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PRELIMINARY REPORT ON THE URBAN GEOLOGY OF THE ANNEXED AREAS IN EDMONTON

by

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INTRODUCTION

Purpose of Study

The recent rapid growth of urban centers in Alberta has imposed an increased demand on the natural resources surrounding these areas. In the development of responsible land planning decisions around the urban centers a thorough understanding of the geologic and geotechnical properties of the surface sediments is required.

This report provides a general geologic data base that will assist in making planning decisions for the recently annexed areas around Edmonton. The information has been collected from existing reports and maps along with an air photo interpretation. No site investigations were conducted to verify or supplement the information. From the data a series of maps were compiled that evaluate the areas with respect to their suitability for various land uses. These maps should serve only as guidelines for future surveys and investigations.

Location of Study Area

The areas of study in this report have been defined by the City of Edmonton Planning Department as those areas recently annexed to the City of Edmonton. Specifically, there are three geographic areas which, for the purposes of this report, are labelled A, B, C.

Area A is located in the northeast part of Edmonton and includes about 23 square miles. It is bounded by the present City boundary to the south, by the Namao airport to the west, by Highway 37 to the north and by the North Saskatchewan River to the east.

Area B is a zone 2 miles wide, extending the length of the present southern boundary of the city. It covers an area slightly more than 27 square miles.

Area C covers a 1 mile wide strip on the western edge of the City, extending 5.5 miles south from Big Lake.

BEDROCK GEOLOGY

A complete description of the bedrock geology in the greater Edmonton area is contained in the Urban Geology of Edmonton (Kathol and McPherson, 1975, pg. 15-24). Summarized briefly, the study areas are underlain by the Edmonton Formation, a succession of non-marine sandstone, shale and coal beds that dip gently to the southwest. The sandstone and siltstone are bentonitic and grade both vertically and horizontally into bentonitic claystone. These gradational contacts, plus the lenticular geometry of the beds, make correlation of individual beds difficult even over short distances.

BEDROCK SURFACE TOPOGRAPHY

Figure 1 shows the topography of the bedrock surface and preglacial valley thalwegs in the three study areas, derived from Carlson's (1967) bedrock topography map of the Edmonton area. Also included in figure 1 are the locations of drill holes where Preglacial sand and gravel deposits were found overlying bedrock. By using a surface topography map and figure 1 the depth to bedrock can be calculated within 25 feet and a rough estimate of total drift thickness can be determined. However for land planning decisions it is essential that precise information on depth to bedrock and nature of deposits in the drift be available. This type of information would be generated from a stratigraphic borehole survey.

A detailed description of the bedrock surface topography has been excerpted from the Urban Geology of Edmonton Bulletin no. 32 (Kathol and McPherson, 1975, pg. 20-24) and included here in this report.

When reading this excerpt be aware that the photos and figures refer to Bulletin 32, not to this report.

BEDROCK SURFACE TOPOGRAPHY

The basic configuration of the bedrock surface in the Edmonton area was set in preglacial time; however, the surface was somewhat modified during and since glaciation of the area. Prior to glaciation, rivers and their many short tributaries flowing northeastward from the eastern slopes of the Rocky Mountains eroded the soft, relatively flat-lying bedrock to produce a series of dendritic drainage basins separated by low bedrock divides. The dominant topographic feature of the bedrock in the area is the Beverly Valley which passes through the northern portion of the city (Figs. 20, 21). Several flat-topped uplands separated by numerous tributary stream valleys are also present.

During glacial periods the bedrock surface was altered. In some places large pieces of bedrock were excavated and carried away by glacier ice while in other places the bedrock was squeezed and folded but not significantly transported. A section exposing such contorted bedrock can be seen on Highway No. 14 in the east portion of the study area (Plate 1, Fig. 1). In many of the testholes drilled for this study, blocks of ice-transported bedrock are present in the glacial till deposits which overlie the bedrock. Approximately 20 percent of the testholes intersected slabs of bedrock in the glacial sediments.

Postglacial bedrock erosion has also occurred in the study area. The North Saskatchewan River has excavated its valley since glaciation, and has cut down into bedrock along the river valley from the southwest portion of the area to Clover Bar (Fig. 20). Northeast of Clover Bar, the North Saskatchewan follows the broader preglacial Beverly Valley and extensive postglacial bedrock erosion has not occurred.

Bedrock erosion has also taken place along many of the tributaries of the North Saskatchewan; in particular, Whitemud, Blackmud, Mill and Oldman Creeks are characterized by relatively deep narrow valleys (Fig. 20). Minor bedrock erosion may have also occurred along Pointe-aux-Pins and Fulton Creeks.

Data are not sufficient to determine whether the bedrock erosion along the Sturgeon River Valley near St. Albert took place in postglacial times.

Glacial meltwater has eroded the bedrock surface in the Gwynne outlet (an overflow channel of glacial Lake Edmonton) south of the study area and possibly in a minor outwash channel near Clover Bar (Secs. 8 and 17, Tp. 53, R. 23).

Bedrock Uplands

Flat-topped bedrock highs, a prominent aspect of the bedrock surface topography, are found between preglacial stream valleys. The individual uplands vary from less than 5 square miles (less than 13 km^2) to over 15 square miles (over 39 km^2). Relief on the uplands generally is only about 10 to 20 feet (3 to 6 m). Side slopes 150 to 200 feet (45 to 60 m) high are common with slope angles of 3 to 4 percent.

The two bedrock highs north of the Beverly Valley (Fig. 20) are examples of this type of landform. Both have little surface relief and rapidly drop 150 to 200 feet (45 to 60 m) into the Beverly and Namao Valleys. The North Saskatchewan River has exposed part of a bedrock high in the downtown area at 82 Street and 109 Avenue. At that point the bedrock elevation is 2160 feet (658 m), whereas the bedrock elevation 5 blocks north (82 Street and 114 Avenue) is 2050 feet (624 m).

Near the western boundary of the area a bedrock high in excess of 15 square miles (39 km^2) has a surface elevation that varies only by about 10 feet (3 m).

The southeast quarter of the map area is dominated by bedrock highs (Fig. 20). The bedrock elevation in the southeast increases away from the Beverly Valley to a maximum of 2429 feet (740 m) at the extreme southeast corner of the study area.

Two miles farther east, a north-south trending bedrock ridge is present which has been termed the Cooking Lake Divide (Carlson, 1967). The maximum bedrock elevation difference in the Edmonton area is 450 feet (121m).

Bedrock Valleys

Beverly Valley

The Beverly Valley is the largest preglacial valley present in the study area (Figs. 20, 21). Its position is reflected on the present land surface by the topographic low that extends from north of Spruce Grove to south of Big Lake, through north-central Edmonton and then northeast towards Fort Saskatchewan. It is a broad valley, up to 5 miles (8 km) wide, with gently sloping valley walls. The valley depth is approximately 200 feet (60 m) with side slopes averaging 2 percent. The valley gradient is gentle, approximately 2.5 feet per mile (about 0.5 m per km). A typical cross-section of the Beverly Valley is shown in figure 22.

Stony Valley

The Stony Valley is the main tributary channel of the Beverly Valley in the study area (Figs. 20, 21). It trends northeast from the southwest corner of the map area to its junction with the Beverly Valley near 111 Avenue and 124 Street. Exposures of sediments in Stony Valley are present at the "Big Bend" section on the North Saskatchewan River (Sec. 16, Tp. 52, R. 25) and along the river banks toward Mayfair Park (Plate 1, Fig. 2).

Gradient and side slope values for the Stony Valley are difficult to ascertain because several small preglacial tributaries and the present North Saskatchewan River disrupt the valley. It is, however, narrower than the Beverly Valley, averaging only 2 miles (3 km) across, and the side slopes are estimated to be 2.5 to 3.5 percent. The valley depth is approximately 100 feet (30 m). The gradient is steeper than the Beverly Valley, being on the order of 7 feet per mile (1.3 m per km). A typical cross-section is given in figure 22.

