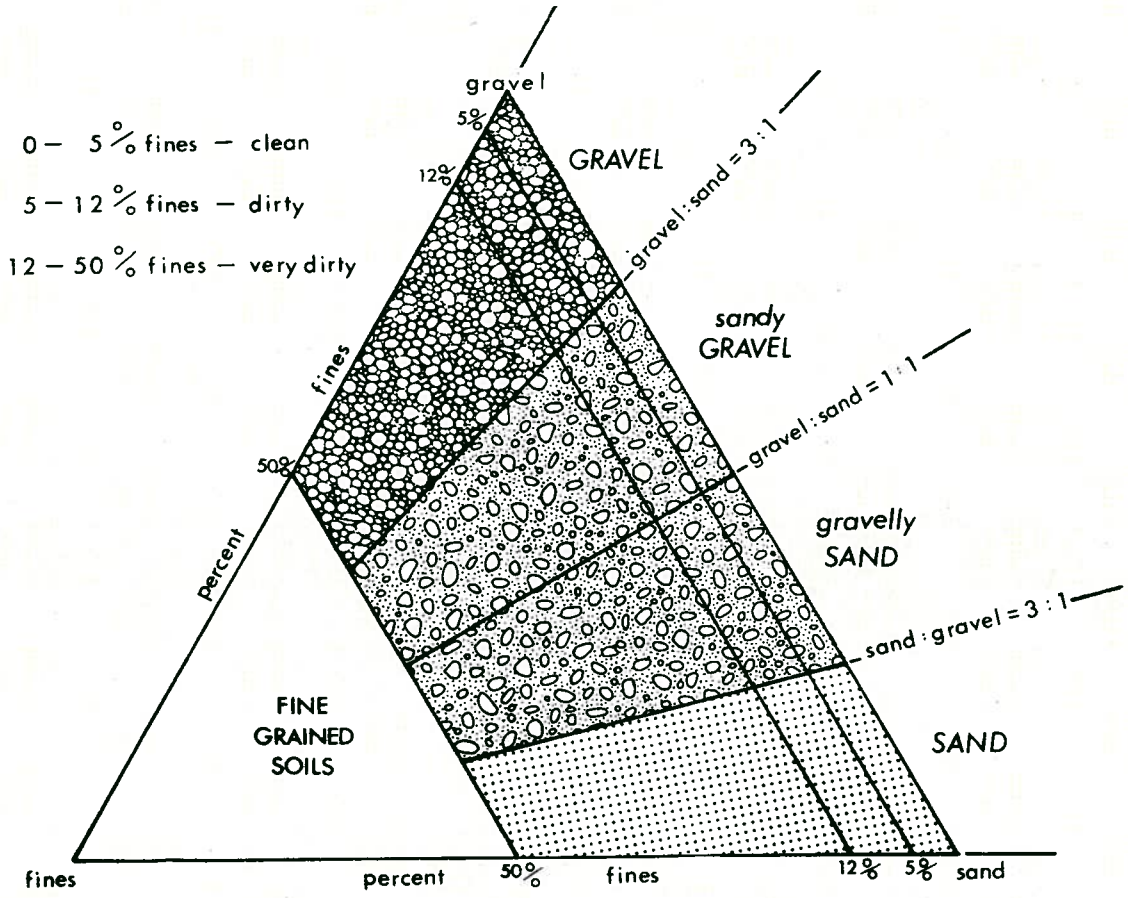


FIGURE 7. Classifications of grain size.

No preglacial sands and gravels have been reported as occurring in the study area. However, Bayrock and Reimchen (1974) briefly discuss a till, occurring on Stony Mountain, that contains a significant proportion of rounded quartzites, possibly derived from Tertiary gravels, signifying that preglacial gravel may underlie the upland.

METHOD

The sand and gravel deposits were categorized into good, fair and poor deposits as sources of aggregate. These categories are based upon textural ranges and do not reflect the economics of extraction (eg. water table elevation, haul distance, deleterious materials) as this information is not available.

