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THE UNIVERSITY OF ALBERTA

APPLICATION OF THE LIQUID LIMIT PARAMETER TO SUBSURFACE TILL CORRELATION IN THE VICINITY OF THE CITY OF CALGARY

by

© ROBERT LARS NOWAK

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY
IN
GEOLOGY
DEPARTMENT OF GEOLOGY

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Application of the Liquid Limit Parameter to Subsurface Till Correlation in the Vicinity of the City of Calgary", submitted by Robert Lars Nowak, in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Engineering Geology.

Supervisor

Frank W. Schwartz

A. MacS. Stalker
External Examiner

February 1981

DEDICATED TO MY WIFE TRUDY, AND
SONS RYAN AND JASON WHO HAVE
TOLERATED THIS EXERCISE IN ACADEMIC NONSENSE EXTREMELY WELL

ABSTRACT

Glacial deposits, consisting mainly of till and glaciolacustrine deposits indicate three or possibly four major ice advances. The First Glacial Event is inferred from fragmentary evidence of a possible Rocky Mountain till and associated glaciolacustrine deposit, preserved within the ancient Calgary Valley drainage system. The other three glacial events are associated with the advance of Laurentide ice. The Second Glacial Event is represented by widespread till deposits preserved on upland areas around Calgary as well as in the ancient Calgary Valley. Recession of this glacier ice sheet resulted in deposition of the Indus till and Indus silt and clay. The Third Glacial Event was also quite widespread and involved coalescence of Rocky Mountain and Laurentide ice. Damming of the Calgary Valley resulted in the formation of numerous glacial lakes which drained southward as represented by position and elevation of meltwater channels and the presence of delta lobes. The Beddington till and Beddington silt and clay were deposited during this episode. The Fourth Glacial Event, also from an eastern source, was short lived. Deposits associated with this advance are thin, except where they infilled pre-existing drainage channels. DeWinton till and DeWinton silt and clay were deposited during this last episode.

Elucidation of the Pleistocene stratigraphy of the Calgary area has been aided by a newly developed subsurface technique for till differentiation and correlation. The liquid limit parameter uniquely identifies four tills, one for each glacial event.

ACKNOWLEDGEMENTS

The author would like to express his grateful appreciation to Doctors R. Green and E. A. Babcock of the Alberta Research Council for funding of this project during the summers of 1974, 1975 and 1976.

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Special recognition is also due to my thesis committee. Never before, have so many, provided so little encouragement toward development of this new correlation technique. The author would also like to acknowledge his unfortunate privilege of having worked with individuals like Dr. A. Stalker and Dr. N. Rutter. Recognition is deserving not for Dr. Stalker's

technical input to this study, but rather for his display of political subtlety which approaches all the finesse of a bull in a china shop. Dr. Rutter is to be commended for his ability to ride the Stalker bandwagon - without even falling off! and for his generosity in appointing Dr. Cruden, my supervisor, as the scape-goat for this whole frustrating affair. Were it not for the all-out efforts of people like Stalker and particularly Rutter, this study may very well have been completed five years ago.

Lastly, thanks is due to the Canadian taxpayer for their generous support of the university system, which has enabled gainful employment for our academic braintrust.

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LIST OF SYMBOLS

▦	Fill
▨	Till
░	Glaciolacustrine sand, silt and clay
▒	Sand and gravel
▤	Bedrock
●	Alberta Research test holes where prefixed by 74, 75, 76, 77, and 78. Others are test holes from Inventory of Environmental Geology of Calgary assembled by Material Testing Laboratories in Calgary, 1972.
▽	Water wells

CHAPTER I

INTRODUCTION

Study Objectives

General Statement

Many attempts have been made over the last twenty years to decipher the glacial history of the Calgary area. The glacial deposits of this area are a complex assemblage of sediments derived from both Cordilleran and Keewatin ice sheets. This complexity results either from incorporation of debris of a previous advance by a subsequent advance, or from mixing of both western and eastern ice where coalescence has occurred; or from interbedding of deposits where glacier fronts have oscillated.

A fundamental assumption has been that all crystalline igneous and high grade metamorphic rocks found in the drift were derived from the Canadian Shield and that all carbonate, quartzite, chert and volcanic rocks found in the drift were derived from the Cordillera. In view of the possible mixing mechanisms previously mentioned, the issue of just how many Shield-type stones are required to constitute an Eastern source has never been resolved. It would appear that parameters such as pebble lithology would only be indicative for the first advance.

The mixing has imposed limitations on the classical techniques of till differentiation and correlation. For example, Rutter (1965), in his study on the surficial geology of the Banff area, concluded that till sheets could not be differentiated on lithologic characteristics. As a result, reliance was placed on geomorphic criteria and the relationship between tills and other glacial deposits in deciphering the stratigraphy. Similarly, Boydell (1972), in his study on the surficial geology of the Rocky Mountain House area, states; "It is concluded that although the heavy minerals support the gross differentiation achieved by the pebble counts, the establishing of relative ages by laboratory analysis will not add significantly to the evidence provided by the morphological and stratigraphic studies."

Within the immediate Calgary area, Tharin (1960) postulated two major advances, while Morgan (1966) and Glendinning (1973) found only one. Yet all three workers used essentially the same classical till differentiation techniques on the same deposits!

Objectives

In view of the apparent shortcomings of the classical till differentiation techniques in certain areas, it was decided to experiment with a new method.

To this end, the study addresses the following objectives:

- to attempt till differentiation and correlation utilizing the concept of liquid limits;
- to apply this new technique to a complex stratigraphic area, such as Calgary, in order to evaluate its usefulness in eludicating the glacial history of an area.

Location of Study Area

The study area is situated near the City of Calgary in Southern Alberta (Figure 1-1). This study is part of a larger study being conducted by the Research Council of Alberta on the urban geology of the Calgary area. The study area is covered by Townships 21 to 26, Ranges 28 and 29, West of the Fourth Meridian and Ranges 1 to 4, West of the Fifth Meridian.

The area is covered by the following 1:50,000 National Topographic System maps which have been used as base maps for this project:

82 - O/1	Calgary
82 - J/16	Priddis
82 - P/4	Dalroy
82 - I/13	Dalemead.

General Physiography

For purposes of discussion, the Calgary area is divided into geomorphic elements on the basis of topographic expression. The study area is found within two physiographic regions; the plains to the east and the foothills to the west.

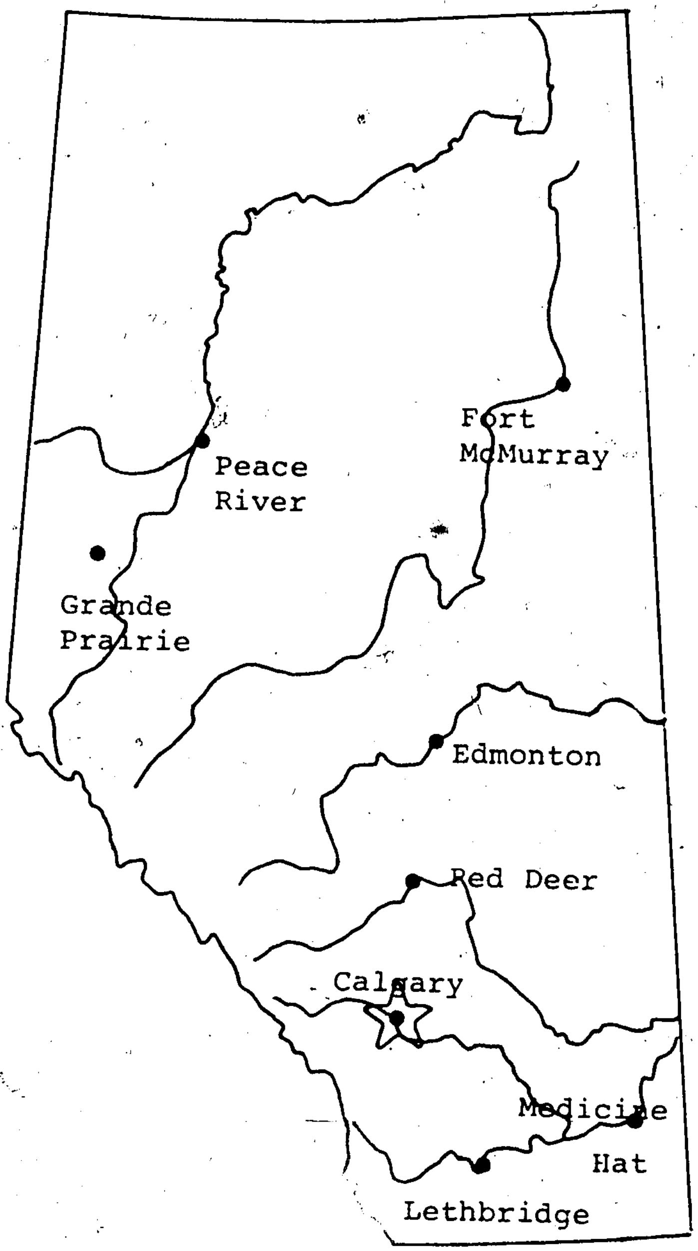


Figure 1-1 Regional Map

The western half of the area is characterized by prominent, bedrock controlled uplands which are refferd to as Big Hill - Nose Hill, Cairn Hill, Copithorne - Towers Ridge, and Pine Ridge. All of these upland features lie above an elevation of 4,000 feet a.s.l. (Figure 1-2).

The Big Hill - Nose Hill complex trends northwest - southeast and covers much of Twp. 25, Rge. 2, and Twp. 26, Rge. 3.

Prominent in the vicinity of the City of Calgary is the large, flat-topped Cairn Hill, which separates the Bow and Elbow River Valleys at the western edge of the city.

Commencement of the foothills region is marked by the Copithorne - Towers Ridge complex which occupies most of the western edge of the study area from south of Cochrane to Millarville. This extensive upland area covers Twps. 21 - 25, Rge. 4, W5M.

Pine Ridge, trending northwest - southeast, is separated from the Copithorne - Towers Ridge complex in the southern part of the study area by a flat lowland referred to as the Priddis Lowland. This lowland slopes northward from an elevation of 3,897 feet near Threepoint Creek to an elevation of 3,788 feet just north of Priddis.

Two other prominent upland areas also warrant mention. High Butte, located within the Camp Sarcee Military Reserve (Twp. 23, Rge. 2, W5M) rises to about 3,900 feet a.s.l. and

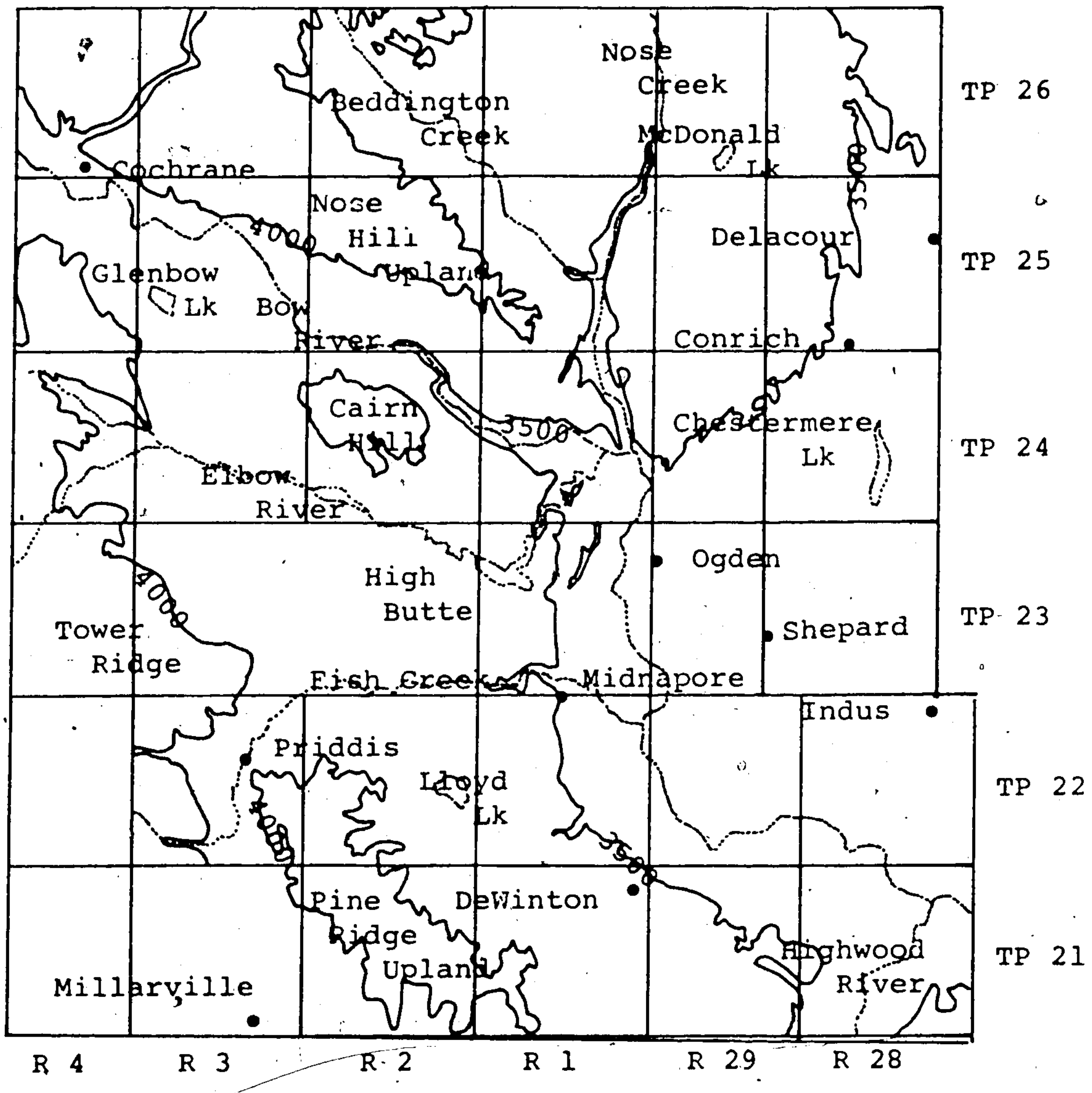


Figure 1-2 Physiographic Features

separates the Elbow River and Fish Creek Valleys. To the north of Calgary in Twp. 26, Rge. 29, W4M, there occurs a series of elongated ridges trending northeast - southwest that rise to an elevation of about 3,600 feet. This topographic feature is called The Sharp Hills.

The eastern half of the area is rolling prairie with a regional slope down to the east. Much of this area is a gently rolling to undulating plain with numerous intermittent sloughs generating a deranged drainage pattern.

One other distinctive feature is the hummocky topography and deranged drainage found on top of the Big Hill - Nose Hill ridge.

Two major rivers, the Bow and Elbow, flow east across the area. In addition, Fish Creek is found in the southwest corner of the map area, and Beddington and Nose Creeks occupy prominent, well-defined glacial meltwater channels north of Calgary.

Review of Previous Research

Stratigraphic Studies in the Calgary Area

A number of studies have been conducted within the Calgary area which are of importance to the present study. These include: Tharin (1960), Morgan (1966), Rutter and Wyder (1969), Glendinning (1973), and Jackson (1977).

Tharin (1960) found evidence for two major glacial advances. The first advance (Spy Hill), from the west, deposited outwash debris down the regional slope to the east and northeast. This outwash was subsequently incorporated in advancing eastern ice (Lochend). The second major advance, from the west, (Morley ice) extended east only to the Jumping Pound River and left the northwest trending Spy Hill ridge unglaciated. From the north, a deflected lobe of ice (Balzac) brought the Foothills Erratics Train (Stalker, 1956), into the Calgary area contemporaneous with re-advance of eastern ice (Crossfield).

Morgan (1966) postulated a single advance incorporating western ice, Erratics Train ice, and eastern ice with Erratics Train ice representing the zone of mixing between the other two. Stagnation of the main flow of Erratics Train ice was linked with evidence from Glacial Lake Calgary and associated meltwater channel deposits to show that the lake followed the ice-front as the ice-front receded eastward. Morgan also found evidence for a western till in the Burns Channel which pre-dated the deposition of the overlying Erratics Train ice.

Glendinning (1973), following Morgan, postulated a synchronous western ice (Till A), a mixed zone (Till B), and an eastern ice. Glendinning extended Morgan's work southward into the Bragg Creek, Priddis Creek and Lloyd Lake area where he deciphered the deglaciation of Lake Calgary.

A fourth study, by Rutter and Wyder (1969), involved the drilling of 19 boreholes in the City of Calgary. Although the chief purpose of their report was to evaluate the usefulness and limitations of borehole stratigraphic techniques, they also provided data on possible new stratigraphic relationships previously left unanswered by surface mapping techniques.