Namao Valley

The Namao Valley, a minor tributary of the Beverly Valley, originates just north of the study area and west of the village of Namao (Figs. 20, 21). It enters the study area in Sec. 7, Tp. 54, R. 24, and joins the Beverly Valley near 118 Avenue and 87 Street. The Namao Valley is typical of the short tributary valleys present in the bedrock surface. Its length is probably not more than 10 miles (16 km); valley width ranges from 1 mile to 2 miles (2 to 3 km); valley side slopes are 1 to 2 percent. The valley depth ranges from 25 feet (8 m) to over 100 feet (30 m); its gradient is approximately 20 feet per mile (about 4 m per km). A representative cross-section is given in figure 22.

New Sarepta and Ellerslie Valleys

The New Sarepta Valley, which originates near the village of New Sarepta in Tp. 49, R. 22 (Carlson, 1967), is the largest of the Stony Valley tributaries (Figs. 20, 21). The valley enters the study area 2 miles (3 km) east of Ellerslie and trends in a northwesterly direction to its junction with the Stony Valley just north of "Big Bend" in Sec. 15, Tp. 52, R. 25. The position of this valley is uncertain in Secs. 13 and 14, Tp. 52, R. 25, because of a lack of deep drillhole information.

The New Sarepta Valley has several small tributaries, the Ellerslie Valley being the largest (Figs. 20, 21). The Ellerslie Valley enters the area 1 mile (2 km) east of Ellerslie and parallels the New Sarepta Valley for 3 miles (5 km). Both valleys become indistinct and close together just outside the study area. It is possible that the Ellerslie Valley is an alternate channel for a stream that also flowed down the New Sarepta Valley.

The New Sarepta Valley is 1 mile (2 km) wide with valley depth ranging from 25 to 50 feet (8 to 15 m). The side slopes vary from 1.5 to 6 percent and the valley gradient is 13 feet per mile (2.4 m per km). The Ellerslie Valley is 1/2 mile (0.8 km) wide with valley depths ranging from 10 feet (3 m) to over 50 feet (15 m). The side slopes vary from approximately 0 to 4 percent and the valley gradient exceeds 25 feet per mile (5 m per km). Cross-sections are shown in figure 22.

Other Preglacial Bedrock Valleys

Several other tributary bedrock valleys are present in the area (Figs. 20, 21).

The Devon Valley, a tributary of the Stony Valley, is present only in the extreme southwest corner of the study area. It is approximately 1 mile (2 km) wide with a depth of 40 feet (12 m).

The Bretona Valley, in the southeastern quarter of the study area, has not been accurately located. The valley depth is quite variable ranging from 20 to 75 feet (6 to 23 m) and its gradient averages 20 feet per mile (4 m per km). The Boag Valley is present in the northeast portion of the study area. The valley is 1 mile (2 km) wide and its depth approaches 50 feet (15 m). Both the Boag and Bretona Valleys originate along the western slope of the Cooking Lake Divide.

SURFICIAL GEOLOGY

The surficial geology map (Figure 2) was prepared from existing maps (Bayrock, 1972, Kathol and McPherson, 1975) and from photo interpretations. The mapping scheme and legend used for figure 2 is the same as that in the surficial geology map (Figure 23) of Kathol and McPherson's 1975 report. This enables a continuity of boundaries and units between the two reports.

I emphasize again that no ground investigations were conducted to verify the interpretations of the units. In many places however, the degree of certainty about the map units is high and such units are bounded by solid, black lines.

In other places the degree of confidence is low and in these places the units are bounded by dashed red lines. These red lines may indicate two things; either the area enclosed is very complex and the deposit varies both in sediment type and distribution, or, very little can be said about the map unit without ground checking. As an example, in Area B, the red lines between the lacustrine deposits indicate a gradational contact between two different sediments. Consequently the boundary has to be arbitrarily assigned on the map and red lines are used. As well, any of the maps derived from the surficial geology map (for example, susceptibility to erosion, slumping) will also carry the same degree of uncertainty in those areas bounded by red.

Another feature of the map units in figure 2 is that no implied thickness is given for most of the units. In some cases the units may be exceedingly thin (<.5 m) or unevenly distributed. However, in the detailed description of the surficial units that follows, Kathol and McPherson (1975) indicate some average thicknesses for the map units. In some places where one unit is thin and overlies another, I have used a double notation, showing one map unit superimposed on another (for example, Figure 2, map unit $\frac{12}{10}$). This notation indicates that unit 12 is thin and may occur as discontinuous veneer over unit 10.

Explanation of Surficial Map Units

The following explanation of surficial map units is extracted from the Urban Geology of Edmonton, Bulletin number 32 (Kathol and McPherson, 1975 pg. 24-28). This is a general description of the units that are found within the present city boundaries but this description is applicable for the map units in figure 2 of this report.

SURFICIAL GEOLOGY

Several investigations have been conducted on the surficial geology of the Edmonton area. The Alberta Research Council (Bayrock 1972) published a surficial geology map of the Edmonton map sheet (NTS 83H) at a scale of 1:250,000 (in pocket). Bayrock and Hughes (1962) published a report about the geology of the Edmonton area between longitudes 113°00' and 114°00'W, and latitudes 53°15' and 53°45'N, which was accompanied by surficial geology maps on a scale of 1 inch to 1 mile (1:63,360). A report on the geology of central Edmonton which discussed a small portion of the study area was published by Bayrock and Berg (1966). Westgate (1969) published a summary report on the Quaternary geology of the Edmonton area. In addition, numerous other workers have published papers which include information on the surficial geology of the area.

The following description of the surficial geology of the area is based on data from all previous studies as well as from field mapping and a controlled drilling program conducted by the authors. The surficial geology map (1:50,000 scale) included in this report (Fig. 23) is a modified version of the maps published by Bayrock and Hughes (1962), and incorporates new data obtained during this study.

GEOMORPHOLOGY

The study area, which is part of the Eastern Alberta Plains (Alberta Government and Univ. 1969), ranges in elevation from 2510 feet (765 m) in the southeast to 1985 feet (605 m) in the northeast along the North Saskatchewan River Valley. Regional slope in the vicinity of Edmonton is to the northeast.

Elements of the preglacial landscape are discernible in the sense that present day uplands coincide with preglacial highs, and low areas generally follow preglacial valleys; however, the near-surface sediments were deposited primarily in glacial and postglacial times.

Quaternary Landforms

The landforms shown in figure 23 have been described previously by Bayrock and Hughes (1962).

Ground moraine is present in the southeast portion of the map area and in scattered localities elsewhere. It forms a level to gently undulating till plain with a local relief less than 20 feet (6 m). Small knobs up to 350 feet (about 100 m) in diameter and 10 feet (3 m) in height and kettles up to 5 feet (1.5 m) deep and 150 feet (45 m) in diameter are common. The ground moraine grades into hummocky dead-ice moraine in the southeast portion of the area.

Hummocky dead-ice moraine is present only in the southeast portion of the area. Studies of similar deposits in western Canada and Europe indicate that this type of deposit is a product of till deposition from stagnant ice (Bayrock and Hughes, 1962). The main topographic elements of this landform such as knobs, kettles, till ridges, moraine plateaus and stream trenches are all present (Bayrock and Hughes, 1962). Knobs and kettles are the most common features of the hummocky moraine (Plate 2, Fig. 1).

Knobs composed mostly of till range up to several hundred feet in diameter and average 15 to 20 feet (4 to 6 m) in height although they may attain heights up to 50 feet (15 m).

Till ridges found in the hummocky dead-ice moraine form closed or linear ridges. Some of the closed ridges are knobs with central depressions higher than the general ground level, giving them the appearance of large doughnuts. Other closed ridges are circular to irregular in outline and have central depressions that are at approximately the same elevation as the surrounding ground. Several hypotheses have been proposed for the formation of the various types of closed till ridges but most workers agree that they resulted from stagnant ice that separated into individual dead-ice blocks, even though there is no agreement as to the mechanism of deposition (Gravenor and Kupsch, 1959). The closed ridges range up to 20 feet (6 m) in height and up to several hundred feet in diameter.