A good deposit is one of wide textural range (sand to gravel — Fig. 7) having potential for a greater number of uses than a fair deposit. A fair deposit has limited textural range (fine to coarse sand with a low percentage of gravel - Fig. 7) and with limited potential use. In poor deposits gravel may be present in small quantities. Generally these deposits are dirty or of very limited textural range (fine to medium sand).

DESCRIPTION OF DEPOSITS

Good, fair and poor deposits of sand and/or gravel as a source of aggregate are outlined in figure 8.

Good Deposits (sand and gravel)

These deposits are glaciofluvial outwash sediments, including meltwater channel sediments and modern river deposits.

Map Unit 1A

This map unit shows abandoned meltwater channel deposits containing fine to coarse sand with variable amounts of gravel and boulders.

W1/2, Tp 97, R 10, W 4th Mer: A large sand and gravel deposit approximately 1 km wide and 5 km long occurs in a meltwater channel near Susan Lake. The deposit is too coarse for penetration by auger drill. However, existing oil company data indicates that the sand and gravel is generally from 3 to 6 m thick (Quaternary Geosciences Ltd., 1976a, 1977). Backhoe test pitting would be needed to appraise the deposit's potential. An Alberta Transportation reservation has been placed on most of this deposit.

Tp 92 to 93, R 10, W 4th Mer: Most of the sediment in this deposit is sand, with gravel and sand occurring as bars and outwash remnants in a complex of meltwater channels. A number of holes have been drilled near Mildred Lake, two of these in sand and gravel. The thickness of sand and gravel varies between 1 and 3+ m and contains clasts up to 10 cm in size. The percentage of sand to gravel is not known. Very limited data is available for this area and backhoe test pitting should be considered.

Tp 89 to 90, R 8 to 9, W4th Mer: Occurring in this location is an area of thin outwash sand and gravel present along the bottom of meltwater channels and as terraces (Bayrock and Reimchen, 1974). Mollard's 1974 study rated parts of this area as poor, based on aerial photo interpretation.

Tp 88, R 7 to 9, W4th Mer: A large area of meltwater channel deposits southeast of Fort McMurray, south of the Clearwater River, serves as a source of aggregate for the area. Backhoe test pits throughout the deposit, to a depth of 4.5 m or less, indicate a range of material from fine sand to gravel, the predominant material being sand to gravelly sand and often dirty. Gravel content can range up to 73 percent, with some clasts larger than 7.5 cm in diameter (Athabasca Realty Co. Ltd., 1975). The deposit generally appears to be shallow (3 to 5 m), overlying clay or till, but many test pits did not reach the base.

South of Gregoire Lake there occurs scattered pockets of generally thin sand and gravel channel deposits (Fig. 8). The composition and thickness of these deposits is unknown.

Map Unit 1B

These map units are of outwash sand and gravel, not including meltwater channel sediments, composed of fine to coarse grained sand with variable gravel content.

Tp 96 to 97, R 10 to 11, W4th Mer: A major deposit of the study area is an outwash bar in the vicinity of Bitumount airstrip (NE1/4, Tp 96, R 11, W4th Mer). Drilling in this deposit (Quaternary Geosciences, Ltd., 1977) revealed a well-graded generally medium to coarse sand with gravel up to 10 cm in diameter, and low in deleterious material. Deposit thickness ranges between 1 to 6 m. Backhoe test pits up to 3 m deep in Alberta Transportation reservation areas (Tp. 96 to 97, R 10, W4th Mer) revealed mainly clean gravelly sand. Gravel content in these test pits ranged between 17 to 62 percent with up to 10 percent being over 15 cm in diameter. The area tested (approximately 2 Lsd's) contained approximately 800,000 m^3 of granular material. As the backhoe tested area is only a small portion of the total deposit, and drill holes elsewhere in the deposit indicate sand and gravel, the reserves in this deposit could be considerable.