Jackson (1977) found evidence for four glaciations in the Alberta portion of the Kananaskis Lakes map sheet (82 J), two of which involved the Priddis map sheet (82 J/16). The oldest of these involved the coalescence of Bow Valley Till from the west with mixed western-eastern Erratics Train Till. The latest glaciation involved an advance of the Laurentide ice sheet that blocked the Bow River Valley and caused deposition of the glaciolacustrine Midnapore Silts and Clays.

Engineering Studies of Till

A number of studies on engineering properties of tills have been undertaken in the last twenty years by civil engineers. The bulk of the research work has been directed toward classifying tills in terms of their engineering property behaviour rather than for till differentiation. However, albeit indirectly, these studies have indicated that till differentiation is possible using such parameters as natural moisture content, shear strength, Atterberg Limits, compressibility characteristics and grain size distribution.

Rominger and Rutledge (1952) used soil mechanics data in the correlation and interpretation of Glacial Lake Agassiz sediments. They successfully used the concept of preconsolidation stress to identify three old drying-out surfaces within the Lake Agassiz clay. Previously, the glaciolacustrine deposits were thought to have been formed during a single depositional stage of glacial Lake Agassiz.

Misiaszek (1960) and Peck and Reed (1960), in their study on Chicago subsoils, concluded that contacts between till sheets could normally be located by conspicuous changes in natural moisture content.

Chryssafopoulos (1963), employing stratigraphic techniques, investigated a number of tills from moraines surrounding Lake Michigan. He used particle size distribution, particularly those sieve sizes at which 80, 60, and 40 percent by weight was passing, together with the minus 200 fraction. Chryssafopoulos actually was concerned with identifying tills rather than with classifying them for engineering purposes. The tills were all clayey and it was found that the data from the minus 200 sieve fraction was sufficient to distinguish the various tills. His analysis confirms that tills do not randomly vary in particle size distribution, but conform to a reasonably predictable pattern for any given ice sheet.

MacDonald and Sauer (1970), in their study on engineering properties of tills in the Saskatoon area, successfully separated the Battleford, Floral and Sutherland Tills on the basis of Atterberg limits and grain size analyses.

McGown (1971), in his study on tills in Scotland, used an approach similar to that of Chryssafopoulos. McGown used the fine soil fraction to classify tills for engineering purposes. He discovered that when the bimodal size distribution of tills was split into two, the fine fraction showed a high degree of conformity within tills derived from the same parent rock type and with similar glacial histories.

Fookes et al (1975), during their engineering geology study for the Hartlepool "A" Power Station in England, identified a lower, middle and upper till separated by fluvioglacial or glaciolacustrine deposits. No data was obtained on the lower till; however, the middle and upper tills were distinguished by their moisture content and liquid limits. The middle till had a moisture content of 10 to 16 percent and a liquid limit range of 27 to 40 percent, while the upper till had a moisture content of 19 to 25 percent and a liquid limit range of 36 to 53 percent.

Edil et al (1977), in their study of tills along the Lake Michigan shoreline, identified a lower, middle and upper till separated by glaciolacustrine or deltaic deposits. The lower till was non plastic with a natural moisture content of 4.8 percent. The liquid limit of the middle till averaged 24.3 percent and the natural moisture content 15.6 percent whereas the upper till had 30.5 and 17.2 percent, respectively.

In general, geologists have provided the stratigraphic framework of the tills and the engineering discipline has attempted to categorize till properties within that pre-established framework. The independent studies have in fact reinforced one another with respect to till differentiation. To the author's knowledge, no attempt has been made to actually use engineering properties to produce the stratigraphic framework.

Method of Investigation

Borehole Program

The present study is limited to a subsurface analysis of till units. Data for this research work was derived from 301 test holes drilled on behalf of the Research Council of Alberta during the summers of 1974 through to 1978. Of the 301 test holes, 132 were chosen for detailed analyses, because of presence of multiple tills or of thick sections of till. Bag samples were taken at 3 to 5 foot intervals in most of the test holes.

The locations of the test holes used in this study are indicated on Figures 1-3 and 1-6.

Laboratory Program

The object of the laboratory program was to evaluate the usefulness of the liquid limit parameter to differentiate tills. The liquid limit test was conducted on all till samples and some glaciolacustrine, fluvioglacial and bedrock samples. To evaluate the usefulness of the liquid limit parameter for differentiating tills, other physical properties such as: texture, natural moisture content, carbonate content and percentage of igneous - metamorphic grains within the coarse sand fraction, were chosen to provide an independent check. Alberta Research also determined the clay mineralogy of some samples. However, as this property can be expected to relate to the liquid limit, it is not an independent measure of the usefulness of the liquid limit technique.

Other Studies

Additional data came from analysis of air photographs and topographic maps. The air photo work was undertaken on 1:31680 photos flown in 1974 and 1:80,000 photos flown in 1970. It was used chiefly to assist in identifying various till advances and/or retreatal stages by determining ice margins, morainal ridges and ice marginal channels.

CHAPTER II

RESEARCH METHODS

Introduction

During the 1974 to 1978 drilling seasons, samples were collected rigorously at 3 to 5 foot intervals. The vast majority of the test holes were drilled by using the dry auger method, the others, by the rotary method. With the latter, both cutting and sidewall core samples were retrieved for laboratory analysis.

The major emphasis in the laboratory program was the measurement of the liquid limit of virtually all till samples. Five other parameters were analyzed to confirm or reject the ability of the liquid limit to differentiate tills. These parameters are: texture, natural moisture content, percent of igneous-metamorphic fragments, carbonate content and clay mineralogy. To verify the potential of the liquid limit technique, it is necessary to use other physical parameters which are totally independent of the liquid limit. In this respect, the clay mineralogy is related to liquid limit and therefore does not qualify as such a parameter.

Laboratory Methods

Textural Analysis

A 60 - 70 gram sample and 50 ml of 4 percent Calgon solution were placed into a plastic graduated beaker and diluted with 300 ml of distilled water. The slurry was mixed for two minutes by an electric mixer. The clay fraction was then determined by employing Stokes' Law. A time was calculated at which all particles greater than 0.002 mm would have passed a given point. For convenience, this point was equated to one-third of the volume of solution. The clay suspension was siphoned off using a fine capillary tube and evaporated to dryness. Assuming a uniform suspension, the total weight of clay would be three times the measured dry weight since exactly one-third of the volume was removed. The remainder of the suspended material was passed through a #230 mesh sieve (0.0625 mm). The material retained on the screen, after wet sieving, represented the sand fraction. This method allowed rapid determination of the relative proportions of sand, silt, and clay. This data has been expressed as the ratio

$$\frac{S}{M+C}$$

where: S = percent sand

M = percent silt

C = percent clay.

Textural analysis is the tripartite division of the minus 2 mm fraction of material into sand (2.0 - 0.0625 mm), silt (0.0625 - 0.002 mm) and clay (finer than 0.002 mm). Its use, in the geologic literature, is based on the assumption that a given deposit can be identified by the relative percentages of each of these three end members.

The data for the S/(M+C) ratio is tabulated on the various stratigraphic logs contained in the Appendix.

Natural Moisture Content

During the drilling of boreholes in the field, a sample was taken every five feet, trimmed, cleaned and placed in a plastic vial for natural moisture content determination. An electric balance was available so that each evening all the vials could be weighed. This process was adopted in hopes of reducing any moisture loss during prolonged transportation or storage. Later, all samples were oven dried at 105° C for 24 hours and the natural moisture content determined.

This parameter has been found to be useful for differentiating either between tills or between till and other glacial deposits.

The natural moisture content data is tabulated on the various stratigraphic logs contained in the Appendix.

Igneous - Metamorphic Content

A 50 to 100 gm sample of air dried till was lightly crushed and washed through a nested No. 18 and 35 sieve. The material passing the No. 18 sieve, but retained on the No. 35 sieve, represented the coarse sand fraction. The sample was then dried and point-counted for the percentage of igneous-metamorphic fragments using a binocular microscope. The percentage of Shield-type lithologies such as granites, gneisses and schists has been used extensively to distinguish between Continental and Cordilleran ice sheets.

The igneous-metamorphic data is tabulated on the various stratigraphic logs contained in the Appendix.

Carbonate Content

The total carbonate content present in the minus 200 (0.074 mm) fraction of the till samples was determined using the Chittick Gasometric method as outlined by Dreimanis (1962). The volume of carbon dioxide evolved in the reaction of an approximate 1.5 gram sample and 20 cc of 6N hydrochloric acid was standardized to 22° Centigrade and one atmosphere pressure, then converted to grams of carbon dioxide and expressed as a calcium carbonate equivalent.

The calcium carbonate data is tabulated on the various stratigraphic logs contained in the Appendix.

Clay Mineralogy

Tharin (1960), who studied the clay mineralogy of the tills in the Calgary area, concluded that eastern tills had illite and montmorillonite in approximately equal amounts, and western tills had an illite content three times that of montmorillonite. The high montmorillonite content is associated with Cretaceous bedrock east of Calgary and it is almost absent in the Tertiary bedrock underlying and to the west of Calgary. Since till is composed of approximately 80% local bedrock material, it might be feasible to determine eastern versus western tills on the basis of the clay mineralogic assemblage.

Using a semi-quantitative estimate obtained from relative peak heights, till samples were analyzed by D. W. Scafe of Alberta Research for percentages of illite, kaolinite, montmorillonite and chlorite. The illite and montmorillonite percentages were used to generate the ratio I/(I+M) where:

I = percent illite

M = percent montmorillonite.

Data for clay ratio is tabulated on the various stratigraphic logs contained in the Appendix.

Liquid Limit

An air-dried sample of 100 - 200 grams (minus 40 mesh) was mixed with distilled water to form a smooth paste and allowed to equilibrate for a minimum of 8 hours prior to processing. The liquid limit was determined by measuring the depth of penetration of a 60 gram, 60 degree cone into a small mold filled with the soil paste according to the method of Hansbo (1957). In reality, this method measures an undrained shear strength which can be converted to a liquid limit value. There are three advantages to using the falling cone method of Hansbo. These are speed, elimination of operator bias, and derivation of value for sandy materials which usually cannot be run using the Casagrande liquid limit device.

Hansbo (1957) gives a chart (Table II, page 45) showing depth of cone penetration (h) versus shearing resistance (Tf). From Elson's (in Norman, 1959) curve fitting formula $LL = \frac{N}{25}^{0.10}$ X Mc where N = the number of blows and Mc the moisture content for that number of blows. The LL determined from the Casagrande device may also be expressed as a shearing resistance.

According to Scott (1963, page 23), the LL as measured in the Casagrande device corresponds to a shearing stress of about 20 - 30 gm/cm^2. Assuming a value of 27 gm/cm^2 as a standard, the LL then corresponds to a shearing resistance of $0.297\ t/m^2$ for the units used by Hansbo (1957). Therefore, in Elson's equation above, $\frac{N}{25}$ may be replaced by $\frac{Tf}{0.297}$ to give LL (cone) = ${\frac{Tf}{0.297}}^{0.10} \times Mc$.

where LL = liquid limit

Tf = shearing resistance

Mc = moisture content.

It was found that LL (cone) could be converted to LL (Casagrande) by the following equation:

$$y = 0.7835\ x + 6.9676$$

where y = LL (cone)

x = LL (Casagrande).

Derivation of this equation was based on 78 trials with a correlation coefficient of 0.88.

The liquid limit data is tabulated on the various stratigraphic logs contained in the Appendix.

CHAPTER III

DISCUSSION OF LIQUID LIMIT TECHNIQUE

Definition of Liquid Limit

Atterberg Limits are index properties used by geotechnical engineers to classify soils. The limits are based on the concept that a soil can exist in any one of four states: solid, semi-solid, plastic and liquid; depending on the water content. The water contents, expressed as a percentage, at the boundaries between these stages are called shrinkage limit, plastic limit and liquid limit, respectively.

From a geological point of view, soil mechanics properties can be subdivided into those that depend almost exclusively on the source and depositional environment of the soil (primary) and those that depend mainly on post-depositional history (secondary) of the deposits (Rominger and Rutledge, 1952).

The primary properties consist of parameters such as grain size distribution, Atterberg Limits, permeability and compaction characteristics, while properties like natural moisture content, unconfined compressive strength, shear strength relations and consolidation characteristics are secondary in nature since they are affected by post-depositional loading history. In general, the primary properties are measured in tests on completely disturbed or remoulded soil samples, whereas the secondary properties are determined from tests on undisturbed samples that essentially represent natural or in-situ soil conditions.

The boundaries or "limits" at which the soils change from one state to another are controlled by a number of interrelated factors (Grim 1950, 1953, 1962) and are summarized as follows:

(1) kind and relative abundance of clay minerals;
(2) kind and relative abundance of non-clay minerals such as quartz or feldspar, in the less than 2 micron range;
(3) grain size distribution of both clay and non-clay minerals;
(4) amount and grain size of organic material;
(5) kind and abundance of exchangeable bases.

Considerable work has been done by Seed et al (1964a, 1964b) dealing with the effect of clay mineralogy on the Atterberg Limits. Their research has been done on artificially prepared mixtures of quartz (less than 2 micron fraction) and commercially available pure clays. Seed et al have drawn the following conclusions from their work:

(1) liquid limits increase with an increase in clay content;
(2) liquid limits increase with a decrease in particle size;
(3) liquid limits increase with an increase in organic matter content;

(4) liquid limits increase with an increase in cation exchange capacity.

Nowak Hypothesis

Based on some earlier work with plastic and liquid limits of tills, the author observed a remarkable consistency in liquid limits in contrast to the generally accepted heterogeneous nature of till. This led to the postulation that Atterberg Limits might uniquely define till advances. The theory was supported, in part, albeit indirectly, by work published by Boulton and Paul (1976).

Dreimanis and Vagners (1971) had demonstrated that the mineralogy and grain size distribution of glacial debris was related to its source rock and distance of transport. Many of the fundamental geotechnical attributes of glacial till are acquired during the erosional and transportation phases in which initial mineralogy and grain size are determined. Boulton and Paul (1976) studied a number of tills of known origin at the margins of modern glaciers and concluded "that for debris in transport by any one glacier, the relationship between plasticity index (liquid limit minus plastic limit) and liquid limit is constant, but that subsequent modes of deposition may introduce considerable variation in these parameters".

The Boulton and Paul data is illustrated in Figure 3-1. Data plotted for englacial debris or unaltered lodgement till

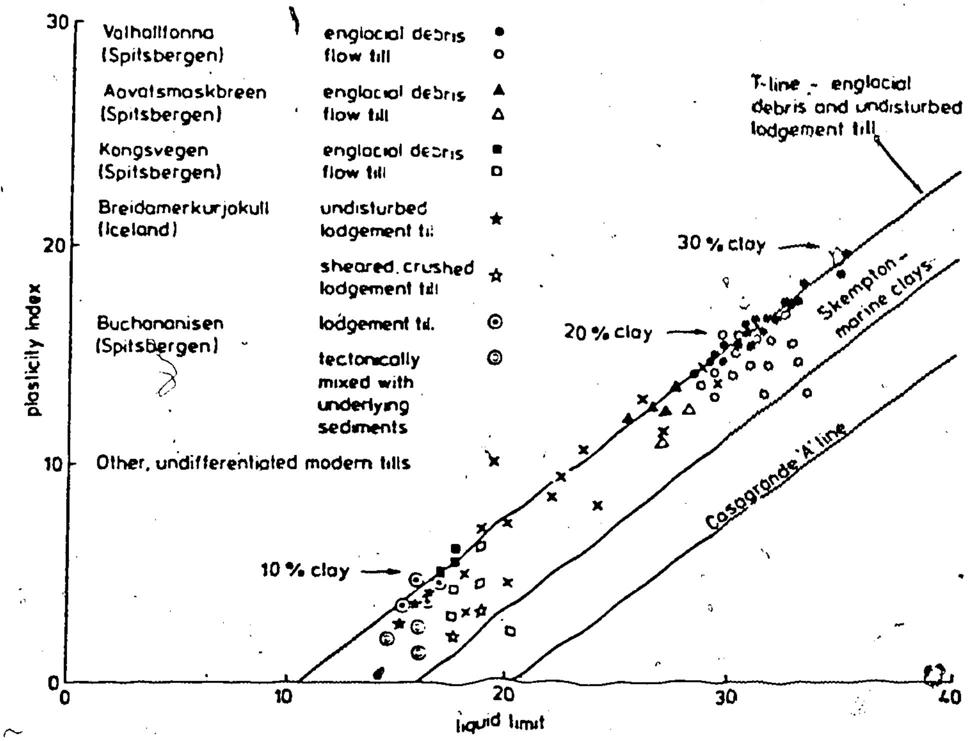


FIG. 3. Liquid limit/plasticity index plot for tills of known origin at the margins of modern glaciers. The solid symbols represent englacial debris or unaltered lodgement till derived from it. These define a straight line, the T-line, which primarily reflects the nature of the grain-size distribution. Percentage clay in the sample increases along the T-line from left to right. The grain-size changes which commonly occur in flow tills due to sorting processes, and the mixing of lodgement tills with other subjacent sediments due to subglacial deformation move points away from the T-line.