Linear till ridges are generally between 1/8 and 1/4 mile (0.2 to 0.4 km) long although a few exceed 1 mile (2 km) in length. They vary from straight or sinuous ridges with relatively even crests to elongate rows of hummocks. The ridges are believed to have been formed by debris slumping into crevasses in glacial ice (Gravenor and Ellwood, 1957).

Moraine plateaus are irregularly distributed in the dead-ice moraine. They are irregular in outline with relatively flat surfaces that are usually at the same elevation or slightly higher than the crests of the surrounding knobs. The plateaus are generally composed of till and overlain by a layer of lacustrine sediments which is usually less than 10 feet (3 km) thick. They are believed to be deposits from superglacial lakes that were surrounded by ice (Bayrock and Hughes, 1962).

Stream trenches occur in the hummocky dead-ice moraine and ground moraine in the southeast portion of the area and are surrounded by lacustrine sediments in the western portion of the area (Fig. 23). They vary from a few hundred feet to several miles in length and are generally less than 1/2 mile wide (0.8 km). They range from a few feet to over 25 feet (<1 m to 8 m) in depth. The channels contain a variety of sediments which may include hummocky dead-ice moraine, glaciofluvial sand and gravel, minor glaciolacustrine deposits and Recent lacustrine and alluvial deposits. In the southeast portion of the area they are believed to have been formed by meltwater flowing from ice in areas where hummocky dead-ice moraine was being deposited. In the western portion of the area, they were formed by meltwater flowing from the pitted delta located to the west.

Kames present in the southwest corner of the map area are up to 600 feet (183 m) higher than the surrounding ground level. They are generally overlain by a few feet of lacustrine sediments and are composed of sand with minor silt and fine gravel and numerous till inclusions.

Outwash sand and gravel is common in the southeast corner of the area (Fig. 23). The deposits vary in size up to a maximum of approximately 2 square miles (5 km^2) and consist of fine- to coarse-grained sand with minor lenses of gravel. The outwash is generally overlain by up to 10 feet (3 m) of lacustrine silt and clay.

Pitted delta deposits occur only in the western portion of the map area (Fig. 23). They have a topographic expression similar to hummocky moraine, and consist mainly of knobs and kettles. These deposits are composed primarily of fine sand and silt, with thin clayey layers which may be pedogenic or geologic in origin, or a combination of the two (Coen, 1965). In some localities the bedding is undisturbed and in others it is highly contorted. Also present are minor pebbles and till inclusions which have probably been deposited by ice rafting. It is believed that the pitted delta was produced by the melting of buried ice blocks in the delta sediments (Bayrock and Hughes, 1962).

Interconnected channels containing fine- to medium-grained sand with minor silt, clay, coarse sand and gravel are present adjacent to the pitted delta. These channels were originally believed to represent a braided channel of the North Saskatchewan River which existed before the North Saskatchewan cut its present valley (Bayrock and Hughes, 1962); however, they are now believed to have been formed by meltwater flowing from the pitted delta (Bayrock, pers. comm.[2]).

Glacial Lake Edmonton sediments are the most common surficial deposit, and occur throughout the map area (Fig. 23). The sediments are thickest in the central part of the area where they overlie major preglacial topographic lows. The outer edge of the lake sediments can be only approximately defined because near the old shoreline the sediments are thin and have been altered by soil-forming processes; this makes positive identification difficult. Furthermore, beaches along the boundaries of the lake are poorly developed or absent because of the short lifetime of the lake. Over short distances there are numerous changes in the composition and grain size of the lacustrine sediments. In general, the lower portions of the lake sediments are composed of sand and silt and contain numerous beds of till-like material, till lenses and pebbles. These sediments are believed to have been deposited relatively close to glacier ice margins where mud flows, slumping and ice rafting of glacial debris was common.

The upper portions of the Lake Edmonton sediments consist of silts and clays with only minor till lenses and pebbles (Plate 2, Fig. 2). They are generally rhythmically bedded and may be varved; however, an annual origin has not been proved. It is thought that the ice margin was fairly remote when these sediments were deposited.

Numerous other small deposits of lacustrine silts and clays occur in areas of ground moraine and hummocky dead-ice moraine (Fig. 23).

Glaciolacustrine sand and silty sand is present in scattered localities overlying till and other glaciolacustrine deposits. The sediments are generally less than 5 feet (1.5 m) thick and consist of fine- to medium-grained sand with occasional pockets of gravel and coarse sand as well as silt and clay. These sands are believed to represent deposition from the outflowing waters of Lake Edmonton (Bayrock and Hughes, 1962).

Aeolian sand is common in the southwest portion of the map area and in scattered localities elsewhere. It occurs as fine- to medium-grained sheet sand, as poorly developed sand dunes, and as well developed parabolic and longitudinal dunes up to 40 feet (12 m) in height. Sources of sediment for the sand dunes were lacustrine sands and meltwater channel sediments near the pitted delta deposits.

Bottomland sediments consisting of Recent clay, silt, sand, peat, muck and marl are present in many topographic lows throughout the area.

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[2] L. A. Bayrock, Bayrock and Reimchen Surficial Geology Ltd., Vancouver, British Columbia.

Slumps, landslides and colluvium are present along the banks of the North Saskatchewan River as well as the banks of many of the tributary valleys (Fig. 23).

Alluvium has been deposited along the valley of the North Saskatchewan River, carved since retreat of the glaciers from the area. Upstream from Edmonton, the valley is relatively narrow with steep banks and has been eroded through both preglacial uplands and buried channels. Downstream the valley widens abruptly and the banks are much lower and more gentle because the river approximately follows the course of the broad preglacial Beverly Valley. Four terrace levels were mapped along the North Saskatchewan River Valley in the study area; however, a fifth level has been observed southwest of Edmonton near Devon. All the terraces consist of sand, gravel, silt and clay. The lowermost or youngest terrace occurs approximately 30 feet (9 m) above the present river level (Plate 3, Fig. 1). This terrace generally has a sand and gravel layer up to 20 feet (6 m) thick which overlies bedrock (Plate 3, Fig. 2). The sand and gravel layer is usually overlain by a layer of silt, clay and fine sand attaining thickesses up to 30 feet(9 m).

The older terrace levels are developed discontinuously along the course of the North Saskatchewan River Valley. The sediments vary significantly over short distances but appear to contain coarser sand and gravel than the lowermost terrace.

In each of the geographic areas A, B, C, there are special features that require detailed descriptions and explanations. Each area is described separately.

Area A

Most of area A is underlain by lacustrine silt and clay deposits (unit 10, Figure 2) that in most places are at least 3 m thick. This unit has a flat to gently rolling topography except in the northeast corner (sections 26, 27, 33, 34, Range 23) where the surface has a pitted, knob and kettle topography, about 3 m in relief. In the southeast corner of area A a thin (≤1 m) discontinuous veneer of sand covers the lacustrine clay deposits. The origin of this sand is uncertain: it is either a thin lacustrine or aeolian veneer, and therefore the area is bounded with a dashed, red line (see map unit $\frac{12?9?}{10}$, Figure 2). A detailed ground survey would identify the thickness, extent and origin of this sand deposit.

In section 20, Range 23 a conspicuous hill (≈ 8 m high) is mapped as unit $\frac{10}{2}$ in figure 2. This hill is interpreted to be a glacially thrust knob composed of mixed till and shale which was subsequently covered by a lacustrine veneer of silt and clay. The depression immediately northeast of the hill (unit 15 Figure 2) is interpreted to be the source area from which the material in the knob was quarried by the glacier. If construction takes place on this hill, it is critical that a detailed stratigraphic investigation be conducted to establish the nature and strength of the material and, to establish the base of the glacially disturbed sequence.