Tp 104, R 4, 9 and 10, W4th Mer: In the extreme north of the study area are two deposits of outwash sand and gravel. The composition and thickness of these deposits is unknown.

Map Unit 1G

Recent alluvial sediments occur along present day streams and rivers either in the channel or as terraces.

Tp 92, R 12, W4th Mer: Along the MacKay River (Fig. 8) are a series of terraces about 6 m above the river comprised of 3 to 4.5 m of silt and clay underlain by 1 to 5 m of sand and gravel. The sand and gravel is poorly sorted and contains an appreciable quantity of local bedrock fragments, clay lumps and organic matter. These deposits have some potential as a source of low quality aggregate (Quaternary Geosciences Ltd., 1977).

The total area of the terraces is approximately 500 ha and with a depth of 1.5 m of sand and gravel these could potentially yield 8,000,000 m^3 of low quantity aggregate. Further field checking would be necessary to ascertain the potential of the terraces.

Tp 87, R 15, W4th Mer: Mollard (1974) rated a number of terraces on the lower Athabasca River as being good prospects. The terraces are small and depths of sand and gravel and overburden are unknown.

Localized deposits of sand and gravel are common in the beds of the major rivers. Generally these deposits are too small to have significant potential for an aggregate supply (Quaternary Geosciences Ltd., 1977).

Fair Deposits (sand)

These sand deposits are glaciofluvial outwash, meltwater channel and glacio-lacustrine beach deposits.

Map Unit 2A

These deposits are infilled channels which occur in close proximity to the Athabasca River between Tp 90 and 104.

The granular material is mainly fine to coarse grained sand with minor lenses or layers of gravel. Silt, clay and minor boulders are also present usually near the base of the deposits.

The thickness of these deposits is variable but generally less than 6 m (Quaternary Geosciences Ltd., 1977).

Map Unit 2B

Within the study area outwash sand is the most common surficial material and has been modified in places by wind and the growth of muskeg. These deposits are

generally confined to the northeast portion of the study area and to the central portion adjacent to the Athabasca River (Fig. 8). On the upland areas outwash sand is scarce.

The outwash sand is variable over short distances ranging from fine to coarse grained sand, the average being in the fine to medium grain sizes. Clay and silt are commonly interbedded with the sand, but generally are only a minor percentage of the material. The sand commonly contains reworked bitumen.

Based on test drilling (Quaternary Geosciences Ltd., 1977) the sand is generally coarse grained near the base of the deposits. Where the sand forms the surface sediment it varies between 6 to 9 m in depth but can be over 30 m (in the townsite area, McClelland Lake). Sand buried beneath 1 to 6 m of lacustrine clay and peat occurs generally in the west central part of the area. The buried sand, which has a thickness of between 6 to 12 m is generally clean, well sorted, fine to coarse grained with minor gravel and overlies till (Quaternary Geosciences Ltd., 1977).

Map Unit 2D

The raised beaches in the study area are shoreline features of a former glacial lake or lakes. They occur between 300 to 500 m a.s.l. on the flanks of Thickwood Hills, Stony Mountain and Muskeg Mountain. The beaches range from a few hundred metres long to over 16 km in length (Quaternary Geosciences Ltd., 1977) and are composed primarily of sand.

Poor Deposits

These deposits are generally a poor source of aggregate being either of limited grain size range or localized small areas of sand and/or gravel. Sandy tills in the eastern part of the study area and the gravelly till on Stony Mountain are included due to their high percentage of sand and gravel. These tills need to be investigated further to determine their potential as a source of aggregate.

Map Unit 3C

Large areas of kame and kame moraine occur in the northern part of the area forming elevated portions of the lowlands and in places show severe past erosion.