Figure 3-1: Liquid limit/plasticity index plot for tills (after Boulton and Paul, 1976).

defined a straight line referred to as the T-line. This T-line primarily reflects the nature of the grain size distribution with the percentage clay increasing along the T-line from left to right. The grain size changes which occur in flow tills due to sorting processes as well as the mixing of lodgement tills with other subjacent sediments, move points away from the T-line.

It appears reasonable to assume that in the predominantly continental glaciation of the prairie region, the liquid limit approach to till differentiation should work since post-depositional modifications to predominantly lodgement-type till would be limited to reworking of upper till boundaries with subsequent glacial advances.

The following quotes from various authors tend to support the hypothesis that the liquid limit can be used to uniquely define distinct glacial advances:

Boulton and Paul (1976) p. 164

We would suggest that the Atterberg Limits serve as good quantitative indicators of the fundamental properties of the debris which is deposited as till.

Christiansen (1960) p. 26

In reference to Qu'Appelle Tills - Atterberg Limits are the most suitable physical characteristics for the description of the gross aspect of till.

Edil et al (1977)

The glacial till deposited by a single ice advance is usually found to be relatively uniform, with respect to its geologic characteristics over a fairly large area, and it is suggested that the same relationship holds with respect to its geotechnical properties.

Shepps (1953)

However, it has been argued that the comparative homogeneity of a till throughout a considerable area implies thorough mixing and hence long distance of travel, at least of the fine fraction.

White (1972)

Tills vary greatly among themselves, but each individual till sheet is more or less uniform in its properties over distance of miles. Characteristics of a till sheet change slowly, generally in a direction normal to ice motion.

Rominger and Rutledge (1952) p. 174

The relative values of the correlation coefficients for the Grand Forks - Fargo data indicate that natural moisture content and liquid limit are the most valuable of the properties in stratigraphic correlation.

Supporting Data for Liquid Limit Technique

General

The ability of the liquid limit technique to identify distinct till units is supported by other physical property determinations. These are: (a) stratigraphic relationships, (b) percent igneous-metamorphic fragments, (c) textural analysis, (d). geophysical response, and (e) fabric analysis.

Stratigraphic relationships and percent igneous-metamorphic fragments constitute the most significant evidence for till differentiation by the liquid limit parameter.

Stratigraphic Relationships

During postulation of the liquid limit differentiation-correlation technique in 1974-75, none of the test holes drilled at that time had encountered any convincing multiple till sections. During the 1976 and 1977 drilling seasons, this information became available and serves as the most powerful confirmation for the new theory. Presence of multiple till sections has enabled the establishment of "key" borehole sections which can be used to trace the various till units over the study area.

Figures 3-2 to 3-4 reflect the four main tills encountered in the Calgary area. With the exception of test hole

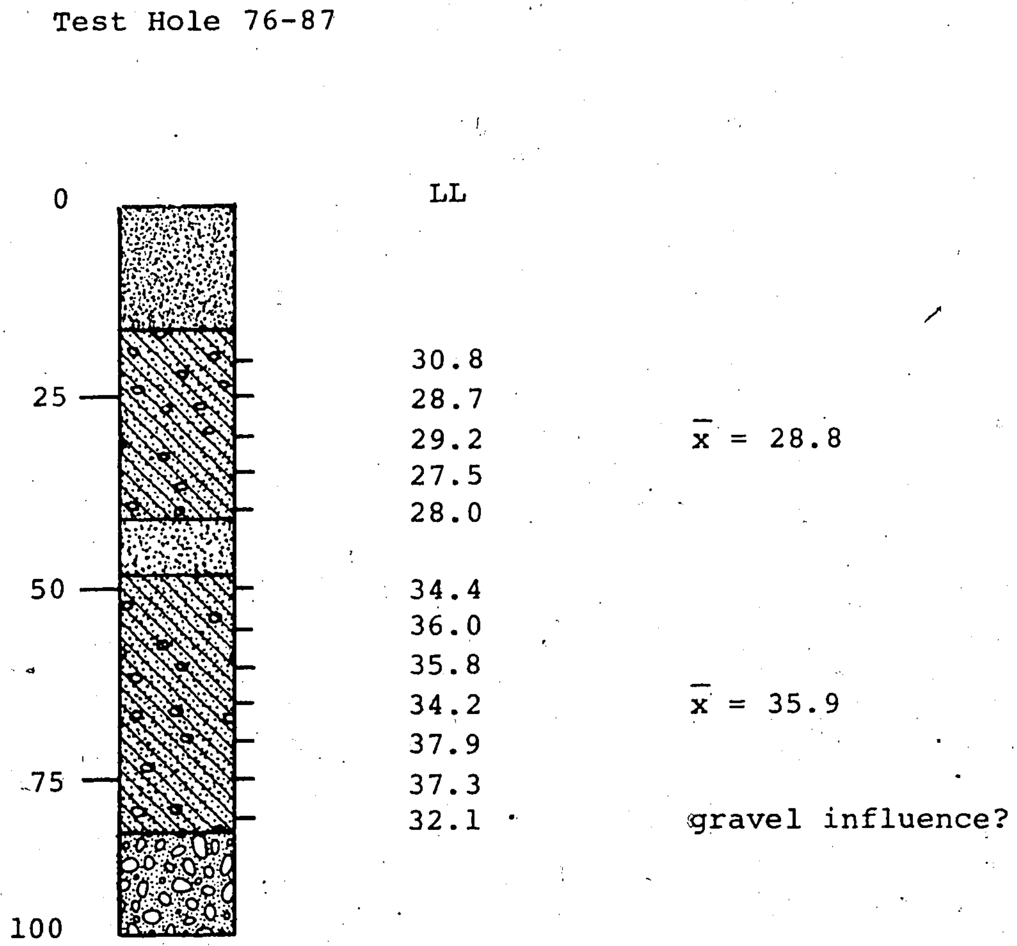


Figure 3-2: Liquid limit till supported by stratigraphic position

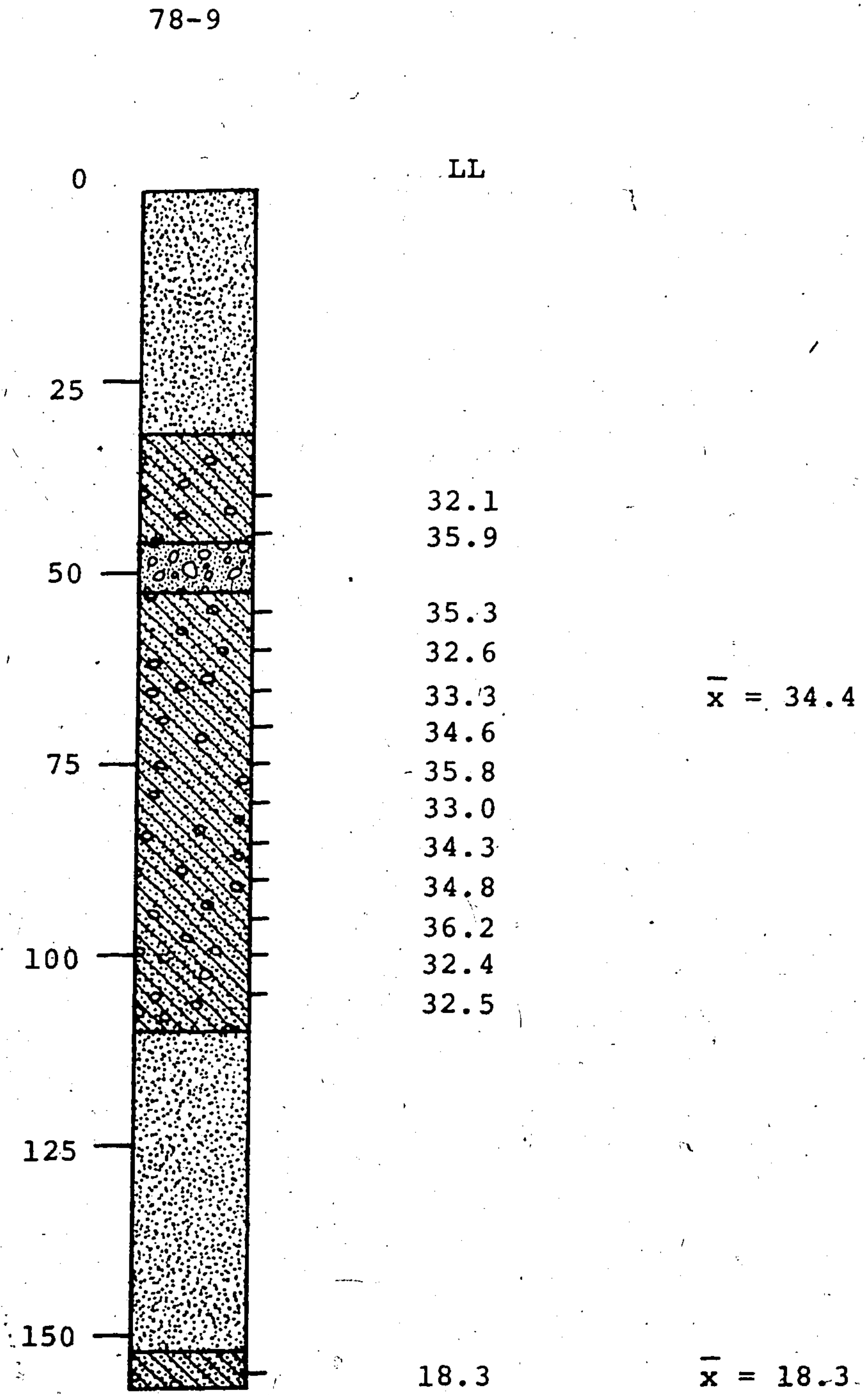


Figure 3-3: Liquid limit tills supported by stratigraphic position

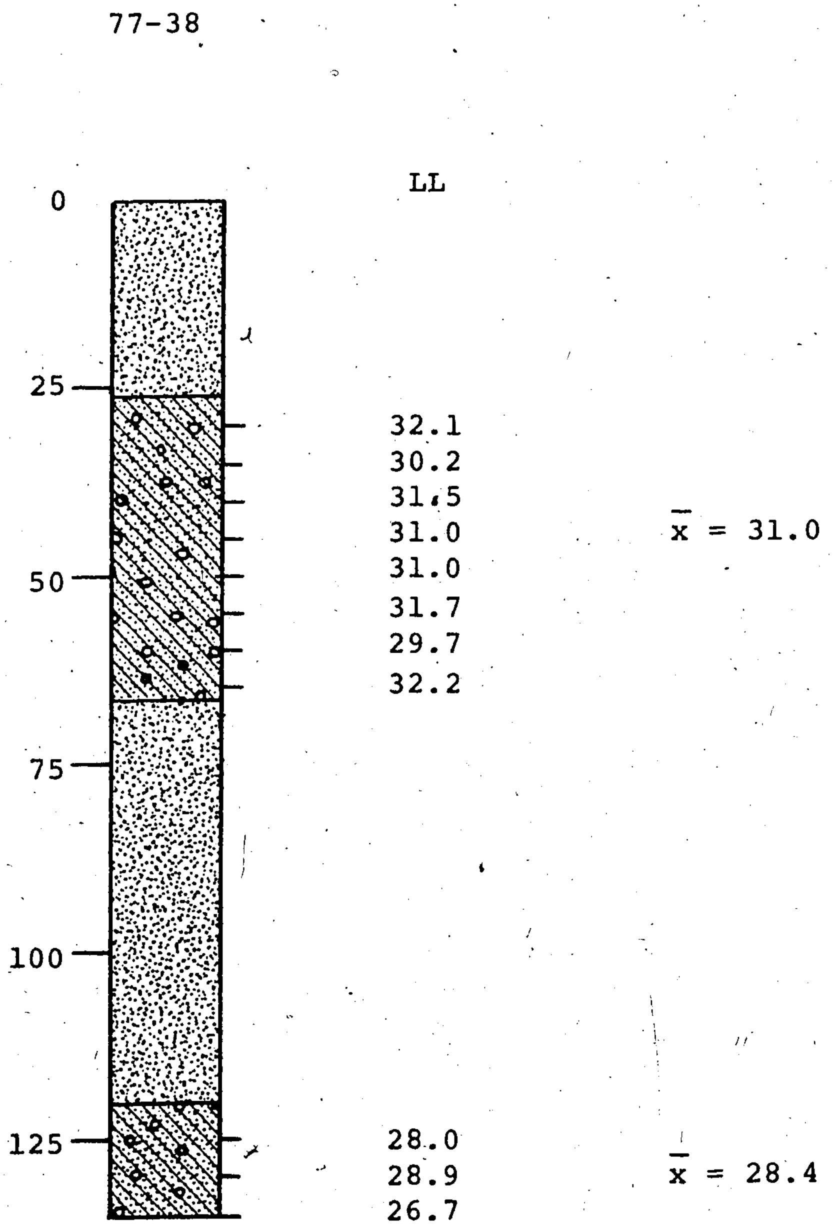


Figure 3-4: Liquid limit tills supported by stratigraphic position

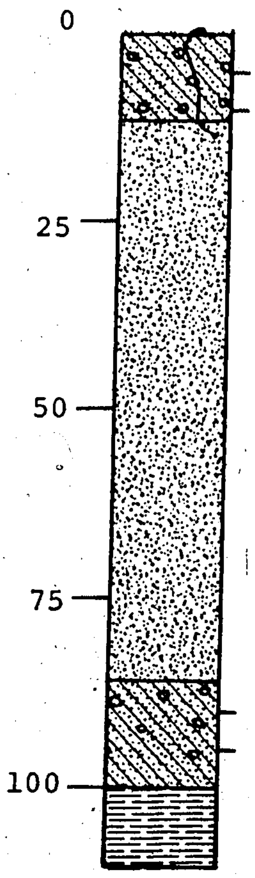
76-87, the others show thick glaciolacustrine sediments (varying in thickness from 42 to 53 feet) separating an upper and lower till. Based on stratigraphic position and the liquid limit values, four different tills can be approximated by the values 18.3, 28.5, 31.5, and 35.5.

Percentage of Igneous-Metamorphic Fragments

Within a given till section, the percentage of igneous-metamorphic fragment shows a distinct difference in content for the various liquid limit till units. For example, Figure 3-5 illustrates a multiple till section with 2 till units - 32.1 and 28.9. The corresponding igneous-metamorphic content also shows a very contrasting break of 25.5 versus 5.5 percent, respectively. A second example, Figure 3-6 illustrates a similar contrast, but for two tills in contact. The upper till has a liquid limit (LL) of 32.7 and an igneous-metamorphic (IM) content of 28.7 while the lower till has an LL of 34.8 and an IM of 4.8.

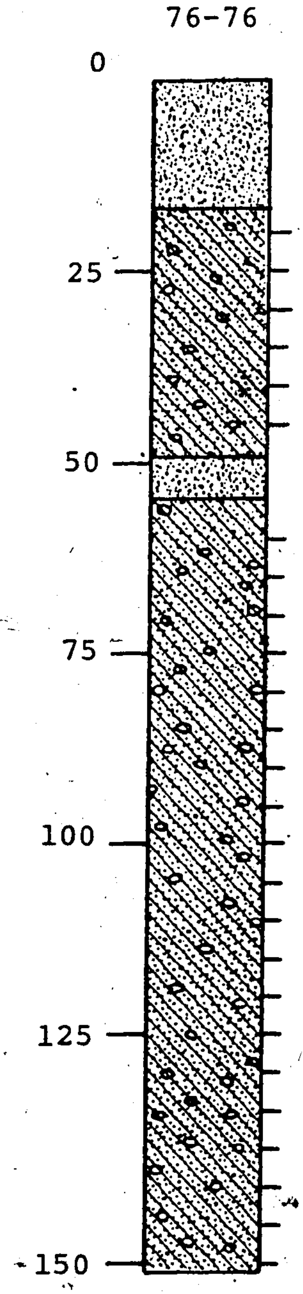
While the igneous-metamorphic content is associated with a change in liquid limit within a given borehole, this relationship is not so consistent from borehole to borehole. As an example, Figure 3-7 illustrates a rather inconsistent distribution of igneous-metamorphic fragments within the same till unit.