Area B

Area B is most geologically complex of the three. Except for the hummocky dead-ice moraine in the eastern quarter, (map unit 2, Figure 2) most of the flat lying area is covered with lacustrine sediment. The numerous red boundaries in the central and west part of the map area indicate gradational textural boundaries between different lacustrine sediments. As an example, the area between the North Saskatchewan River and Whitemud Creek has lacustrine sand in the west grading to silt and clay in the east. The area where two map units are shown together (4?9?, Figure 2)indicates where the origin of the sand is uncertain.

The most complex unit of area B is shown as $\frac{7}{10,1}$ (Figure 2). This notation indicates that a thin, discontinuous sand deposit overlies either lacustrine clay, till, or in some places, bedrock. This sand veneer was deposited by glacial meltwater that eroded the underlying material as Glacial Lake Edmonton drained to the south-east through the Gwynne Outlet. Where the erosion was minimal, sand was deposited on lacustrine clay; where the erosion was more intense all the lacustrine sediment was eroded and sand was deposited on till; where the erosion was severe, (3 km south of Ellerslie), both the lacustrine and till deposits were eroded and sand was deposited on bedrock. Detailed ground checks with shallow drilling (<15 m) will help define the boundaries of the eroded deposits.

One area that is of concern with respect to construction is map unit 16 (Figure 2) found in section 9 and 16, Range 25. This is an area of slumped sediment along the river bank and it indicates that any area within .5 km of the river bank may be prone to slope failure.

Area C

Most of area C is underlain by lacustrine sand deposits which have a pitted, knob and kettle topography (map unit 5, Figure 2). This unit grades to lacustrine silt and clay in the north and east, and to lacustrine sand with an undulating topography, in the south. The surface sediments in area C are generally quite thick (>3 m).

Recommendations For Future Work

Before final planning of development occurs, a detailed surface mapping program (to depth of 3 m) should be undertaken to outline clearly the nature of the surface sediments, their distribution, thickness, lateral continuity, the drainage, topography and relief of the three areas A, B, C. Appendix 1 is a breakdown of costs in conducting a mapping program. Included is the time and manpower required to map the three areas.

STRATIGRAPHY AND THICKNESS OF SURFICIAL DEPOSITS

As indicated in our meeting 17 November, data are not available for the subsurface geology. As a result it will be necessary to conduct a stratigraphic survey on an one mile grid to acquire the necessary data. A proposal for a drilling program is given in Appendix 2 listing the costs, equipment, manpower and time required to undertake the program.

In area A there was sufficient borehole data to prepare four generalized cross-sections, the locations of which are shown in figure 3.

In figure 4 the cross-sections show that the drift is thickest over the buried valleys (see Figure 1) and thinnest on the intervalley divides. Lacustrine silty-clay blankets the entire map area and varies between 2 to 6 metres thick. The description by Kathol and McPherson (1975, pg. 32) for the distribution of lacustrine deposits in the greater Edmonton area is included here.

Glaciolacustrine Sediments

The distribution and thickness of glaciolacustrine sediments (hereafter referred to as lacustrine sediments) in the study area are outlined in figure 29.

Lacustrine sediments are generally absent from most of the southeast portion of the area where ground moraine and hummocky dead-ice moraine are present on the surface. In this area only a few small lacustrine deposits occur, with sediments being less than 10 feet (3 m) thick.

The thickest deposits of lacustrine sediments occur in the western portion and the extreme southwest corner of the area, where thicknesses usually exceed 30 feet (9 m) and often exceed 70 feet (21 m).

Elsewhere in the map area, lacustrine sediments averaging 10 to 30 feet (3 to 9 m) thick occur in a broad northeast-southwest trending belt which approximately follows the present course of the North Saskatchewan River; however, the sediments have been completely removed by erosion within the river valley itself. Within this broad belt there are numerous small areas, too many to describe individually, in which the lacustrine deposits are either greater than 30 feet (9 m) or less than 10 feet (3 m) thick. These are outlined in figure 29. Small areas where lacustrine sediments are thickest are believed to have resulted from sediment deposition in depressions in the underlying till surface.

The lacustrine deposits are underlain by till in almost all of the map area A. Till is thickest in the buried valleys and is as much as 32 m thick in the northwest corner of the map (Figure 4). In some places ice thrust bedrock is incorporated as blocks in the till. These blocks vary in thickness from less than 1 metre to as much as 10 metres (Figure 4). The abundance of ice thrust bedrock in the surficial sediments in the Edmonton area demands that numerous stratigraphic boreholes be drilled in order to map the top of the undisturbed bedrock. If these bedrock blocks are not located, foundations may fail if constructed on thrust bedrock slabs that overlie unconsolidated surficial sediment. A recent example is the site of the City of Edmonton Convention Center. The Center is located over a bedrock surface that is fractured and disturbed by glacial ice. To remedy potential foundation problems, expensive construction methods were employed to anchor the foundation to the bedrock. Had the planners been aware of the high costs in ameliorating the site, they may have chosen a more geologically suitable location during the initial planning stages. The description by Kathol and McPherson (1975, pg. 32) of the distribution of till in the greater Edmonton area is included here.

Glacial Till

The possibility of two distinct till sheets existing in the study area has been debated. Warren (1954) described a grey till near Edmonton separated from an overlying brown till in numerous localities by stratified quartzose sands which he called the Tofield sand. Bayrock and Berg (1966) confirmed the presence of two colors of till but did not acknowledge the presence of separate till sheets. They stated:

> "The till is brown where oxidized, grey where unoxidized; the color change from brown to grey occurs about 20 feet below the surface and is not a reflection of a change in composition. Lenses of stratified sand and gravel are commonly present in the till; the lenses are usually less than 1 foot thick and represent minor washing of glacial debris by running water."

Westgate (1969) indicated the presence of a greyish brown lower till separated from a yellowish brown upper till by the Tofield sand.

The authors observed the differently colored tills discontinuously separated by lenses of sand and gravel but, in spite of data from numerous outcrop sections and a detailed drilling program, could not establish the presence of two tills with any degree of certainty or confirm the continuity of the Tofield sand. So, in this report, the till deposits are considered a single unit which often contains lenses of glaciofluvial sediments.

Throughout much of the study area, the till is between 25 and 50 feet (8 to 15 m) thick (Fig. 28). Areas of relatively thin till occur on two bedrock uplands located on the west and east sides of the Namao Valley, where the till is less than 10 feet (3 m) thick over areas of about 2 square miles (5 km^2) and 7 square miles (18 km^2) respectively. Although surficial deposits are relatively thick in the vicinity of the pitted delta deposits along the western boundary of the area, the till is quite thin–less than 10 feet (3 m) thick wherever drillhole data is available. An area of approximately 5 square miles (13 km^2) near Blackmud and Whitemud Creeks also is underlain by till less than 10 feet (3 m) thick. Other small areas where till is thin occur throughout the area as shown in figure 28.

The till is generally thickest along the buried valleys. In excess of 50 feet (15 m) of till occurs along the entire length of the Beverly Valley. It may actually exceed 75 feet (23 m) in thickness in many places, but additional deep drilling would be required to confirm this. Similarly the till is greater than 50 feet (15 m) thick along the Stony Valley and could be considerably thicker.

Approximately 1 mile (1.6 km) northwest of Bretona, the till is greater than 100 feet (30 m) thick along the Bretona Valley. Elsewhere along the valley it generally exceeds 50 feet (15 m) and often is more than 75 feet (23 m) thick. The upper reaches of the Boag Valley, along the east boundary of the study area, contain over 75 feet (23 m) of till. Other areas where the till exceeds 50 feet (15 m) in thickness occur in the southeast portion of the area where ground moraine and hummocky dead-ice moraine are present on the surface (Fig. 28).