They consist primarily of stratified silts and fine grained silty sands. Lenses of clay, till and coarse sand are also present in minor amounts. Often reworked bitumen is present in the sand in the oil sands area. The thicknesses of these deposits is up to 80 m in some localities in the Fort Hills and 72 m east of McClelland Lake, but they generally are less than 30 m thick (Quaternary Geosciences Ltd., 1977).

Map Unit 3E

The occurrence of aeolian sand is widespread in the form of dunes or sheets. Glaciofluvial outwash sand constitutes the source for most of this material. The sand is well sorted and generally fine grained and composed primarily of quartz grains.

Within the proposed townsite, Klohn Leonoff Consultants Ltd. (1978) noted that the dunes are between 1.5 to 6 m high, averaging less than 3 m. The silt content here ranges between 2 to 10 percent, averaging 5 percent. Between McClelland Lake and the Firebag River the dunes are up to 9 m high (Quaternary Geosciences Ltd., 1977).

Map Unit 3F and 3F-l

Map Unit 3F is a till composed primarily of sand derived from the Athabasca Formation. The sand content exceeds 90 percent and the balance is made up of silt, pebbles and boulders (Bayrock and Reimchen, 1974). A large area of this till occurs in Tp 92 to 100, R 4 to 7, W4th Mer in the eastern part of the study area. On the surficial geology map by Bayrock (1971) this has been labelled as outwash sand. However, more recent work by Bayrock and Reimchen

(1974) to the south has called it till and noted that on cursory examination the till appears to be sandy outwash. Mollard's aerial photo interpretation (1974) rates it as poor and it is likely that the deposit is, indeed, a sandy till and is labelled as such on the map (Fig. 8).

Map Unit 3F-1 is a till rich in gravel (rounded quartzites) occurring on Stony Mountain. Only the thicker hummocky till has been outlined on the map (Fig. 8). Alberta Environment (Geotechnical Branch, 1973) analysed three samples, apparently from this till. The texture ranged from medium to coarse sand with 17 percent gravel up to 7.5 cm in diameter (W1/2 Sec 35, Tp 85, R 7, W4th Mer; SW Sec 7, Tp 87, R 7, W4th Mer) to clean gravelly sand with 50 percent gravel content up to 15 cm in size (Pit: Sec 35, Tp 85, R 9, W4th Mer). Mollard's aerial photo study has rated parts of this till area as poor.

Given the above textural data this gravelly till is worthy of further investigation.

Bedrock

Map Unit BK

This unit is comprised of areas of Precambrian Shield outcropping at the surface. These areas could possibly be a source of quarry rock for the manufacture of aggregates.

Devonian Limestone: Mollard (1974) tested some small grab samples of limestone from the Devonian Waterways Formation for potential as a source of aggregate for concrete. The samples were obtained from exposures 13 km downstream and 16 km upstream from Fort McMurray on the Athabasca River. Test results indicate that the limestone at these locations is unsuitable for concrete aggregate. Further testing would be required to adequately determine the quality of the limestone for various uses. It is possible that unweathered, better quality material suitable for concrete and other uses is present.

ADDITIONAL WORK REQUIRED

Reconnaissance exploration for sand and gravel in northern Alberta encounters higher costs and more difficult access than in southern Alberta. Consequently aerial photo interpretation is the main basis for a reconnaissance survey. As such, this study satisfies the requirements for a reconnaissance level survey and further field exploration would require input from a client or user. The input should include amount and quality of aggregate needed, allowable distances of transport (study area), time and degree of detail needed.

At a meeting with Alberta Energy and Natural Resources, July 25th, 1980, it was indicated by representatives of the Northeast Commission that detailed aggregate information is required in an area centred around the Alsands plant site and the proposed townsite. Initial construction at the townsite could start in the winter of 1980/1981. To give future direction to exploration they will prepare a memorandum stating their requirements and that of other aggregate users. The means of obtaining resource data was discussed and it was tentatively decided that due to the short time available consultant companies would be used. The coordination of the consultants would be by either Alberta Energy and Natural Resources or the Geological Survey Department of the Alberta Research Council.