76-74



LL	IM
32.7	27.6
31.4	23.4
$\bar{x}$ = 32.1	25.5
29.8	4.4
27.9	6.5
$\bar{x}$ = 28.9	5.5

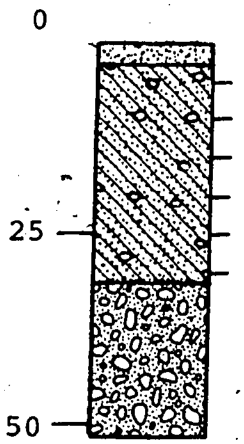
Figure 3-5: Liquid limit tills supported by igneous-metamorphic content



LL		IM	
33.1		27.3	
32.3			
31.7		34.0	
32.8	$\bar{x} = 32.7$		$\bar{x} = 28.7$
33.7		24.8	
32.0			
33.5			
35.1		2.4	
34.8			
34.8		3.8	
33.6		2.7	
35.0		8.4	
34.5		6.5	
35.4		2.9	
35.9		9.9	
35.7		9.1	
32.7	$\bar{x} = 34.8$	9.2	$\bar{x} = 4.8$
38.4		6.3	
34.7		6.5	
38.1		5.0	
34.3		6.5	
34.0		5.8	
32.8		5.4	
33.7		1.3	
34.1		-	
33.4		-	
35.0		-	

Figure 3-6: Liquid limit tills supported by igneous-metamorphic content

77-46



LL	IM
40.4	16.8
35.6	5.9
38.4	3.1
37.1	0.8
33.5	-
32.9	1.0
$\bar{x} = 36.3$	$\bar{x} = 5.3$

Figure 3-7: Variability of igneous-metamorphic content within same unit

An examination of the IM content in various test holes contained in the Appendix of this study indicates that it may be quite high or low for the same unit. However, in general, this phemomena appears to be related to topographic criteria. For till 31.5, an average IM content of 1.7 and 0.6% is present in test holes 76-108 and 75-14 which both occur in upland areas. The same till unit occurring as valley fill deposits contains 25.5 and 28.7 percent, for example, in test holes 76-74 and 76-76, respectively. A similar relationship occurs for till 35.5 with an IM value of 1.6 percent in the upland test hole of 77-45 as compared to 21.4 percent in the valley fill test hole of 76-37. The variability in IM content appears to be a function the erosional, transportational and depositional mode of the ice sheet explained as follows. For a continental glacier, the bulk of the material is transported in the basal position according to the glacier process model of Clayton and Moran (1974), with decreasing amounts of material upward within the ice sheet. As the glacier encounters upland and upland flank areas, local shearing takes place and local debris is added to the ice sheet in the intermediate or englacial position resulting in an apparent dilution of previous material. Tharin (1960) showed that the upland and flank positions within the Calgary area were covered by extensive Cordilleran-type outwash which became incorporated in westward advancing continental ice. It is interesting to note that while the igneous-metamorphic content can vary within the ice sheet as a function of elevation, the liquid limit remains quite consistent.

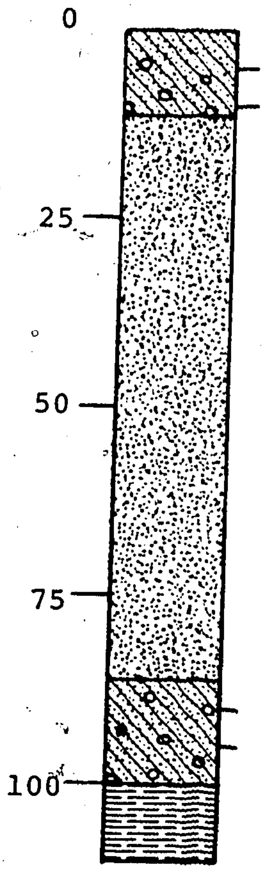
Textural Analysis

As indicated in the chapter on Research Methods, the percentage of sand-silt-clay has been recorded as a ratio of sand divided by silt plus clay. In general, the higher the ratio, the greater is the contribution by the sand size fraction, that is, the sandier is the till.

With respect to key multiple till sections, the textural analysis tends to support the difference in till type as determined by the liquid limit parameter. Two multiple till sections separated by thick glaciolacustrine sediments are shown in Figures 3-8 and 3-9. Note the excellent grouping and distinct difference in S/(M+C) ratio. A similar case with two tills in contact is shown in Figure 3-10.

As is the case with the igneous-metamorphic content, there is excellent differentiation between tills in the same test hole, but the consistency is lost while tracing the same till from test hole to test hole. Continuity in units appears to be supported only by the liquid limit in both the horizontal and vertical direction of a till sheet.

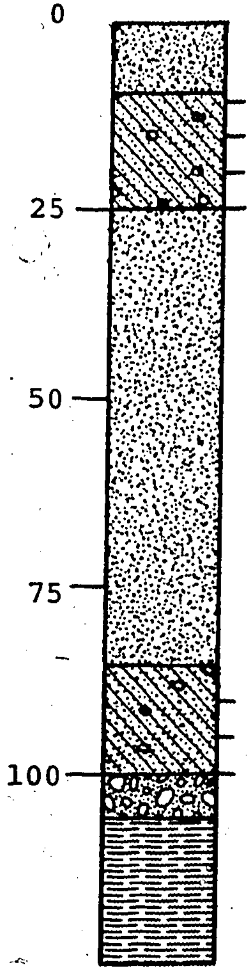
76-74



LL	S/(M+C)
32.7	0.47
31.4	0.41
$\bar{x}$ = 32.1	0.44
29.8	0.25
27.9	0.27
$\bar{x}$ = 28.9	0.26

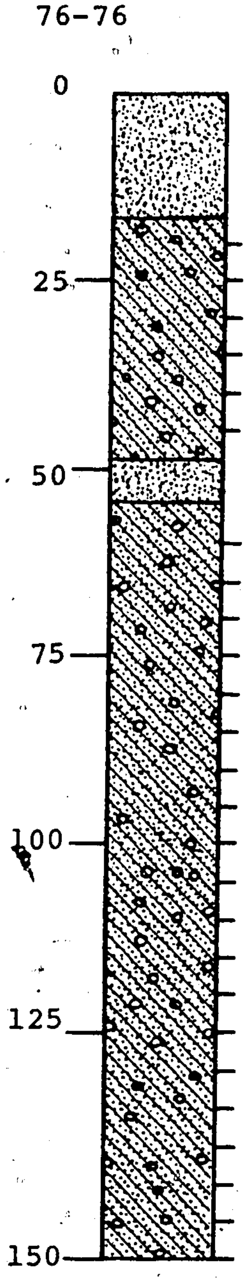
Figure 3-8: Liquid limit tills supported by sand ratio

77-22



	LL	S/(M+C)
	32.4	0.23
	31.5	0.22
	32.8	0.20
	33.0	0.22
$\bar{x}$ =	32.4	0.22
	28.5	0.32
	27.6	0.30
	28.1	0.35
$\bar{x}$ =	28.5	0.32

Figure 3-9: Liquid limit tills supported by sand ratio



LL		S/(M+C)	
33.1		0.35	
32.3		0.35	
31.7	$\bar{x}$ = 32.6	0.43	$\bar{x}$ = 0.40
32.8		0.43	
33.7		0.35	
32.0		0.49	
35.1		0.20	
34.8		0.27	
34.8		0.30	
33.6		0.27	
35.0		0.28	
34.5		0.32	
35.4		0.32	
35.9		0.30	
35.7	$\bar{x}$ = 34.8	0.28	$\bar{x}$ = 0.28
32.7		0.28	
38.4		0.23	
34.7		0.27	
38.1		0.25	
34.3		0.25	
34.0		0.33	
32.8		0.33	
33.7		0.32	
34.1		0.25	
33.4		0.23	
35.0		0.23	

Figure 3-10: Liquid limit tills supported by sand ratio

Geophysical Response

Geophysical logging, in particular the gamma ray log, effectively supports the use of the liquid limit parameter for till correlation. Although geophysical logging has excellent potential for differentiating subsurface units, it is not used in the Quaternary field. Success to date has been made with other logs, particularly the spontaneous potential and single point resistance logs by Christiansen's work with the Saskatchewan Research Council.

The natural gamma log is used to distinguish between sand and clay material. In general, the log pattern swings to the left for granular materials and to the right with increasing clay content. The natural gamma log is very accurate in determining contacts between units and whether or not those contacts are sharp or gradational. Dyck (1971) states "Properly used borehole logs provide the best geophysical technique to detect in-situ small differences in physical properties".

Figure 3-11 illustrates an application of Dyck's statement to a till as recorded by a natural gamma log run by Alberta Environment. The figure is a longitudinal section through a buried valley south of Indus. Note the extremely consistent log response pattern across the three test holes

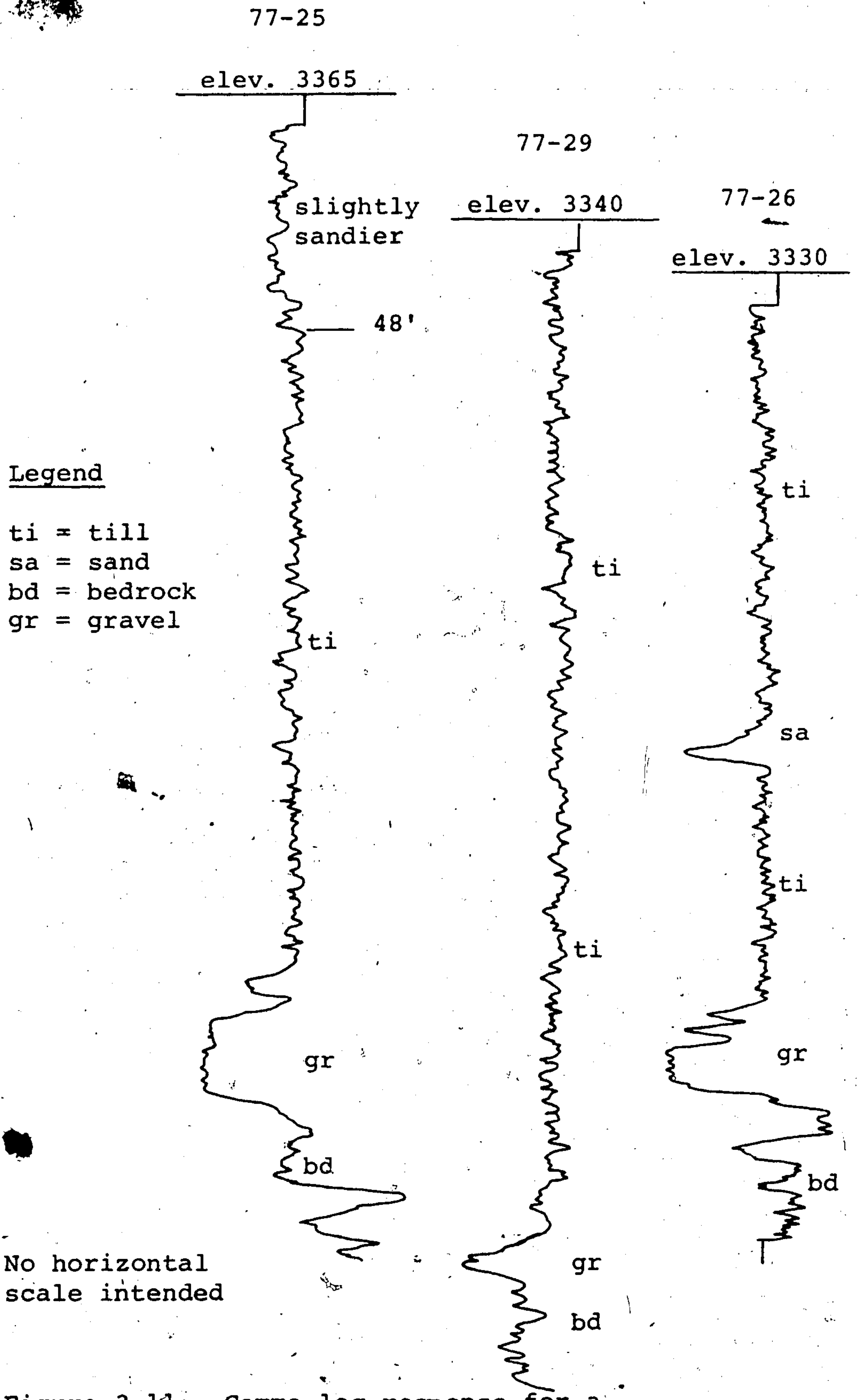


Figure 3-11: Gamma log response for a consistent till unit

with the exception of a sand lens at 77-26. The stratigraphic profile, from top to bottom, is till, gravel, and bedrock.

Examination of the till units in the stratigraphic profiles of Test Holes 77-25, 77-29 and 77-26 shows a very consistent till as reflected by the liquid limit parameter. In Test Hole 77-25, the unit is slightly sandier in the upper 48 feet. This is represented by a slight swing to the left on the gamma log and by liquid limits in the high twenty range. For the remainder of the test hole, as well as 77-29 and 77-26, the consistent natural gamma response is reflected in the consistent liquid limit response. The liquid limit data can be summarized as follows to illustrate the above point:

77-25	N*= 25	LL*= 35.3 ± 1.7
77-29	N = 40	LL = 35.1 ± 2.0
77-26	N = 28	LL = 35.4 ± 1.0.

The natural gamma log also distinguishes between two tills within the multiple till section illustrated in Test Hole 77-22. The gamma log in Figure 3-12 reflects a till (28.1 on basis of liquid limit) overlying gravel, then capped by a thick glaciolacustrine sequence, the basal unit

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* where N = number of samples analyzed
LL = liquid limit mean and standard deviation

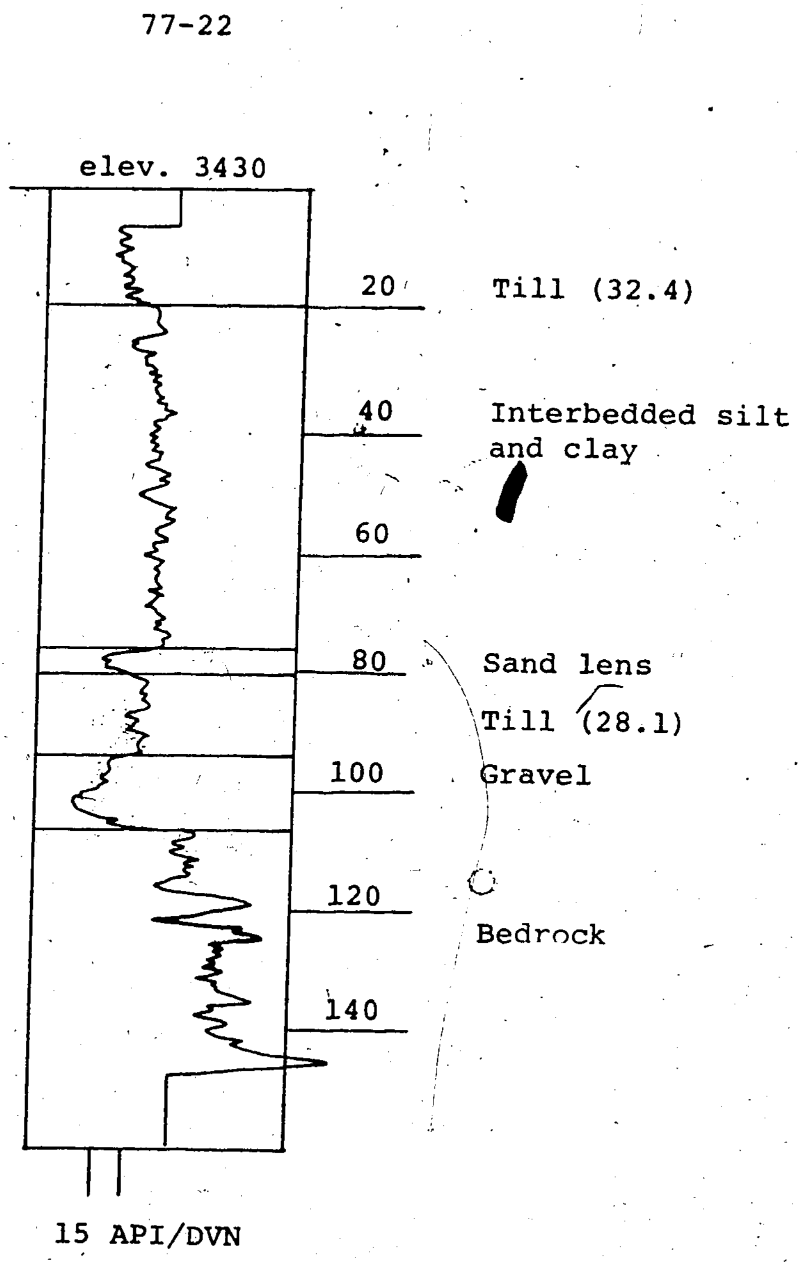


Figure 3-12: Gamma log versus Liquid Limit Tills

of which is a sand. This glaciolacustrine sequence is then overlain by a slightly sandier till (32.4 on basis of liquid limit).