Till is underlain by bedrock on most of the preglacial valley divides (Figure 4). In the preglacial channels however, thick sequences of fluvial sediment underlie the till (Figure 4). These are interpreted to be preglacial in origin and are composed of sand and gravel, called Saskatchewan Gravels and Sands by Kathol and McPherson (1975). These deposits of sand and gravel vary in thickness from about 5 m on the valley edges (Figure 4) to at least 15 m in the center of the buried valleys (Figure 4). These deposits are a major aquifer in the Edmonton area and where they are near the surface, they have a high economic potential for concrete aggregate. Kathol and McPherson's (1975, pg. 31-32) detailed description of this deposits is included here.

Saskatchewan Gravels and Sands

Oligocene and younger gravels and sands found throughout Alberta were deposited by streams flowing northeastward or eastward from the Rocky Mountains. Deposition of this preglacial alluvium continued intermittently from the last half of the Tertiary Period well into the Quaternary Period. During this time, gradual uplift of the Plains caused the streams to incise deep valleys. These streams also migrated laterally during their history. The downcutting and lateral migration often resulted in remnant bedrock uplands being left between the streams.

The preglacial gravels deposited by these streams can be divided into three types:

(1) high-level sediments, which commonly form protective caps which retard erosion on bedrock uplands; these preglacial gravels and sands are the oldest and represent early stages of lowering of the land surface;

(2) intermediate-level sediments which typically form benches and terraces in proximity to major preglacial stream valleys;

(3) low-level sediments deposited by streams prior to glaciation and which are found as channel fill at the base of preglacial valleys.

The name used for alluvium belonging to this third group is Saskatchewan gravels and sands (Stalker, 1968). Although the term Saskatchewan Sands and Gravels has been used by many workers (Bayrock and Hughes, 1962; Westgate, 1969; McPherson and Kathol, 1973), the term Saskatchewan gravels and sands as used in this report conforms with that of Stalker (1968).

In discussing these deposits Stalker (1968) states:

> "Advent of the first Laurentide ice-sheet ended deposition of Saskatchewan gravels and sands. However, this ice-sheet did not overrun all areas at the same time. Its effects were felt progressively westward, as the advancing ice raised base levels of the rivers, caused their currents to slow, and forced each stream to deposit part of its load. In many buried valleys on the plains much sand and silt overlies the coarser elements of the Saskatchewan deposits, and most of this apparently was deposited in proglacial lakes formed during advance of that first glacier (Stalker, 1963; p. 4; Westgate, 1965, pp. 91-93). As a rule those deposits are included with the Saskatchewan gravels and sands."

Saskatchewan gravels are generally quite similar in lithology throughout the Plains and are composed mainly of quartzite rock fragments. Minor amounts of chert, arkose, petrified wood, coal and clay ironstone are present. Large quartzite boulders mixed with clay ironstone and bedrock fragments are often found at the contact with bedrock. The Saskatchewan sands are similar in lithology to the gravels, but generally contain a higher percentage of local bedrock material. The sands are usually fine- to medium-grained and poorly sorted. Both the sands and gravels are rounded and contain minor silt and clay beds.

Saskatchewan gravels and sands are present in the study area primarily as channel fill deposits in the numerous stream valleys that formed part of the preglacial drainage system of the North Saskatchewan River. Intermediate-level terrace deposits occur along some of the valleys and may be older than Saskatchewan gravels and sands as defined by Stalker (1968).

The Beverly Valley contains the largest quantity of Saskatchewan gravels and sands (Figs. 20, 27). Grain size and sediment thickness vary over short distances but generally the valley contains 50 to 75 feet (15 to 23 m) of fine-grained sand over 10 to 15 feet (3 to 5 m) of gravel. The thickness of sediments overlying the Saskatchewan deposits ranges from over 150 feet (over 45 m) in the northwest to approximately 75 feet (23 m) in the northeast (Fig. 27). In the northeast where the North Saskatchewan River follows the preglacial Beverly Valley the river has partially removed the overburden. Several sand and gravel pits are located in that area.

The Beverly Valley has two intermediate-level terraces: one on its south flank in the northwest part of the study area and another on its south flank in the east-central portion of the area (Fig. 27). The terrace to the northwest is approximately 25 feet (8 m) thick and is composed mainly of fine-grained sand. It occurs approximately 50 feet (15 m) above the thalweg and is overlain by about 75 feet (23 m) of sediments (Fig. 27). The terrace deposit in the east-central portion of the area varies from 0 to 25 feet (0 to 8 m) in thickness, ranges from fine sand to coarse gravel, and is usually overlain by more than 25 feet (8 m) of sediments.

The Stony Valley, although not as large as the Beverly Valley, contains significant quantities of sand and minor gravel (Fig. 27). Thicknesses of 75 feet (23 m) are common, overlain by 50 to 75 feet (15 to 23 m) of glacial and postglacial deposits (Fig. 27). The New Sarepta, Ellerslie and Namao Valleys contain up to 50 feet (15 m) of channel fill consisting mainly of sand (Fig. 27). Overlying sediments generally exceed 50 feet (15 m) in thickness. The other buried valleys contain thin layers of Saskatchewan sand overlain by thick glacial drift (Fig. 27).

No subsurface data was available for either areas B or C. In any case, a drilling program is required to map and sample the subsurface sediment in all three areas. Data from that program will be important especially when designing the deep storm sewer systems. The four cross-sections that are included in this report serve only as guidelines for future borehole sites and provide an initial idea in area A of what types of sediment may be encountered during the drilling program.

APPLICATION OF GEOLOGY TO LAND USE PLANNING

This section of the report discusses the application of the geologic data from figure 2 to various land use maps. Specifically these land use maps describe: general construction conditions (Figure 5), solid waste disposal (Figure 6), susceptibility to erosion (Figure 7), susceptibility to slumping (Figure 8) and sulfate hazard potential (Figure 9). Where knowledge of the surface sediment is uncertain, or complex (shown in red lines in Figure 2) the corresponding areas in the land use maps will also have the same degree of uncertainty. No attempt has been made to alter or expand the criteria defined by Kathol and McPherson (1975) for each of their land use maps. For this reason their entire section that discusses geology for land use planning (pg. 44-49 of bulletin 32) is included here as a description for figures 5 through 9 of this report. Figure 5 of this report supplements figure 40 of Bulletin 32, figure 7 supplements figure 41 of Bulletin 32, figure 8 supplements figure 42 of Bulletin 32, and figure 9 supplements figure 38 of Bulletin 32. The description of the sulfate hazard potential was prepared by R. MacMillan of the Soil Survey Department, Natural Resources Division, ARC and is included as a supplement to the general description by Kathol and McPherson (1975).

GEOLOGY FOR LAND USE PLANNING

As popular concern for the environment develops, land use planners are faced with the problem of comprehensively assessing environmental conditions. The result is that the demand for geologic information concerning the natural capabilities and limitations of the area is growing. In this chapter, data concerning the engineering properties of the deposits in the study area are synthesized with previously discussed information about the nature and distribution of the sediments. This synthesis is the basis for a series of land use maps in which the Edmonton area is rated in terms of the following factors:

(1) general construction conditions
(2) suitability for solid waste disposal
(3) susceptibility to erosion
(4) slope stability
(5) deep sewer construction.

These are by no means all the factors that may have a bearing on development; however, they are felt to be of considerable importance in the Edmonton area. It is hoped that these maps will help satisfy the increasing demand for information.

The maps are intended to serve only as general guidelines for regional development or further studies, and when using them two facts should be kept in mind. Firstly, the maps rate the suitability of various areas for development in terms of the geologic and geotechnical characteristics of the sediments. Because numerous disciplines interrelate in land use planning, as outlined previously in table 1, final development decisions would require input from other fields of study. In some cases, geologic and geotechnical factors may have a controlling influence on development decisions, in other instances these factors may be of limited importance to final development plans. Secondly, the maps are based on currently known geologic data and, although considerable data are available, it will certainly be necessary to conduct detailed site investigations prior to development because of the extreme variability of the geologic deposits over short distances.