Some deposits in the study area, away from the zone of oil sand development appear to have good potential for aggregate, but nothing is known about their characteristics. If further work is required to upgrade the information concerning those deposits, then helicopter-supported field work would be the most economical method.

SUMMARY AND CONCLUSIONS

Available information pertinent to sand and gravel resources of the study area was assembled, rated and is presented in Tables 1 and 2. The rating enabled areas to be outlined where information was lacking to some degree.

Figure 8 outlines the areas of sand and/or gravel with good, fair and poor potential as an aggregate source. These categories were based on reported textural range for the deposits.

Sources of sand and gravel are widely scattered throughout the study area with a major concentration adjacent to the Athabasca and Clearwater Rivers and in the northeast portion of the area.

Major deposits of sand and gravel, which form the better prospects (Map Units 1A and 1B, Fig. 8) are found within approximately six miles on either side of the Athabasca and Clearwater Rivers (Tp 87 to 99, R 7 to 10, W4th Mer).

These deposits contain fine to coarse sand with variable amounts of gravel up to 73 percent, with thicknesses of between 1 to 6 m. Other good prospects lie on Stony Mountain and as terraces on the MacKay River (Map Unit 1G). These better prospects have not been tested for sand and gravel as such, except for a small area near Bitumount airstrip, and the deposit south of the Clearwater River (Tp 88, R 7 to 9, W4th Mer).

Potential sources of aggregate for the townsite by McClelland Lake lie within 13 km distance to the southwest in the vicinity of Bitumount and Susan Lake and to the northwest of McClelland Lake (W1/2, Tp 99, R 9, W4th Mer).

Large deposits of sand (Map Units 2A and 2B) exist north of township 91, extending to the northeast corner of the study area. These deposits contain fine to coarse sand, generally clean and well graded. Depth is variable, generally 6 to 9 m but in places over 30 m.

The poorer prospects for sand and gravel are aeolian sand and kame deposits. Aeolian sand (Map Unit 3E, Fig. 8) is widespread in the form of sheets or dunes and generally limited in grain size range. The kame deposits (Map Unit 3C, Fig. 8) are mainly composed of silts and silty sand with minor amounts of sand and gravel.

A gravelly till (Map Unit 3F-1) on Stony Mountain may be a source of sand and gravel in lieu of better deposits, but this remains to be determined. The better deposits adjacent to the Athabasca River north of Fort McMurray have been partially explored using an auger drill and backhoe. Generally these deposits have not been tested sufficiently to adequately determine textural variation, depth and deleterious material inclusions. Access to these deposits, to give good control, is likely to be difficult and backhoe test pits are probably a preferred means of testing. The extent of further testing of these deposits will largely be determined by user or client needs.

This report is considered to be at the reconnaissance level of information for northern Alberta.

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APPENDIX I.

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 that contains less than 5 percent fines.

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

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 breakdown 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.

dirty sand - said of sand that contains between 5 and 12 percent fines.

fines - sediment with particle diameters less than .075 mm.

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.

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 meltwater flowing directly from glaciers; composed of well-sorted clay, silt or sand.

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 three parts gravel for every part sand.

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).

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

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.

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.

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.

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 three parts and for every part gravel.

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).