Fabric Analysis

Glendinning (1973) in his study on surface tills in Calgary south of the Bow River concluded that three till fabrics could be identified - a westerly source near the Foothills, a mixed west and northerly source through Calgary and in particular, Cairn Hill, and an easterly source for the prairie east of Calgary. Although this study does not extend very far to the west, it is interesting to note that the change in till fabric for the central and eastern part of his study is substantiated by liquid limit defined tills. On Cairn Hill, the following test holes and liquid limit data serve to illustrate the point:

74-69	N*= 2	LL = 27.0 ± 1.6
74-61	N = 2	LL = 27.5 ± 1.1
74-45	N = 3	LL = 26.2 ± 0.8
74-46	N = 2	LL = 27.7 ± 0.6

Southeast of Calgary, where an easterly source direction is indicated, surface tills yield the following information:

77-25	N = 25	LL = 35.3 ± 1.7
76-37	N = 21	LL = 35.1 ± 2.1
76-81	N = 28	LL = 33.8 ± 2.4
77-26	N = 28	LL = 35.4 ± 1.0

where N = number of samples analyzed

LL = liquid limit mean and standard deviation

Interpretation Techniques Using the Liquid Limit Parameter

A number of significant phenomena were revealed during the course of data analysis. These are:

(1) use of natural moisture content to show influence of inclusions as well as map lithology;

(2) weathering or slope wash influence on liquid limits;

(3) influence of sand or clay inclusions on liquid limits;

(4) gradational contacts;

(5) thrusting.

Moisture Content

It was pointed out in Chapter 1 that others have successfully used natural moisture content to define contacts between till sheets (Misiaszek, 1960; Peck and Reed, 1960; and Milligan, 1976). However, that conclusion was not substantiated in this study. It is thought that a shorter sampling interval of perhaps 1 or 2 feet might help to delineate changes in till units much better than the five foot interval employed in this study. It is also possible that borehole geophysics could be used to map moisture content. Recent work by the United States Geological Survey using a percent moisture calibrated neutron log appears to have some potential as a till differentiation and correlation technique.

A point of interest arising from the use of natural moisture content is its ability to distinguish different lithologic units within a given test hole. As so often is the case, there is only a fine distinction between a till and a non-laminated glaciolacustrine deposit with ice-rafted pebbles. This set of conditions is often met in the supraglacial free water environment where flow till is associated with glaciolacustrine deposition.

It appears that moisture content can readily be used to differentiate the two types of sediment. This phenomenon is illustrated in Table 3-1. When Test Hole 74-74 was drilled in the field, the entire sequence was initially interpreted as till. Closer examination of auger cuttings indicated interbeds of glaciolacustrine silty clay. In Table 3-1 note the high moisture content zones which reflect the clay-silt portion of interfingering till and lake sediments. These occur at depths of 5, 10, 15, 25, 30, 35, 65 and 95 feet where the moisture content exceeds 20 percent. The change in moisture content is supported by a change in sand ratio. The lower the sand ratio, the greater the influence of fine-grained material and hence the higher the moisture content. The moisture content and sand ratio serve to modify the unit to an

Table 3-1: Application of Moisture Content to Sediment Differentiation Within the Supraglacial Depositional Environment

Test Hole 74-74

Depth	Moisture Content	Sand Ratio
5	21.00	0.08*
10	21.16	0.02*
15	14.69	0.02*
20	18.33	0.13
25	22.77	0.04*
30	22.14	0.03*
35	18.99	0.07*
40	19.39	0.11
45	16.97	0.10
50	16.13	0.14
55	15.97	0.12
60	18.93	0.11
65	22.59	0.05*
70	19.00	0.16
75	18.95	-
80	16.87	0.24
85	16.50	0.22
90	16.03	0.19
95	20.30	0.07*
100	17.10	0.26
105	13.05	0.30

*interbeds of glaciolacustrine silty clay upper glaciolacustrine deposit with flow till interbeds and a lower till unit with minor glaciolacustrine inclusions.

The moisture content parameter also shows a remarkable ability to differentiate between sediment types as illustrated in Tables 3-2 and 3-3. In Table 3-2, the moisture content is able to distinguish between two glaciolacustrine facies, an upper silt and clay unit and a lower sand unit. Breaks in moisture content are also associated with the till and bedrock units. Table 3-3 illustrates a similar characteristic of moisture content, this time applied to alluvial, glaciolacustrine, till and bedrock units.

Weathering or Slope Wash Influence

Till at the surface weathers chemically through oxidation, hydration, leaching of carbonates, and by mechanical changes in particles and in till structure and in some downward movement of very fine materials (White, 1972). At the surface, these weathering horizons vary in thickness and degree of development among different tills. Willman et al (1966) in their study of weathering profiles of glacial tills in Illinois, considered the mineral composition of buried weathering profiles and the changes effected by weathering in the pebble, sand, silt and clay fractions. In the in-situ profiles, vertical grain size variation results from solution of carbonates, clay eluviation and illuviation, disaggregation

Table 3-2: Application of Moisture Content to Lithologic Determination

Test Hole 74-68

Depth (ft.)	Lithology	Moisture Content %
5	lacustrine silt and clay	19.03
10	lacustrine silt and clay	15.70
15	lacustrine silt and clay	17.41
20	lacustrine silt and clay	13.36
25	lacustrine silt and clay	17.84
30	lacustrine silt and clay	14.55
35	lacustrine silt and clay	15.26
40	lacustrine silt and clay	15.84
45	lacustrine sand	22.42
50	lacustrine sand	24.89
55	lacustrine sand	23.65
60	lacustrine sand	23.59
65	lacustrine sand	25.57
70	lacustrine sand	25.81
75	lacustrine sand	25.61
80	lacustrine sand	25.88
85	lacustrine sand	26.20
90	lacustrine sand	26.51
95	lacustrine sand	26.50
100	lacustrine sand	26.11
105	till	18.07
110	bedrock	10.21

Table 3-3: Application of Moisture Content to Lithologic Determination

Test Hole 74-65

Depth (ft.)	Lithology	Moisture Content %
5	alluvial	4.73
10	alluvial	5.63
15	glaciolacustrine	23.86
20	glaciolacustrine	27.85
25	glaciolacustrine	28.45
30	glaciolacustrine	35.41
35	glaciolacustrine	23.19
40	glaciolacustrine	26.19
45	till	13.13
50	till	11.39
55	till	10.81
60	till	18.48
65	till	15.25
70	till	16.76
75	till	15.23
80	till	12.62
85	till	12.73
90	bedrock	10.67

and decomposition of silicate minerals. On the basis of weathering characteristics, the authors were able to define eight profile zones before encountering unaltered till. It was found that the percentage loss of silicate minerals from the pebble and sand fractions was quite small upward, and that decomposition of silicate minerals occurred primarily at the top of the profile. In addition, the clay minerals displayed a gradational upward sequence of alterations from the unaltered till, characterized by a progressive increase in expandable clay minerals, and in the uppermost part of the profiles, heterogeneous swelling clays. The implication here is the change in sand-silt-clay ratios as a result of mechanical and chemical breakdown of till. Differences in liquid limits between weathered and unweathered tills are shown by Smith (1968) in his study of surficial materials in McHenry County, Illinois (Table 3-4).

From Table 3-4, it is apparent that the liquid limit reflects the increase in clay content as a result of the weathering process.

Within the Calgary area, the upper five or ten feet of a given till unit has a higher liquid limit than the remainder of the unit.

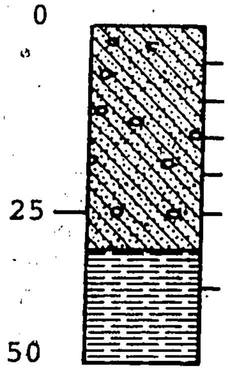
Examples of the change in liquid limit is illustrated by Tables 3-5 and 3-6. Table 3-5 indicates a liquid limit of 36.2 for the upper five foot sample which changes significantly at the 10 foot depth. Analysis of the sand-

Table 3-4: Changes in Liquid Limits for Weathered and Unweathered Till (After Smith, 1968)

Till	Weathered	Unweathered	Gravel	Sand	Silt	Clay	Moisture Content	Liquid Limit
Winnebago		x	4	42	45	13	9	17
Winnebago	x		3	39	32	26	15	27
Marengo		x	6	33	47	18	12	21
Marengo	x		3	26	40	33	15	36
Gilberts		x	12	32	56	12	10	18
Gilberts	x		3	36	38	26	29	34
West Chicago		x	16	53	41	6	12	17
West Chicago	x		10	50	41	16	17	28

Table 3-5: Weathering Influence on Liquid Limit, East Slope of Nose Hill Upland

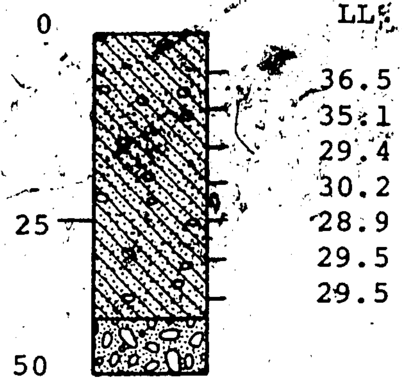
74-19



LL	$\frac{S}{M+C}$	MC
36.2	0.15	16.3
29.2	0.35	12.3
27.9	0.48	9.7
28.3	0.31	12.2
37.4	0.08	13.6
27.3	0.08	7.1

Table 3-6: Weathering, Slope Wash or Slumping and its Effect on the Liquid Limit

74-34



ratio indicates a "fining upwards" in the profile coupled with a higher moisture content associated with the increase in "fines" content.

The second example in Table 3-6 shows an upper ten feet with liquid limits in the mid thirty range overlying fairly consistent limit values with depth. The sequence is not comparible with surrounding test holes in the area. Its occurrence is interpreted as a weathering, slump or flow-till type of phenomenon.

As a consequence of the examples cited, caution has been used in distinguishing a thin upper unit as a distinct "liquid limit" defined till.

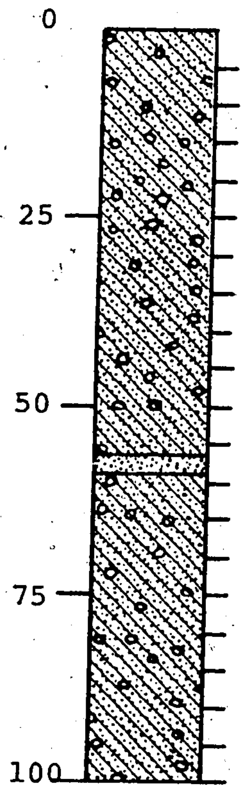
Influence of Inclusion

During selection of till samples for determination of the liquid limit parameter by the falling cone method, care was taken to avoid taking obvious inclusions of sand, clay or nearly disintegrated bedrock fragments, since they could be expected to locally influence the liquid limit value. The same influence can be seen on a larger scale, as illustrated in Tables 3-7 and 3-8.

Table 3-7 is a partial stratigraphic profile from Test Hole 76-81. Note the sand layer at 56 - 59 feet. The liquid limit values for this till average 33.4 percent which includes the influence of the sand layer. The zone from 30 to 70 feet appears to be influenced by "dilution" of the higher limit

Table 3-7: Influence of Sand Inclusions on the Liquid Limit

76-81

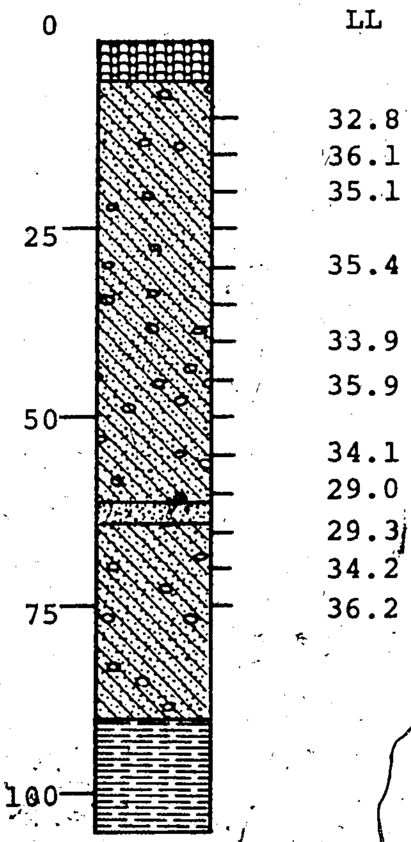


LL

36.0
33.2
36.6
35.6
36.4
32.1
28.6
27.3
32.4
31.5
32.3
29.5
27.5
32.5
36.4
33.9
30.9
33.9
36.3
32.3

Table 3-8: Modifying Influence of Sand Layers on the Liquid Limit of Till

76-110



values seen above and below this zone. Similarly, in Table 3-8, a sand layer occurs at 61 - 64 feet with limits being affected immediately above and below the sand inclusion.

Although there are no pertinent examples, it appears reasonable to assume that a clay layer would have the reverse effect to that of a sand layer, namely to increase the liquid limit in the area of discontinuity.

Gradational Contacts

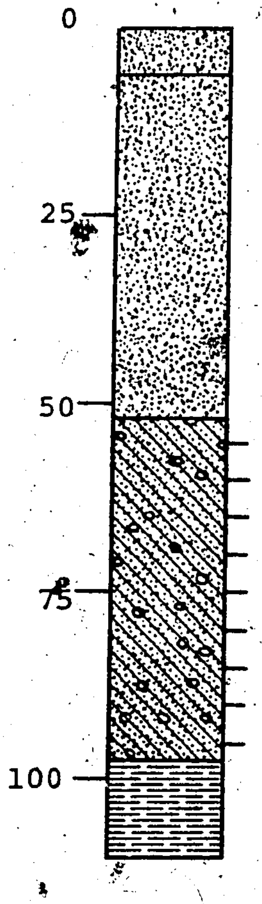
In addition to the influence imposed on the limits by sand or clay inclusions, a similar phenomenon can be observed at the contact between units. Five examples serve to illustrate the effect of till/till contacts, till/sand and gravel contacts, till/bedrock contacts and till/glaciolacustrine contacts.

Table 3.9 illustrates how liquid limits are affected at till/till contacts. Analyses of all test data has not disclosed a 28.6 till overlying a 32.5 till, but rather the reverse. It is inferred that the basal portion of the upper till shows reworking of the lower till during glacial erosion resulting in an anomalous condition at the contact.

Table 3-10 illustrates the influence on liquid limits at a till/sand and gravel contact. Note that the till is characterized by a consistent limit average of 27.4 percent. The underlying sand and gravel, likewise, has enough fine material to yield a liquid limit average of 25.0. An obvious

Table 3-9: Variation in Liquid Limit Values Across Till/Till Contacts

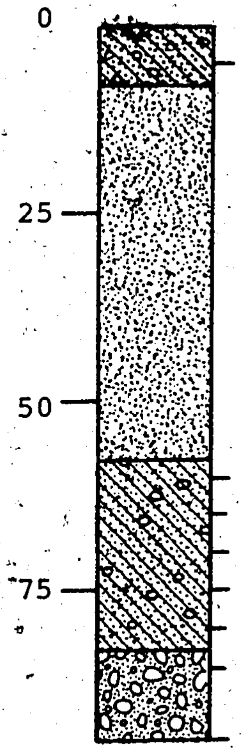
76-79



LL		
28.2		
28.8	Upper Till	28.6
32.7		
32.2		
35.3		
34.5		
32.6	Lower Till	35.1
36.1		
37.1		

Table 3-10: Liquid Limits at Till/ Sand and Gravel Contacts

74-78



LL	$\frac{S}{M+C}$
31.3	0.01
32.8	0.04
25.8	0.67
27.4	0.28
28.3	0.20
25.9	0.30
29.8	0.32
25.8	
24.2	0.52

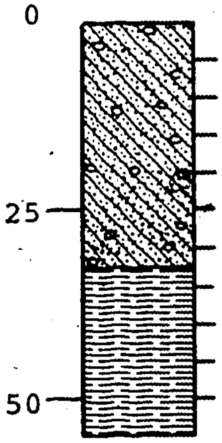
question is whether or not the sand and gravel has locally been responsible for a total modification in the liquid limits of the till. This particular test hole occupies an upland position. It is therefore feasible that local incorporation of the underlying preglacial gravel has generated a unique liquid limit till.