GEOTECHNICAL CHARACTERISTICS OF THE GEOLOGIC DEPOSITS

Considerable data on the geotechnical properties of geologic deposits in the Edmonton area are available from both published and unpublished reports. Also, many samples collected during the field surveys and drilling program were analyzed for general material properties and indices. This information has not been included in this report because, in spite of a large volume of data, it is still not sufficiently detailed to replace site investigations.[5] In place of specific information, a chart has been prepared which outlines material properties and indices of geologic deposits in the Edmonton area (Table 7). Ranges of values for the different properties and indices for the various sediments should fall within the ranges indicated. Nonetheless, departures from these ranges are possible because of local lithologic variations as well as changes in environmental setting (for example, topographic position, water tables and so on).

The information presented (Table 7) has been utilized in conjunction with the geologic and hydrologic data to construct the land use maps for the study area.

LAND USE CAPABILITIES AND LIMITATIONS IN THE EDMONTON AREA

In table 8, the various geologic deposits in the Edmonton area, both on surface and in the subsurface, are described in terms of their capabilities and limitations for a variety of land uses. In order to exploit this information fully, table 8 should be used in conjunction with data concerning the distribution of the geologic materials provided on the surficial and bedrock geology maps, stratigraphic cross-sections and subsurface contour maps.

The information about the various deposits has been synthesized in subsequent sections of the report and maps have been prepared which outline the capabilities for and limitations to development of various parts of the study area.

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[5] This data is on open file at the Alberta Research Council and is available upon request.

General Construction Conditions

General construction as used in this report refers to any construction activities that occur as a result of development of the Edmonton area. In figure 36 the study area is rated in terms of its suitability for general construction. The geologic materials present in the various areas as well as their development capabilities and limitations are outlined in the legend accompanying the map. It should be noted that with proper engineering design virtually all of the Edmonton area could be developed. Therefore the maps tend to rate the various areas in terms of natural geologic capacities and problems.

Areas near stream valleys have been classified as having the most geologic limitations for development because extensive investigation and design is often required to ensure bank stability. Areas where Recent lacustrine, glaciolacustrine, pitted delta and mixed lacustrine-till deposits occur are suitable only for construction of light structures because of the moderate to high compressibility; however, if foundation loads can be transmitted to more competent underlying layers, these areas are generally suitable for heavier structures. Other factors that may be detrimental to construction in these areas include sulfate contents, potential swell, susceptibility to frost action and susceptibility to erosion and slumping on steep banks and cuts.

Those areas characterized by other geologic sediments were rated as generally suitable for most types of construction; in particular, till and bedrock are generally more than adequate foundation materials for most types of structures. Again, specific localized problems that may be encountered in these areas are outlined in figure 36.

In developing the rating system for the general construction conditions map, sulfate content of the geologic materials was considered because of the potential for sulfate attack on concrete. In order to determine the areas where sulfate attack is most likely, sulfate content was determined in 542 samples collected in the study area. The results are summarized in figure 37 which shows the sulfate content of the deposits at various localities and depths. Figure 38 is a synthesis of this information. The potential for sulfate attack on concrete is based on the rating system of the United States Bureau of Reclamation (1966) which is as follows:

Rating	% Water Soluble Sulfate Content
Negligible attack	<0.10
Mild but positive attack	0.10 to 0.20
Considerable attack	0.20 to 0.50
Severe attack	>0.50

It was observed that sands are generally lowest in sulfate content: lacustrine clays and silts are generally highest. In addition, areas of high sulfate content correspond quite closely to areas of Solonetzic soils as indicated on the soils map of the Edmonton area (Fig. 39).

Solid Waste Disposal

As population increases and industry expands (especially in urban areas) the quantity and type of solid wastes also increases rapidly and disposal becomes a major task. The ultimate solution is to recycle wastes to generate useful products; however, since the technology of recycling has not been adequately developed and costs for recycling may be prohibitive, another form of disposal is required. One of the most widespread methods of disposal is the sanitary landfill site. If a site is properly selected and maintained, it can be an acceptable method of disposal.

Criteria for Selection of Sites for Solid Waste Disposal

Much research has been conducted on sanitary landfill sites and several important facts have been demonstrated (as summarized by Hughes *et al.* 1971):

(1) A polluting leachate can be produced by refuse in contact with groundwater or surface water. In Britain, Illinois and Wisconsin, it has been demonstrated that precipitation can infiltrate refuse and produce leachate. This may also be the case in the Edmonton area although the authors are not aware of any research that has been conducted locally to demonstrate that this is the case.

(2) In fine-grained materials with relatively low permeability such as fine sand, silt and clay, dissolved solids in refuse leachate travel relatively short distances; however, in fractured deposits and permeable sands and gravels, the solids may travel considerable distances.

(3) Gases are produced by decomposition of refuse; these gases are predominantly methane and carbon dioxide and to a lesser extent hydrogen sulfide.

(4) The length of time required for refuse to stabilize and cease production of contaminants is difficult to predict because it is dependent on factors such as available moisture, temperature, materials present in the landfill, and conditions of burial and compaction.

(5) The design of protective measures for otherwise unsuitable sites appears feasible and is being studied in California and Illinois.

Table 7. Geotechnical characteristics of geologic deposits in the Edmonton area

Material		Liquid Limit[1]	Plasticity Index[1]	Soil Density[2]	Compressibility	Shear Strength[3]	Potential Swell	Permeability[4] (cm/sec)	Frost Action
Recent Lacustrine	silt	30 - 50		low - medium	medium - high	low - medium	low - medium	10^{-4} - 10^{-5}	high
	clay	45 - 75	25 - 40	low	high	low - medium	high	10^{-6} - ↓	low
	organic clay	60 - 75	20 - 30	low	high	low	high	10^{-6} - ↓	low - medium
Stream Alluvium	gravel			high	very low	high	very low	1.0 - ↑	low
	sand			medium - high	low	high	very low	1.0 - 10^{-2}	low - medium
	silt	30 - 50		medium	medium - high	low - medium	low	10^{-4} - 10^{-5}	high
	clay	45 - 75	25 - 40	low - medium	high	low - medium	medium - high	10^{-6} - ↓	low
River Terrace	gravel			high	very low	high	very low	1.0 - ↑	low
	sand			medium - high	low	high	very low	1.0 - 10^{-2}	low - medium
	silt	30 - 50		medium	medium - high	low - medium	low	10^{-4} - 10^{-5}	high
Aeolian	sand			low - medium	low	medium - high	very low	10^{-1} - 10^{-2}	high
Glaciolacustrine	sand			medium	low	medium - high	low	10^{-1} - 10^{-2}	medium - high
	silt	30 - 50		low - medium	medium - high	low - medium	low - medium	10^{-4} - 10^{-5}	high
	clay	45 - 75	25 - 40	low	high	low - medium	high	10^{-6} - ↓	low
Pitted Delta	sand			medium - high	low	medium - high	low	1.0 - 10^{-2}	medium - high
	silt	30 - 50		low - medium	medium - high	low - medium	low	10^{-3} - 10^{-5}	high
Lacustro-till		30 - 35	15 - 30	medium	medium	medium	medium	10^{-3} - 10^{-6}	low - medium
Outwash	gravel			high	very low	high	very low	1.0 - ↑	low
	sand			medium - high	low	high	very low	1.0 - 10^{-2}	low - medium
Kame and Crevasse Filling	gravel			high	very low	high	very low	1.0 - ↑	low
	sand			medium - high	low	medium - high	low	1.0 - 10^{-2}	variable
	till	30 - 45	15 - 25	medium - high	low - medium	medium	medium	10^{-4} - ↓	low - medium
Hummocky Moraine	till	30 - 45	15 - 25	medium - high	low - medium	medium	medium	10^{-4} - ↓	low
Ground Moraine	till	30 - 45	15 - 25	medium - high	low - medium	medium	medium	10^{-4} - ↓	low
Saskatchewan Gravels and Sands	gravel			high	very low	high	very low	1.0 - ↑	low
	sand			medium - high	low	high	very low	1.0 - 10^{-2}	low - medium
Bedrock	sandstone				low	medium	high	10^{-3} - 10^{-6}	
	siltstone				low	medium	high	10^{-4} - ↓	
	shale				low	medium	high	10^{-5} - ↓	
	bentonite	>100	>50			low	very high	10^{-6} - ↓	
	coal				low	low	low	variable	

[1] Atterberg limits (see glossary)
[2] low < 100 lbs/ft^3
medium 100-115 lbs/ft^3
high > 100 lbs/ft^3
[3] Assuming confined conditions

[4] ↑ higher permeability likely
↓ lower permeability likely

The well designed landfill site has characteristics which minimize the pollution of water and air and, in addition, is aesthetically pleasing. Location of sites in relatively uninhabited areas, construction of fences, planting of trees and regular burial of garbage with fill material make the site more acceptable.