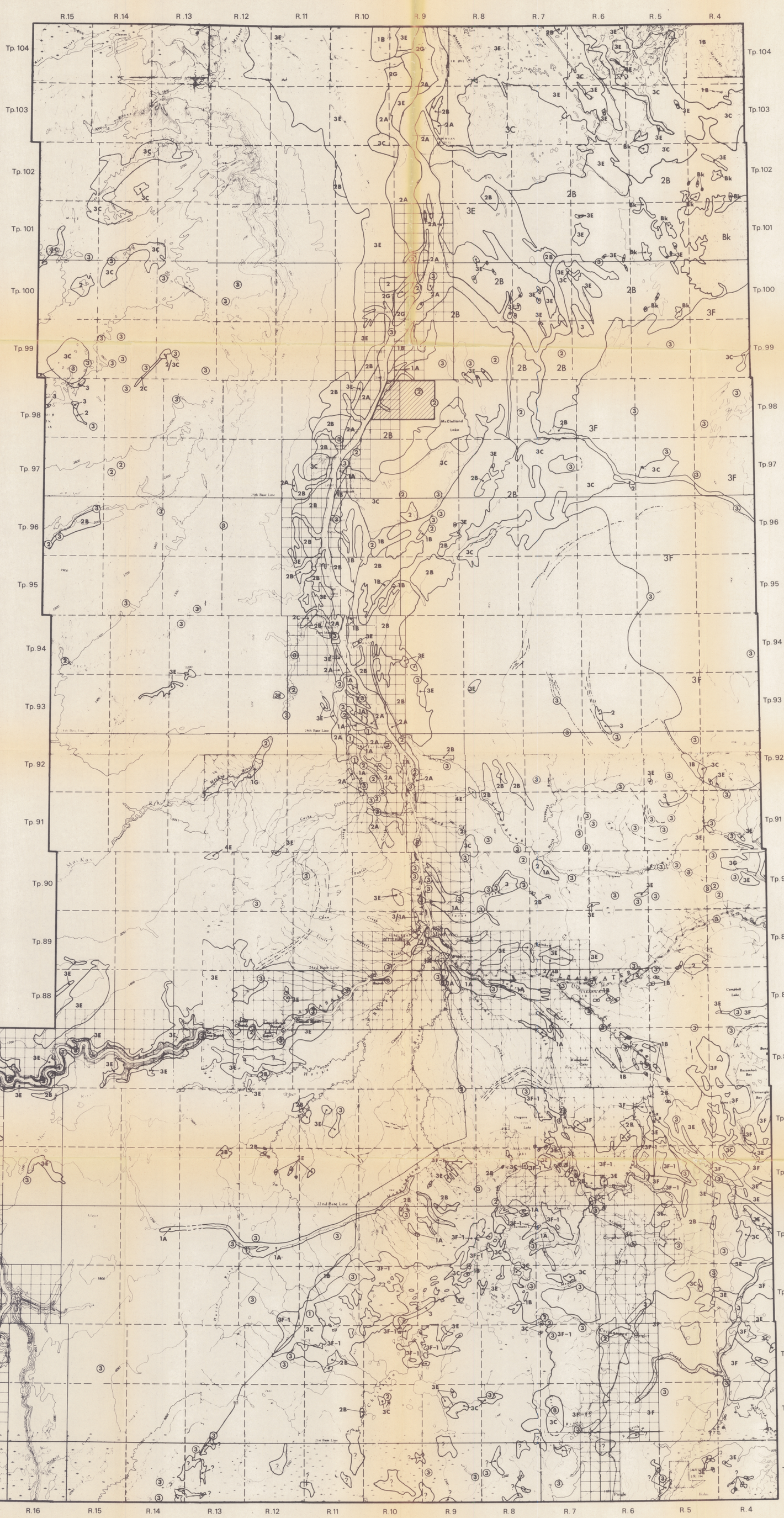
shale - a fine-grained sedimentary rock formed by the consolidation of clay, silt or mud and characterized by a finely stratified structure, shale is generally soft but sufficiently indurated so that it will not fall apart on wetting; a poor aggregate material because of its softness and fissility.

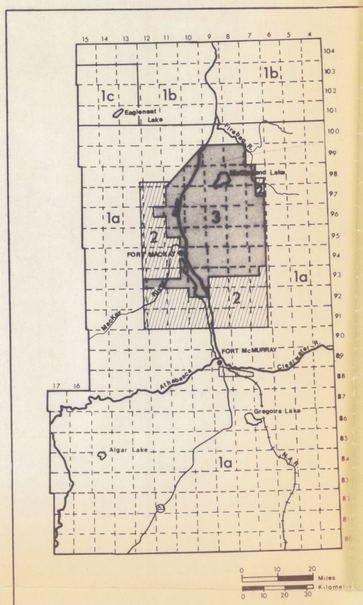
silt - a rock or mineral fragment or detrital particle having a diameter in the range of 1/256 or 1/16 mm (Wentworth scale).

terrace - a large bench of 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.