Table 3-11 illustrates the gradational contact at the till/bedrock interface as reflected by liquid limit values. This characteristic is observed to oocur quite frequently and has led to the coining of a new term - bedrock till. This term is defined as a till whose stone content is made up almost exclusively of bedrock fragments of in-situ origin. For all intensive purposes, it is a reworked bedrock unit more than a true till. The liquid limit data in Table 3-11 shows the influence of the bedrock and then becomes gradational into the true liquid limit value of the till. The sand ratio in this table also reflects the interbedded nature of the Paskapoo bedrock. Depth 25 to 35 feet is a sand(stone) and 40 - 50 feet a shale or clay(stone).

Table 3-12, which also examines a till/bedrock contact is very similar to Table 3-10 which shows till/sand and gravel. There is a fairly sharp contact between the 31.4 till and the 37.0 till. However, notice that the till very loosely resembles the limit character of the underlying bedrock. Is it a true till or bedrock till? Analysis of the stone content suggests it is a true till.

Table 3-11: Modification of Liquid Limit Values at Till/Bedrock Contacts

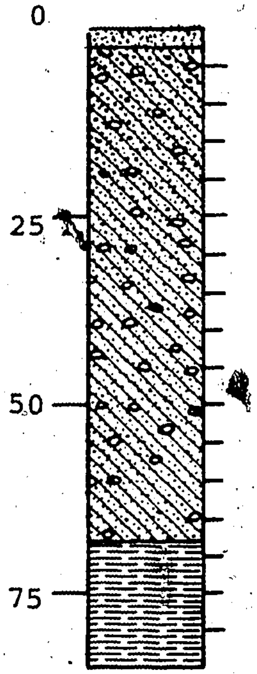
74-18



LL	$\frac{S}{M+C}$
25.4	0.27
26.7	0.21
27.7	0.23
29.7	
32.1	0.81
33.0	0.65
34.8	0.56
39.7	0.02
41.4	0.01
37.5	0.08

Table 3-12: Bedrock Influence at Till/Bedrock Contacts

74-44



LL
31.1
32.8
32.0
31.7
30.9
33.1
32.3
31.9
32.2
30.2
26.4
31.6
37.5
36.5
38.8
35.2

Table 3-13 illustrates a typical gradational contact at a till/glaciolacustrine interface. Sand layers within the glaciolacustrine unit have been reworked (21.7) and are transitional into more consistent liquid limits in the upper part of the till.

Lacustro-Till Environments

Because of the major problem associated with the liquid limits in a flow till/glaciolacustrine environment, it is worth looking at two additional illustrations. It was pointed out that where moisture content data is available, it will generally aid in identifying intercalations in the flow till environment. The two examples are from buried valleys, one the Calgary Valley, and the other the Elbow Valley, respectively.

Table 3-14 illustrates a rather erratic distribution of limit values. Most of the units are described as lacustro-till which can be defined as a clay with numerous ice-rafted pebbles or a till deposited in an aqueous environment and hence stratified or "banded". Because additional support data is absent, it is very difficult to interpret the limit data.

Figure 3-13 illustrates a similar case to the above. For interest, the stratigraphic field profile has been compared to the gamma ray log. The field log identifies a till from 57 - 67 feet. The gamma log suggests no till. This would imply that the field logged till is probably a glaciolacustrine unit with ice rafted pebbles. Only a single till is identified on the gamma log from 92 to 109 feet rather than 97 to

Table 3-13: Modification of Liquid Limit Values at Till/Glaciolacustrine Contacts

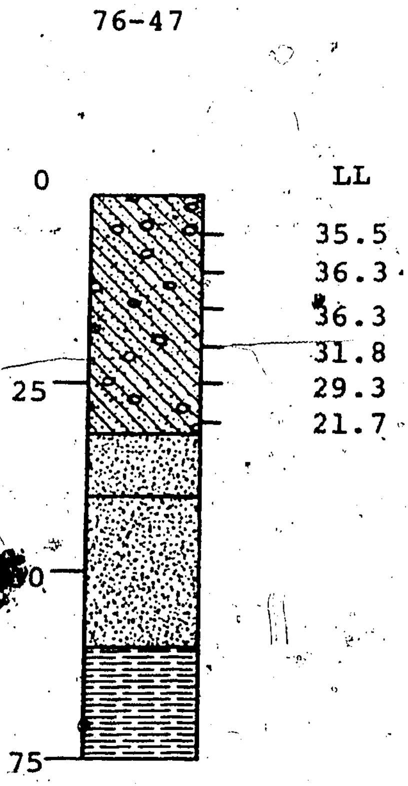
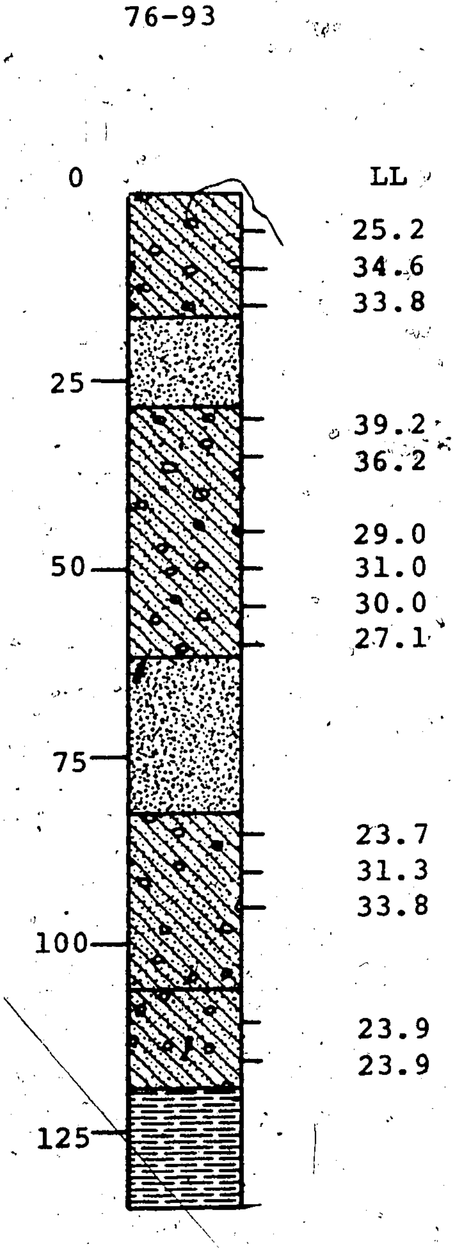


Table 3-14: Variation in Liquid Limit Values Within Lacustro-till Environments



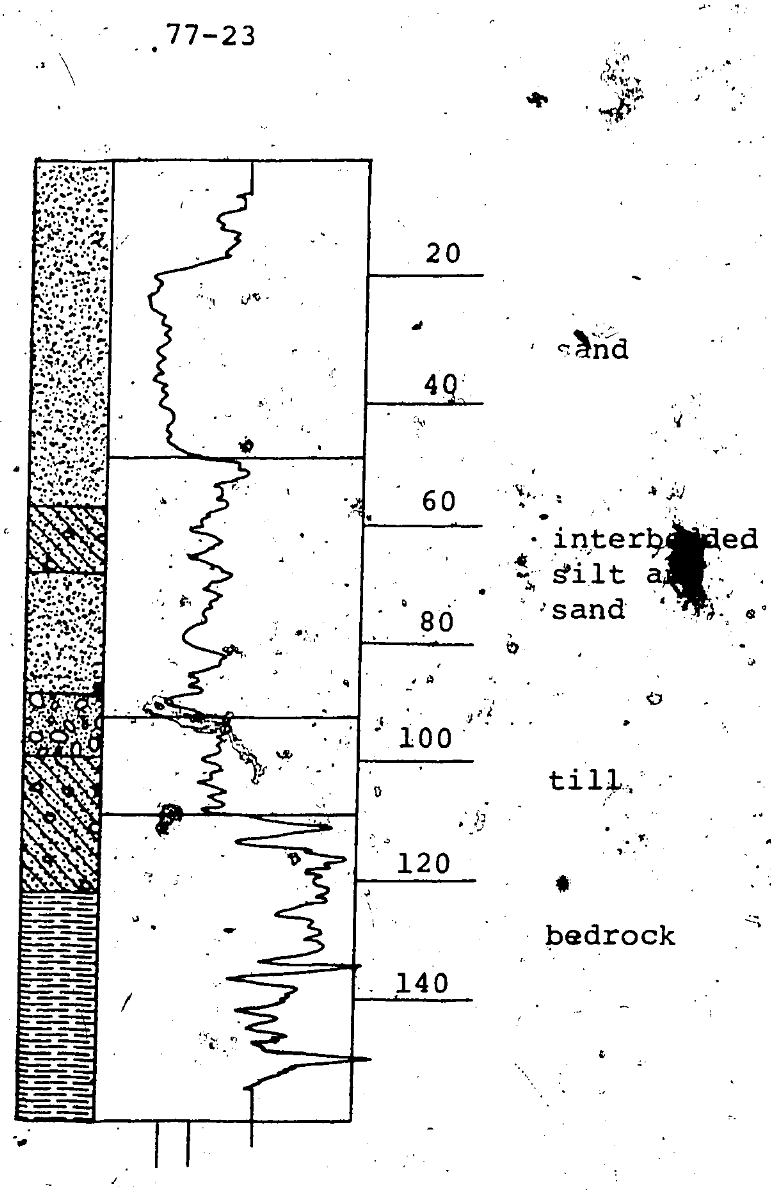


Figure 3-13: Problems associated with lacustro-till environments

120 feet. The gravel layer is not apparent on the gamma log. However, because the hole was mud rotary drilled, the gravel could be simply a well washed till sample. In addition to the interpretation problems associated with lacustro-till environments, the analysis of field and geophysical logs suggests Quaternary workers can readily create their own problems with interpreting glacial stratigraphy. This is a good example in borehole work where a multiple till is created to confuse the issue. It points to the urgent need, when working with borehole data, to supplement field data with some mechanical logs that can eliminate judgement decisions.

Till Differentiation and Correlation

In view of the potential sources of error in utilization of the liquid limit technique to define tills or till advances, it is surprising that it even works. However, no matter how remarkable the coincidence, the till units defined by liquid limits are supported by a wide range of other physical properties which have been addressed at the beginning of this chapter.

The basic approach to till differentiation and correlation was to place boundaries on the stratigraphic log profiles so as to minimize standard deviations. The boundaries were then carried laterally and adjustments made to effect a reasonable regional correlation.

The author would probably be remiss if he did not attempt to answer the question why the liquid limit technique works.

Glendinning (1973) mentioned in his thesis that clay mineralogy, as used by Tharin (1960), in his original work on the Calgary area, served as a potentially good correlation tool and that this aspect deserved further exploration. Contrary to this belief, it can be shown that clay minerals cannot uniquely define tills. It had been thought that the liquid limit values were a reflection of clay mineralogy. However, this does not appear to be the case. During the course of this project, the Alberta Research Council has undertaken the clay mineral determination of some 278 tills in the Calgary area. The clay mineral identification consisted of illite, montmorillonite, kaolinite and chlorite. Tharin (1960) had concluded that eastern tills had illite and montmorillonite in approximately equal amounts; while western tills had an illite cont[illegible] three times that of montmorillonite. It would therefore seem reasonable to expect that eastern and western tills could readily be distinguished by their clay mineralogy, in specific, the illite/(illite + montmorillonite) ratio defined by this author.

The analysis of those 278 clay samples calculated on the basis of the above-defined illite ratio yields an average value of 0.68 with a standard deviation of 0.09. It would appear very obvious that the till units as defined by the liquid limits are therefore not related to clay mineralogy.

In addition to the nature of the clay minerals, the author had tabulated four other parameters which controlled liquid limits for idealized clay systems. These were: clay content, nature of exchangeable cations, particle size and organic matter content. While some degree of uniformity does occur for artificial clay-quartz systems (Seed et al, 1964), the complexity of interrelated factors in real world situations is not readily understood.

Clay particle size has been shown to influence the liquid limit parameter. In general, the smaller the particle size the greater the surface area and hence the more moisture that can be adsorbed. It is highly unlikely that laboratory preparation of samples could produce a uniform particle size to account for the consistent liquid limits of the various tills. It appears intuitive that the glacial transport mechanism must be responsible for the production of the relatively minor variations in particle size in order to account for the similarity in liquid limit values.

The nature of exchangeable cations, likewise, has been a factor in effecting limit values. However, tills are generally considered as impermeable or semi-permeable materials. Except for fracture systems, movement of groundwater through tills can be expected to be very slow. Cation exchange capacity in the tills does not appear to have the same dominance that it does in the artifically prepared clay-quartz systems.

The organic matter content of tills is generally too insignificant to readily explain the difference in liquid limit values.

The liquid limit appears to be largely proportional to the clay mineral versus non-clay mineral percentage rather than the variation in the different proportions of individual clay minerals. This would tend to explain the distinct lack of variability observed in the clay mineral anslyses of the 278 till samples. Since the clay mineralogy is not the governing factor, it appears logical that the basic clay mineralogy, and hence liquid limit value, is controlled by the degree of incorporation or dilution of material being overriden and eroded by the glacier.

The interrelationship of mixed clay structures, and geologic history of till material in the real life soil system tends to yield a more simplistic liquid limit value than evaluation of each individual factor in an artificially prepared soil system.

It is the author's feeling that the answer to the riddle can be found in work by Szabo et at (1975) and Shilts (1971, 1973) in dispersion trains associated with glacier transport. Szabo et al (1975) studied the dispersion characteristics of mineralization from the Mt. Pleasant volcano vent. The following pertinent statements are taken from Szabo's work:

> "Whereas dispersion trains of Cu, Pb and Zn in the fine fraction of till can be traced for only 2 to 5 km from the mineralization source, they extend for more than 16 km in the coarse fraction of till".

> "The distributions of Cu, Pb and Zn in the fine fraction show little variation with depth in the till. In the coarse fraction, however, there is a clear difference in both the vertical distribution pattern and the absolute levels of Cu, Pb and Zn down-ice from Mt. Pleasant".

The implications of Szabo's work to use of the liquid limit parameter for differentiating till appears straight forward. To avoid anamolous situations in glacial transport, one should examine the fine fraction which is characterized by no variation in the vertical and little in the horizontal direction. This would tend to explain the rather consistent range of liquid limit values in the vertical profile of a given till.

Further to this, it is concluded that the uniqueness of the four defined liquid limit tills is due exclusively to the incorporation of previously deposited glacial drift or bedrock.

CHAPTER IV

STRATIGRAPHY - EVIDENCE AND DESCRIPTION

Bedrock Geology

The entire Calgary area is underlain by the Paskapoo Formation of Tertiary age. It is believed to have been deposited on a floodplain extending from the foothills eastward. Holes drilled for this study indicate that the Paskapoo Formation is composed of yellow, brown, blue and sometimes yellow and green claystones and shales. These various units of the Paskapoo Formation are of variable thickness and are presumed to be quite lenticular, as the units cannot readily be correlated in spite of the large number of "control" drill holes available. The sandstone and shale units vary from soft to hard and many outcrops, particularly along the flanks of bedrock highs show fracturing of the upper surfaces.

Lithologic units within the Paskapoo Formation vary from thinly bedded (3/4") to massive (15'). All beds are essentially flat lying. The Paskapoo is continental in origin and is characterized by considerable variation in grain size: sand content 3.7 - 58.4%, silt 29.9 - 77.5% and clay 11.7 - 57.2%. Information on the physical properties of bedrock units are tabulated on the various stratigraphic logs contained in the Appendix.

Numerous outcrops of bedrock exist within the study area and may be viewed along the Nose Creek and Beddington Creek meltwater channels in Twp. 25, Rge. 1, W5M; along the Bow River in Secs. 5 and 6, Twp. 25, Rge. 2, W5M; within the Elbow River Valley in N.E.-6-24-1-W5M, and along the Glenmore Reservoir; as well as on the crown and flanks of Nose and Cairn Hill Uplands.

Bedrock lithologies within the Calgary area vary from soft clastics and claystones to firm or hard fissured sandstones and shales. Most occurrences of bedrock, both in drill holes and outcrop sections, have an upper 3 - 6 foot weathered zone. Because of this weathered zone, problems can occur in defining the top of bedrock.

Numerous water well drill holes record up to 46 feet of brown to blue clay overlying firm bedrock and underlying thick gravels and sands. This material could be interpreted as a glaciolacustrine deposit or as soft bedrock. Its stratigraphic position between bedrock and overlying gravels suggests that this unit, where recorded, is soft bedrock.