Landfill gases can be handled by venting the landfill to the atmosphere followed by burning the gas at the vent (Elissen *et al.* 1957, Dunn, 1960).

Criteria for selection of refuse disposal sites to minimize water pollution — both surface water and groundwater — have been developed for Illinois by Cartwright and Sherman (1969) and for the Edmonton area by Green and Currie (1970).

In establishing the criteria for the Edmonton area, Green and Currie discussed several important interrelationships between refuse disposal sites and the hydrologic environment:

(1) *Climate:* Because the ground is frozen in the Edmonton area in the winter, no percolation of water into the ground occurs from November to March. Most recharge occurs in spring when the ground is generally saturated, but may also occur in the summer and fall during periods of heavy or prolonged rainfall. Precipitation in the Edmonton area averages 18.6 inches (47.2 cm) annually of which 10 to 20 percent (1.9 to 3.7 in or 3.8 to 9.4 cm) may penetrate into the ground to reach the water table.

(2) *Topographic Position:* Precipitation may run off on the surface, penetrate into the soil to be used by plants, evaporate to the atmosphere, or penetrate into the ground and form part of the groundwater system. Groundwater moves through geologic deposits from topographically high areas (called recharge areas) to topographically low areas (called discharge areas). Recharge areas are generally unsuitable for waste disposal sites because pollutants may migrate downward and become part of the groundwater system. Similarly areas of high groundwater discharge such as springs along stream banks are unsuitable because of the danger of polluting surface waters. Areas where either low recharge or discharge is occurring are the most favorable for the location of waste disposal sites.

(3) *Geologic Materials:* In fine-grained materials with relatively low permeability such as fine sand, silt and clay, dissolved solids in refuse leachate travel relatively short distances minimizing the potential for pollution. However, in fractured deposits and permeable sands and gravels, the leachates may travel considerable distances, thus enhancing the possibility of pollution. Another important factor is the capacity of the material for ion exchange: fine-grained materials such as silts and clays are particularly effective in removing dissolved solids from refuse leachate by ion exchange, but coarse granular materials are less effective, allowing pollutants to remain in the leachate longer.

Based on research by Cartwright and Sherman (1969) in Illinois, and on the factors discussed previously, Green and Currie (1970) compiled a set of criteria for solid waste disposal site selection in the Edmonton area, as follows:

(1) Type of unconsolidated material:
- Favorable: glacial lake silts and clays, till, windblown silts
- Unfavorable: sand, gravel
- Questionable: fissured till, fissured lacustrine sediments

(2) Thickness of unconsolidated material:
- Favorable: 50 feet or more (<15 m)
- Unfavorable: less than 50 feet (<15 m)

(3) Type of bedrock:
- Favorable: shale, siltstone
- Unfavorable: sandstones, coal seams

(4) Site topography:
- Favorable: flat plains (prairie) areas
- Unfavorable: depressions where water accumulates; ravines and gullies; stream or river terraces and flood plains; other sites where leachate might discharge into surface water bodies
- Questionable: dry valley bottom sites (require specific evaluation)

(5) Groundwater situation:
- Favorable: limited groundwater discharge (areas of saline soils, phreatophytic plant growth)
- Unfavorable: groundwater recharge areas; active groundwater discharge areas (springs, seepages, bogs, standing water on the surface)
- Questionable: groundwater situation undefined (specific evaluation required)

(6) Relations to nearby water wells and aquifers:
- Favorable: all nearby wells are deep; all aquifers covered by 50 feet (15 m) or more favorable materials; no domestic wells within 1000 feet (300 m); no municipal or industrial wells in the area
- Unfavorable: shallow wells within 1000 feet (300 m); aquifer covered by less than 50 feet (15 m) of favorable materials; municipal or industrial wells or both in the area (wells as distant as several miles may induce groundwater pollution because of pumping effects).

By utilizing these criteria, the various types of geologic materials in the study area have been rated in terms of their suitability for solid waste disposal in table 8.

It should be noted that little if any research on the distance of travel of pollutants in the groundwater has been conducted in the Edmonton area, so the values for aquifer overburden thickness and distance of sites from existing wells have been chosen somewhat arbitrarily in an attempt to provide an adequate margin of safety. Future studies may reveal that these values should be modified.

A map has been prepared which outlines the expected suitability of the study area for solid waste disposal in terms of geologic, hydrologic, and hydrogeologic conditions (Fig. 40). Because of the expected variations of conditions affecting waste disposal over short distances, site investigations will be necessary to confirm the suitability, or otherwise, of any particular area for solid waste disposal.

Susceptibility of Geologic Deposits to Erosion

Many interrelated factors affect the susceptibility of geologic deposits to erosion; some of the more important include:

(1) type of geologic materials
(2) material properties (in particular grain size and density)
(3) slope
(4) vegetative cover
(5) soil type
(6) groundwater
(7) time
(8) climate.

At any specific site, all factors have a bearing on the erodibility of the deposits; however, the relative importance of each factor will vary at different localities.

During the field investigations, it was observed that there was some degree of consistency in the nature of the erosion of different geologic materials. Based on these observations, it is possible to rate the geologic deposits in terms of their susceptibility to erosion as shown in table 8. The complexity of the interrelated factors affecting the erodibility of the deposits at any given location is indeed a problem; however, the rating system represents (in a general manner) conditions likely to be encountered in the field. The grouping of slopes into those less than 10° and those greater than 30° is a simplification because changes in erodibility are gradational with slope changes; slopes less than 10° are not expected to be susceptible to significant erosion whereas slopes greater than 30° will generally be susceptible to erosion.

Erosion problems are not likely to be severe in the Edmonton area; but localized areas of steep slopes, especially along the North Saskatchewan River and its tributaries, may exhibit significant erosion. Erosion will generally be greatest in bedrock sandstone, pitted delta silts, fine lacustrine sands and silts, fine aeolian sands and fine alluvial sands and silts (Table 8).

In figure 41, various portions of the study area have been rated in terms of their susceptibility to erosion. The legend accompanying the map outlines the materials found within each map segment, indicates the factors which contribute to erodibility of the materials and outlines preventive measures that may be undertaken to control erosion.

Slope Stability

In attempting to assess the stability of slopes in various materials or combinations of materials, a great deal of information can be obtained from observations of both previously excavated slopes and natural slopes.

Utilizing this information, plus hydrogeologic data and the previously outlined information on geologic and geotechnical properties of the materials, the authors rated the various geologic materials in terms of slope stability. This rating system as well as factors contributing to the rating are outlined in table 8. The rating indicates the general conditions to be expected in various materials. However, only site investigations could produce the necessary specific information.