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





Level of detail – areal coverage

LEGEND

1 Aerial photo interpretation.

major information source -

a) Mollard, 1974
ARC - Surficial Geology
b) ARC - Surficial Geology
c) A.O.S.E.R.P. - Soils

2 Aerial photo interpretation with some field checking.

3 Aerial photo interpretation, field mapping and drilling.

Total area 11,370 miles (2,944,482 hectares).

Level of detail	% area	sq mi
1	11	1260
2	7	720
3	82	9390

LEGEND

Example: 1A

Sand and gravel resource potential rating — Deposit genesis and type

Sand and gravel resource potential rating

1 .....Good: *sand and gravel deposits; potentially a wide range of uses.*

2 .....Fair: *sand deposits; potentially fewer uses than sand and gravel.*

3 .....Poor: *variety of deposits; the deposits can be (a) of wide occurrence but very few potential uses (b) localized deposits; small volume; incorporated into silt and clay.*

Deposit genesis and type

A .....Glaciofluvial meltwater channel sediments: *fine to coarse grained sand; variable amounts of gravel and boulders; commonly occurs as bars; in part early Athabasca River deposits.*

B .....Glaciofluvial outwash deposits: *fine to coarse grained sand; variable amounts of gravel and boulders; occurs as outwash plains or bars.*

C .....Glaciofluvial ice contact deposits: *composed primarily of stratified sand and silt; minor gravel, clay and till lenses; occurs as kames and kame moraine.*

D .....Glaciolacustrine beach deposits: *mainly sand; occurs as a relict beach ridge.*

E .....Aeolian deposits: *wind blown; mainly sand; occurs in dune and sheet form.*

F .....Glacial till: *sandy; derived from the Athabasca Formation; hummocky and ground moraine.*

F-1 .....Glacial till: *high proportion of gravel derived from Tertiary gravels; hummocky moraine.*

G .....Fluvial deposits: *sand and gravel in or adjacent to modern rivers; overburden of silt and clay; occurs on terraces or as channel deposits.*

Bk .....Bedrock: *outcrops of the Precambrian Shield.*

2B .....*area information.*

(3) .....*point information - Mollard, 1974.* (The number refers to the sand and gravel resources potential rating).

-·-·- *abandoned beach.*

——— *approximate geological boundary.*

– – – – *indefinite geological boundary.*

▨ ..... *Phase 1 study area: proposed townsite (Shetsen, March, 1980).*

Geology compiled and modified by J.C. Fox, 1980 from Quaternary Geosciences Ltd., 1976a, 1977; Mollard and Associates Ltd., 1974; Bayrock and Reinchen, 1973; Bayrock, 1969, 1970; Turchenek, 1980; Alberta Land Inventory, 1951, 1952.

NOTES

The sand and gravel deposits outlined were rated for potential use as an aggregate source using texture, genesis and deposit type where this information was available.

The available information used was organized into levels of detail - see inset map. No fieldwork was done.

31	32	33	34	35	36
30	29	28	27	26	25
19	20	21	22	23	24
18	17	16	15	14	13
7	8	9	10	11	12
6	5	4	3	2	1

SCALE 1: 250,000

5 0 5 10 Miles / Kilometres

5 0 5 10 15 Miles / Kilometres

FIGURE 8. SAND AND GRAVEL RESOURCES OF THE ATHABASCA OIL SANDS AREA

FIG. 8 SAND AND GRAVEL RESOURCES OF THE ATHABASCA OIL SANDS AREA