This study also identifies another deposit referred to as a bedrock-till. A number of examples illustrated in Chapter III, clearly show a till-bedrock interface transition where the basal part of the till (based on liquid limits and lithology) reflects bedrock characteristics. The bedrock till is composed almost exclusively of reworked bedrock fragments in a fine matrix.

Saskatchewan Gravels and Sands

Stratigraphic Position

Saskatchewan gravels and sands is the name loosely applied to numerous, widely scattered deposits of gravel and sand found on the Canadian Prairies. This deposit is identified chiefly by its lack of stones from the Canadian Shield and its stratigraphic position, overlying bedrock below drift in buried valleys or on low ground. Although Stalker (1968) has determined a list of criteria for determining whether gravels are truely of preglacial origin, this study follows the generally applied looser definition of Saskatchewan gravels and sands.

The Saskatchewan gravels were first described by McConnell (1885). He interpreted this deposit to be Pliocene in age and derived, in part, from the Miocene beds in the Cypress Hills. The occurrence of this deposit was found to be more widespread than first believed and a subsequent paper by Dawson and McConnell (1895) suggested that the Saskatchewan Gravels were outwash deposits from an early Pleistocene Cordilleran glaciation which advanced to a point somewhere east of Calgary. Earlier work by Stalker, 1963, 1968, uses the original term [illegible] sense of meaning implied by McConnell in 1885. That is, the Saskatchewan gravels and sands refer solely to the last series of deposits laid down by preglacial rivers before Quaternary glaciation disrupted the regional drainage.

Distribution and Thickness

Saskatchewan gravels and sands are found capping the Nose Hill, Cairn Hill and Pine Ridge Uplands; in part along the flanks of these uplands and also in buried valleys. On the Nose Hill Upland, the thickness of gravels and sands exceeded 15 feet. Supplementary information obtained from water well drilling records, indicated a maximum thickness of 162 feet in the southwest corner of LSD 11, 32-25-2-W5M. Similarly on Cairn and Pine Ridge Uplands, the test drilling was unable to penetrate the gravel and sand section by more than 15 feet. A maximum thickness of 85 feet was established on Cairn Hill from a water well at N.W.-5-27-24-2-W5M. Within the modern-day Bow Valley, a maximum thickness of 25 feet of Saskatchewan gravels and sands was encountered in Test Hole 77-25. Examination of water well records yielded a total thickness of 62 feet of granular material at S.W.-13-14-25-3-W5M.

Lithologic Description

Table 4-1 contains pebble counts from three locations on

Table 4:1 Pebble Lithology of Saskatchewan Gravels and Sands

% Pebbles	74-29	74-53	74-76	74-45	74-61
Carbonate	46.0	62.7	67.7	63.3	49.8
Quartzite	28.1	28.0	19.3	19.3	22.8
Sandstone	18.8	7.1	8.1	14.7	26.1
Grit	6.3	1.8	1.9	[illegible]	Tr.
Chert	Tr		1.2	Tr	Tr
Other		Tr	Tr	[illegible]	Tr

Nose Hill (Test Holes 74-29, 74-53 and 74-76) and two locations on Cairn Hill (Test Holes 74-45 and 74-61). These pebble counts yield a "carbonate-quartzite-minor sandstone" lithologic assemblage for Saskatchewan gravel and sand deposits. The gravels are fairly sandy with little to moderate amounts of clay binder, and relatively high calcium carbonate contents between 20.9 and 38.0 percent. The deposits are described in water well boreholes as gravel, sand and gravel or gravel and boulders. Water well drill records also indicate cementation as a characteristic of these deposits on upland areas as well as in buried valleys.

A number of liquid limit tests on the fine matrix component of the sands and gravels gave a range of 18.7 to 28.9 with an average value of 24.8.

Pleistocene Lithostratigraphy

Introduction

This section establishes the Pleistocene subsurface stratigraphy, by citing the evidence, characteristics and areal extent, where feasible, for all deposits associated with each glacial event. The stratigraphic relationships for each unit are illustrated by cross-sections whose locations are indexed in Figures 1-3 to 1-6.

To avoid any age connotations or correlations with units previously named (Tharin, 1960; Morgan, 1966; Stalker, 1960, 1963, 1973), the author has established a new set of informal names, together with subsurface reference sections.

First Glacial Event

Glenbow Till

Stratigraphic Position

The first glacial sediments within the study area are assumed to have been deposited by Cordilleran ice. A single occurrence of Glenbow till is believed to exist within the old Bow River Valley south of Cochrane. The type reference section is Test Hole 78-8 which contains a multiple till section. Evidence for this thin till is provided by stratigraphic position, sand fraction lithology and

Atterberg Limits. The base of the unit was not encountered, however, it is overlain by a glaciolacustrine unit. The reader is referred to the stratigraphic profile of Test Hole 78-9 in the Appendix.

Although the till encountered in this test hole is only 3+ feet thick, it does appear to have a number of distinguishing characteristics. Because the complete unit was not penetrated, more than one origin may exist for this deposit. It is either till or dirty gravel.

Liquid Limit

A single liquid limit value of 18.3 percent was determined for the Indus till. The value is characteristic of a sandy till with little or no fines and appears to be typical of a western till based on the following deduction.

The author recently had the opportunity to be involved with an extensive test hole and test pit program for the upgrading of the Smith-Dorrien Road in Kananaskis Country. Till at this site is unequivocally of Cordilleran origin. Analysis of some 60 samples of till gave a liquid limit range varying from indeterminate to an average of 17.5 percent. The low liquid limit value, the stoney nature of the till, and its lithologic composition lend some credence to its western origin.

Lithologic Description

The Glenbow till is grey in color, quite stoney and contains an abundance of carbonate pebbles. Shield-type lithologies were not present in any size fraction of this till. The sand/silt-clay ratio of 0.06 indicates a very silty till composed predominantly of rock flour. The sand ratio has a significant contrast to other tills of eastern origin. A single determination for calcium carbonate equivalent yielded a value of 56.0 percent - the highest value of any till samples within the study area.

Glenbow Silt and Clay

Stratigraphic Position

The name Glenbow silt and clay is used for glaciolacustrine sediments which underlie the oldest eastern till in the study area at Test Hole 78-9. The deposit can be traced from the Bow River, near Cochrane, to an isolated area south of Shepard but north of the river. Stratigraphic relationships for these two areas are illustrated in Figures 4-1 and 4.2 In this area, the lacustrine deposit overlies sandy gravel of assumed Saskatchewan gravel and sand origin. South of Shepard, the lake deposit rests directly on bedrock.

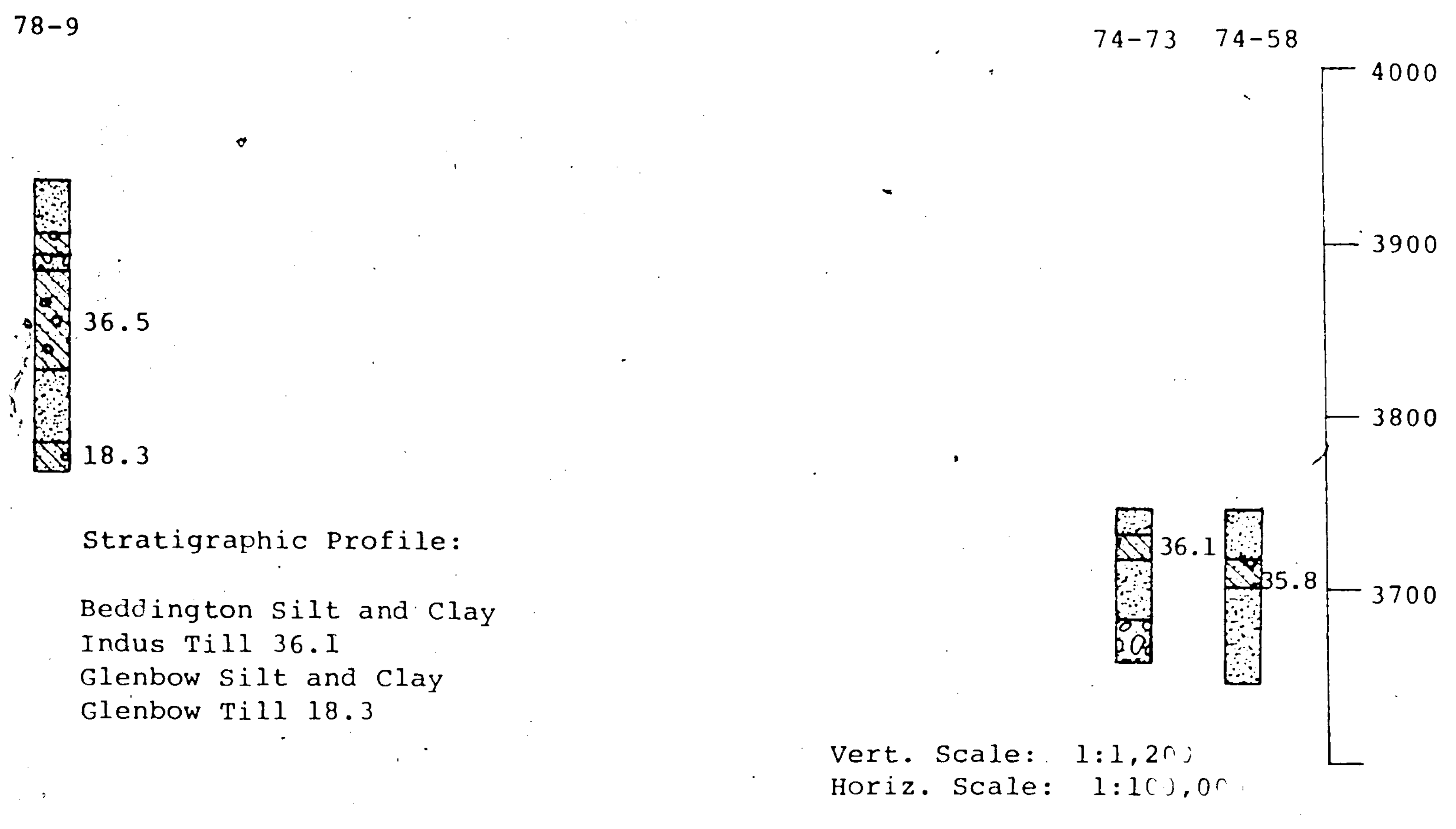


Figure 4-1

Cross-section Bow Valley

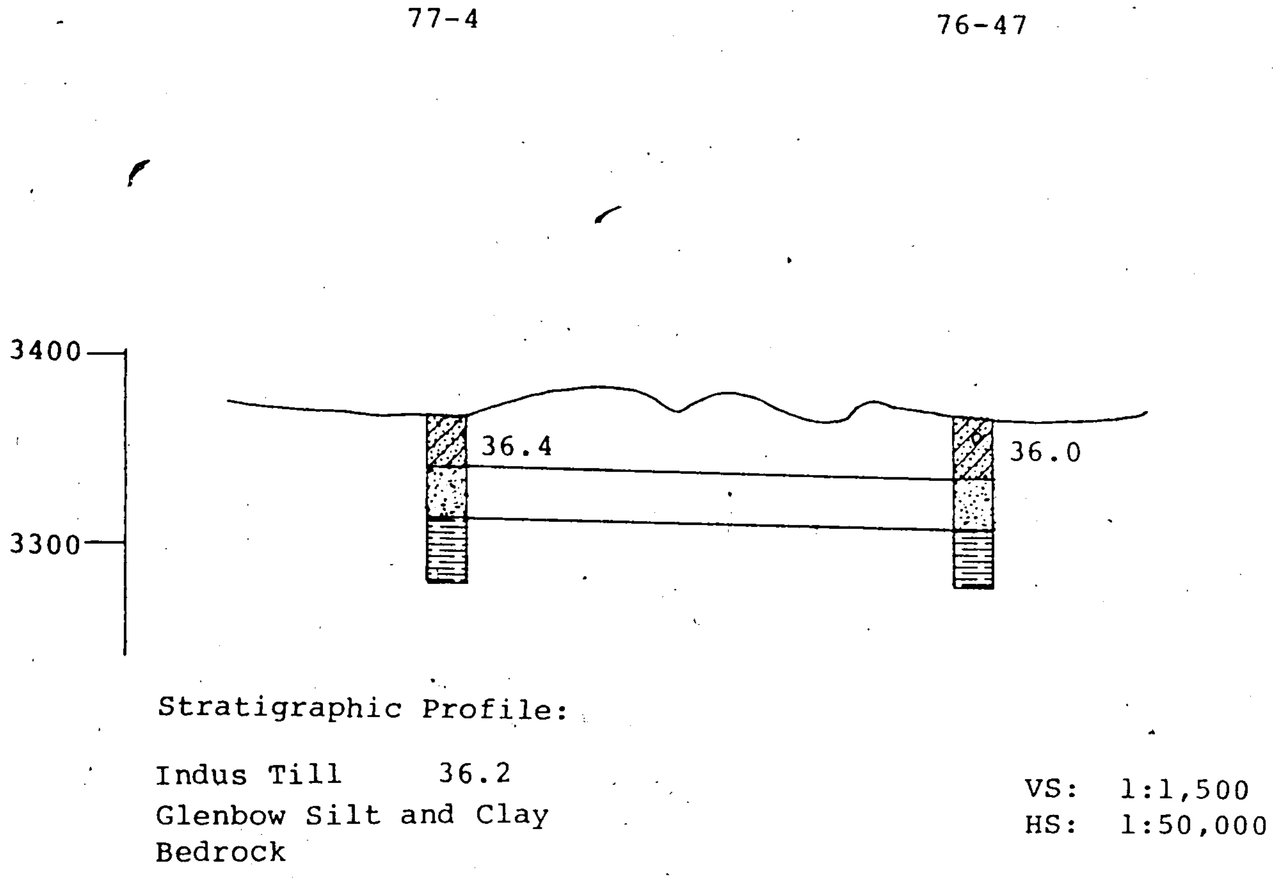


Figure 4-2

Cross-Section Lower Bow Valley

Distribution, Thickness and Physical Attributes

The Glenbow silt and clay unit varies in thickness from 25 to 55 feet and is confined to buried valley(s) associated with the old Calgary Valley system.

The sediments invariably indicate a "fining-upward" sequence with silts and sands at the base grading upward into varved or banded silts and clays. An examination of the stratigraphic profile for Test Hole 74-73 gives a clear indication for the fining-upward or transgressive sequence. It should be noted that the liquid limit and moisture content increase upward in the profile, while the sand ratio decreases.

Second Glacial Event

The Second Glacial Event is the most widespread event delineated within the study area and is clearly of eastern origin.. The glacial deposits associated with this event are the Indus till, Indus silt and clay, and Indus gravels.

Indus Till

Stratigraphic Position, Distribution and Thickness

The name Indus till is proposed for a fairly homogeneous, thick, till which occurs as a valley fill deposit south of Indus. The type reference section is represented by Test Hole 77-26. Stratigraphic evidence for this event is provided by stratigraphic relationships, liquid limit, percent igneous-metamorphic fragments, texture, geomorphology and ice direction.

The Indus till has a variety of stratigraphic relationships. The most common position is overlying bedrock or sand and gravel. However, locally, the till rests on glaciolacustrine sediments. The Indus till is found distributed in old buried valleys, in lowland plain areas and on bedrock controlled uplands and upland flanks.

On the Nose Hill Upland, the till overlies Saskatchewan gravel and sand (Test Holes 78-3 and 74-33) and, to a minor extent, bedrock (Test Hole 78-7). The till attains a maximum thickness of 62 feet in Test Hole 74-77. Where it occurs on uplands, the Indus till is a surface till characterized by a hummocky morphology. Along the eastern and southern flanks of the Nose Hill Upland, the till is overlain by a veneer of younger till or glaciolacustrine sediment. Stratigraphic relationships are illustrated in cross-section

Figure 4-3. To the east of the Nose Hill Upland in the vicinity of Beddington and Nose Creeks, the Indus till has been removed by erosion.

On the Cairn Hill Upland, Indus till is absent except for local remnants preserved along the southeast flank of the upland in Test Holes 74-40 and 74-44. In both cases, Indus till overlies bedrock and is overlain by younger till.

In the area of the Bow Valley, within both the Calgary and Dalemead topographic sheets, the Indus till occurs as valley fill overlying either bedrock or gravels. Within the Calgary sheet, Indus till overlies Glenbow silt and clay in Test Holes 78-9, 74-73 and 74-58, and is overlain by Indus silt and clay. The reader is referred to stratigraphic profile 78-9 in the Appendix.

In the Glenbow Lake area just south of the Bow River the Indus till overlies bedrock and is overlain by hummocky Glenbow silt and clay. The stratigraphic relationships are illustrated in Figure 4-4.