A map has been prepared in which the study area has been rated in terms of slope stability (Fig. 42). The legend accompanying the map describes the various types of geologic materials that occur and also outlines the factors contributing to slope stability in different parts of the study area. In using this map, slope stability refers to both the stability of natural slopes and to the stability of any man-made slopes that may be created during development. In many instances, slope stability will not be a problem as long as cuts are adequately designed. The least stable natural slopes generally occur along the valley of the North Saskatchewan River and its tributaries where natural slopes are steep. Most bank failures originate in lacustrine clays and in shales. The most stable natural slopes are found where glacial till or bedrock sandstone forms the banks. The least stable cut slopes would also likely exist in lacustrine clays and shale; the most stable slopes would probably occur in glacial till and bedrock sandstone. It follows then, that careful slope design is more critical in areas where clays and shales are present.

Sulfate Content of the Geologic Materials

Phase 1

The accompanying map information (Figure 9) is interpretive in nature. It does not represent a synthesis of field investigations carried out for the express purpose of determining the concentrations and distribution of soluble sulfate in the Edmonton area. Rather, the generalizations documented by Kathol and McPherson (1975, pg. 47 and Figure 38) were applied to the extended study area. They recognized that soluble sulfate concentration, at least in the 0 to 5 foot depth, was related to the nature of the parent geologic material and the relative proportion of Solonetzic soils as indicated by the soil map of the Edmonton area. Thus, an extension to figure 38 (Potential Sulfate Hazard in the Edmonton Area) was constructed by determining the distribution of soils as previously mapped in this area (Bowser et al., 1962). These soils were then rated according to the previously established legend for figure 38. No attempt was made to either verify the accuracy of the original soil map or to sample and analyse the sulfate content of soils in the expanded area.

Phase 2

It is recommended that a field investigation be carried out in order to evaluate accuracy of the interpreted sulfate hazard ratings within the expanded area. Such an investigation is desirable in order to establish confidence in the estimated ratings and in order to document the actual levels of soluble sulfate found within each rating class. The collection of field samples could be done in conjunction with any planned geologic drilling program or could be done independently for the top 2 metres by a soil technician equipped with a hand auger. The survey would involve 10 man days of field work for a surveyor and assistant, about 12 man days for laboratory analysis, and about 10 man days for analysis of the information and preparation of a report by a professional pedologist. The report would provide a determination of the mean value and confidence limits for the concentration of soluble sulfate within each of the classes

1 to 7 at a 90% confidence level. Additionally, a synthesis of the soils information could be prepared to update that aspect of the study area data base. Costs for the proposed survey are detailed in Appendix 3.

SUMMARY AND RECOMMENDATIONS

This report provides surficial geologic information on the recently annexed areas in Edmonton. The information has been compiled from existing maps and reports as well as an air photo interpretation. Five land use maps have been derived from the surficial geology map. These maps provide infomration on (1) general construction conditions, (2) erosion potential, (3) potential for slumping, (4) solid waste disposal, and (5) sulfate hazard potential of the surficial sediments in the annexed areas. Also, included is a series of geologic cross-sections compiled from existing borehole information in the northeast annexed area. These cross-sections provide a general outline of the subsurface deposits and will help in designing future stratigraphic surveys in that area.

Included in the appendices of this report are proposals for three mapping programs. Appendix one is a proposal to produce a detailed map of the surficial geology in the three annexed areas. The program is specifically designed to resolve the problem areas outlined in red in the surficial geology map of this report. Appendix two is a proposal to map the subsurface geologic deposits by means of a stratigraphic borehole survey. Sixty-three rotary testholes and twenty auger testholes are proposed to map the subsurface deposits and bedrock surface. This information is especially critical for the design of underground tunnels and for locating potential buried aquifers. Appendix three is a proposal to sample and map the surficial sediments in order to determine their sulfate hazard potential with greater detail and precision.

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Appendix 1: Proposal for Surficial Mapping

In many areas of the surficial map (Figure 2) the surface geology is complex or unknown (See areas bounded by red.) A program is required to map in detail (1:20,000) the nature, distribution, thickness, and physical characteristics of the surface deposits. The results of such a program will enable planners to design their programs with high degree of confidence about the properties of the surface sediment. This knowledge will also aid in estimating construction methods and costs in areas of different sediment type. Listed is the manpower, capital costs and time required to complete a map program.

Proposal for Mapping Surficial Geology

Manpower			
1 Geologist	@ $300/day		
1 Technician	@ $200/day		
Activity			
Field Mapping and Sample Collection	10 days X $500/day	=	$ 5,000
Laboratory Analysis	5 days X $200/day	=	$ 1,000
Report Writing, Map Preparation:			
Geologist	10 days X $300/day	=	$ 3,000
Technician	5 days X $200/day	=	$ 1,000
Total Manpower Cost			$ 10,000
Overhead @110%			$ 11,000
Total Manpower and Overhead			$ 21,000
Equipment and Supplies			
1 Vehicle Expenses			$ 300
1 Portable Soil Auger Expenses			$ 200
Total			$ 500
Total Cost for Surface Mapping Program			$ 21,500

Appendix 2: Proposal for Stratigraphic Mapping Program

The stratigraphic mapping program is required to provide information on the nature, extent, thickness, strength and variability of the surface sediments. It will also provide accurate depths to the undisturbed bedrock surface. Figure 4 is an example of a general outline of the subsurface sediments in Area A. However, the density of boreholes and the type of information collected from these boreholes is not sufficient to produce the detailed cross-sections that the planning departments require. Detailed information is especially important during the design of deep storm sewer systems and underground transportation routes. As an example, the presence of undetected large bodies of saturated sand can have a catastraphic effect during excavation of underground tunnels.

The proposed drilling program would place a rotary borehole at one mile intervals, drilled deep into bedrock. This would require a minimum of 27 rotary holes in Area A, 29 rotary holes in Area B and 7 rotary holes in Area C (a total of 63 holes). From the rotary drilling program the accurate depth to bedrock and major lithologic units can be mapped. Twenty auger drill holes are also proposed, to be drilled at selective sites. These testholes will provide good samples and a very accurate description of the detailed subsurface geologic units.

Following is an estimate of the manpower, equipment rental and operating costs necessary to complete the program. The proposal assumes that the program will be contracted to the private sector and will be supervised by the Geological Survey of the Alberta Research Council.

Estimates For A Stratigraphic Survey in the Annexed Areas

Manpower Costs

1 Geologist - Private Company - $50/hr.

1 Geologist - Supervisor from Alberta Research Council - $30/hr.

Rotary Drilling Program

63 holes: estimate 3 holes drilled per day = 21 days

1 Geologist @ $50.00/hr X 10 hrs/day X 21 days = $ 10,500

Auger Drilling Program

Estimated 20 holes: 1 hole drilled per day = 20 days

1 Geologist @ $50.00/hr X 10 hrs/day X 20 days + $ 10,000

ARC Supervision of Field Activity 10 days X $300/day = $ 3,000

Report Preparation (Writing, Drafting, Typing)

Private Company - 10 days @ $650/day $ 6,500

ARC Supervision of Report

10 days @ $300/day $ 3,000

Total Manpower Costs $ 33,000

Rental Costs

1 Rotary Rig	21 days X $1500/day	$ 31,500
1 Logging Unit	21 days X $600/day	$ 12,600
1 Auger Rig	20 days X $1200/day	$ 24,000
Vehicle Rental, Field Equipment, Miscellaneous operating costs		$ 1,500

Total Rental Costs $ 69,600

Total Costs (Manpower, Rental, 10% Contingency) $112,600

Appendix 3: Proposal to Determine Sulfate Content in Surface Sediments

Activity	Man Days	Approx. Cost
Field Survey and Sample Collection	10 (professional)	$ 1,750
	10 (assistant)	$ 800
Office Data Analysis and Report Writing	10 (professional)	$ 1,750
Laboratory Analysis	10 (technologist)	$ 1,200
Manpower Total		$ 5,500
Overhead @ 110%		$ 6,050
Vehicle Operating Expenses		$ 300
TOTAL		$11,850