Although surficial materials have been extensively reworked in the City of Calgary proper, some stratigraphic information is available from the "Inventory of Environmental Geology of Calgary, Alberta". Cross-section Figure 4-5 shows

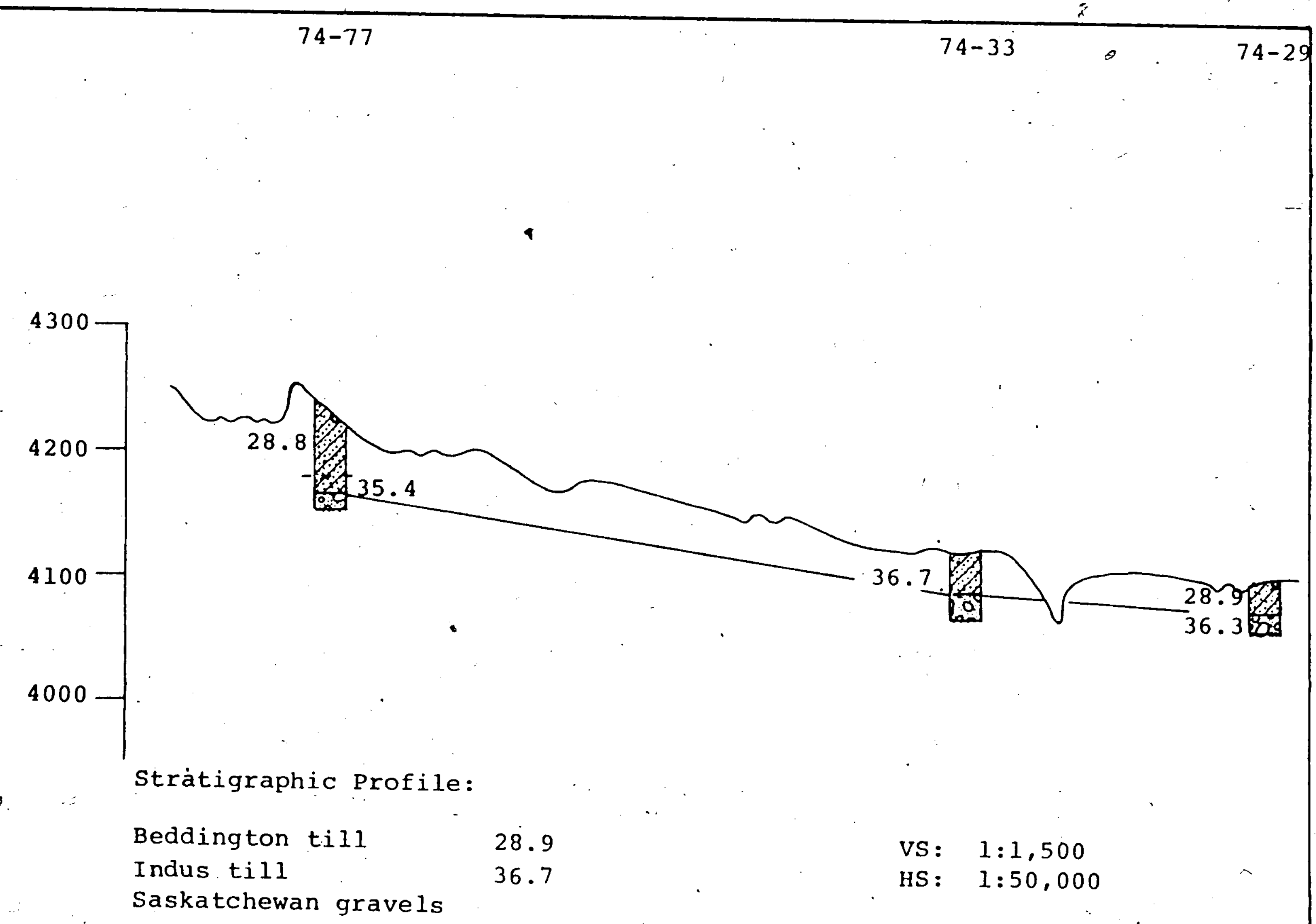


Figure 4-3

Cross-Section Nose Hill Upland

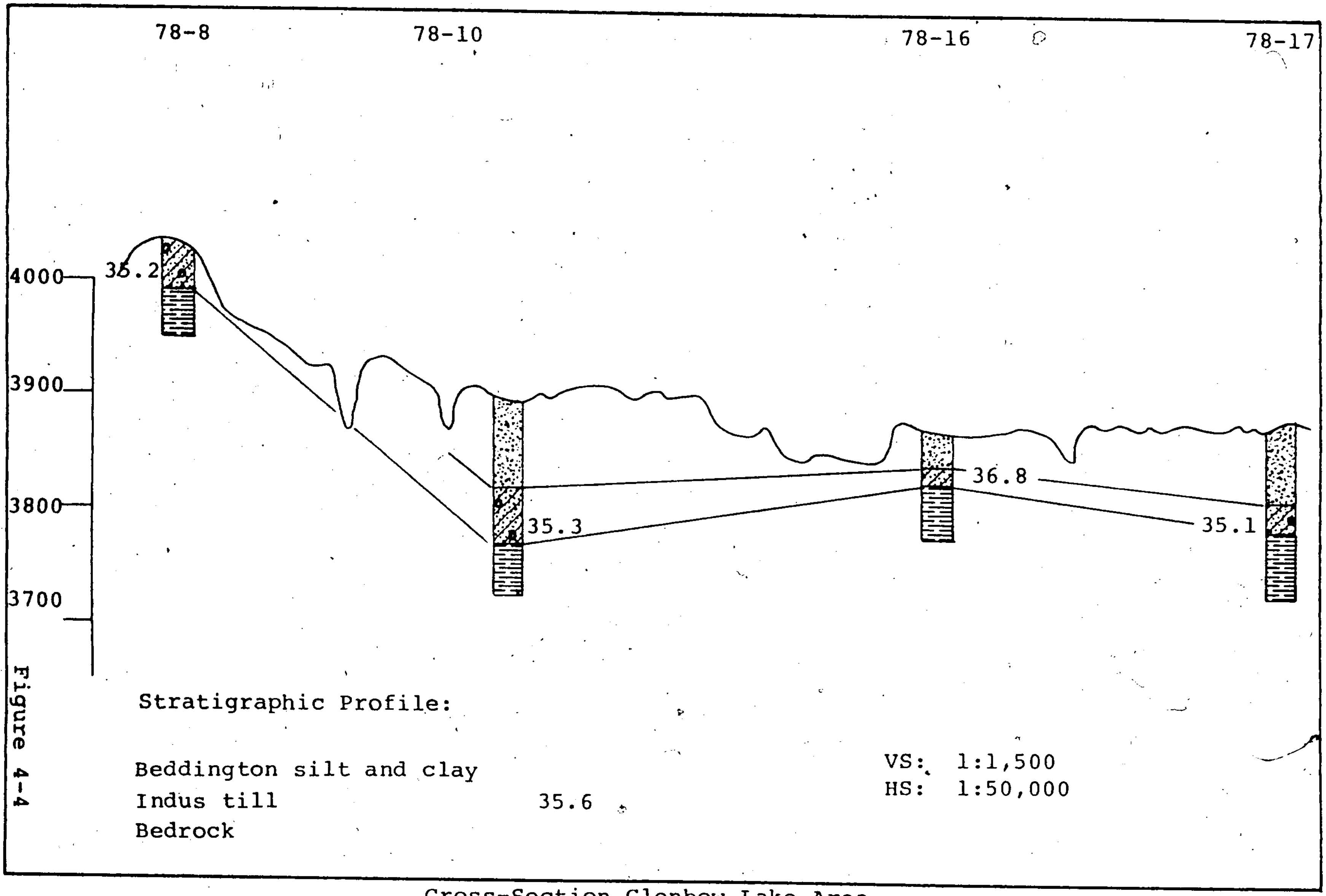


Figure 4-4

Cross-Section Glenbow Lake Area

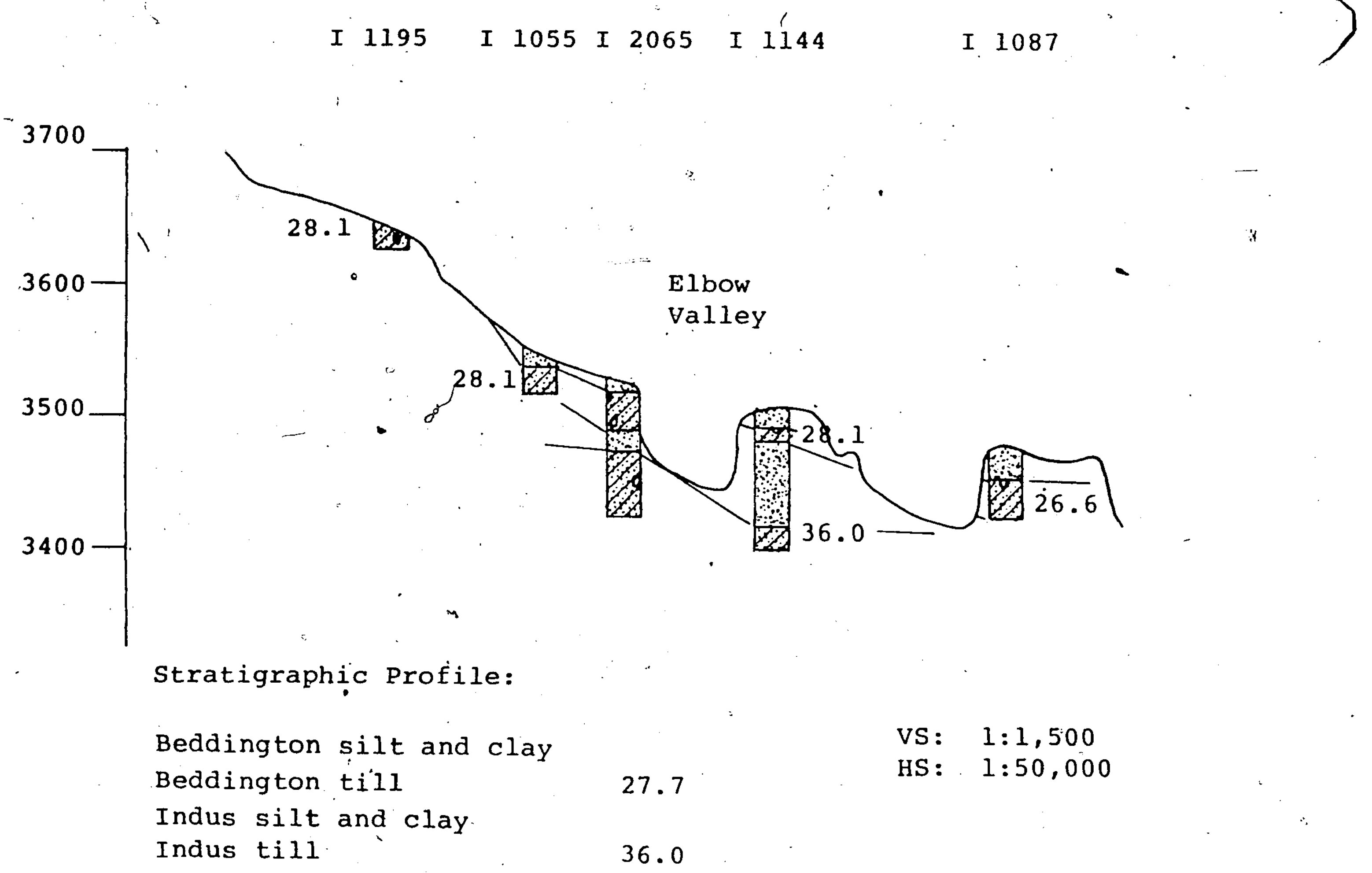


Figure 4-5

Cross-Section Elbow Valley - Downtown

Indus till as a valley fill within the Elbow River Valley. The base of the till was not encountered, but the unit is overlain by glaciolacustrine sediments.

To the east of Calgary, on the Dalroy sheet), the Indus till is either the surface till or it is covered by a discontinuous veneer of younger till. The contact for this younger till and the Indus till trends north-northeast along Chestermere Lake (Figure 1-2). The elevation of this morainal contact varies from 3250 in the north to 3375 in the southern part of the Dalroy sheet. This contract can be traced further south on the Dalemead sheet up to the Bow River. Stratigraphic relationships for the Indus and younger till are indicated in Figure 4-6. Air photographs of the western part of the Dalroy sheet indicate numerous recessional moraines. The ground moraine of this area is locally covered by outwash veneers and lacustrine sediments.

To the southeast part of Calgary on the Dalemead sheet, the Indus till overlies sands and gravels (Test Holes 77-25, 77-26 and 77-29) or Glenbow silt and clay (Test Holes 77-4 and 76-47), or bedrock (Test Holes 76-84, 76-37 and 76-110).

In most cases, the Indus till is at the surface, although it is veneered locally by lacustrine and outwash silts and sands. In the southeast corner of the Dalemead

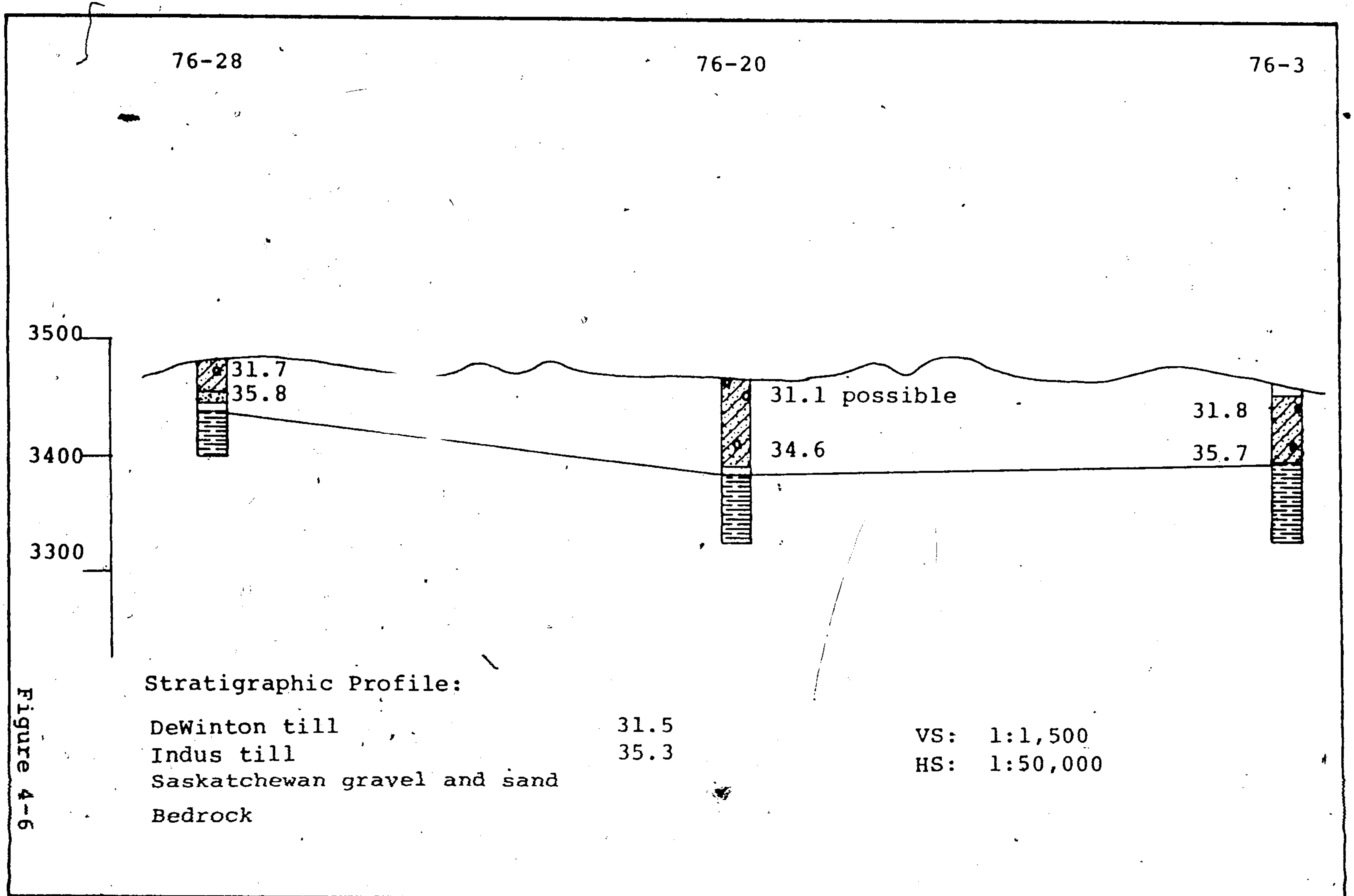


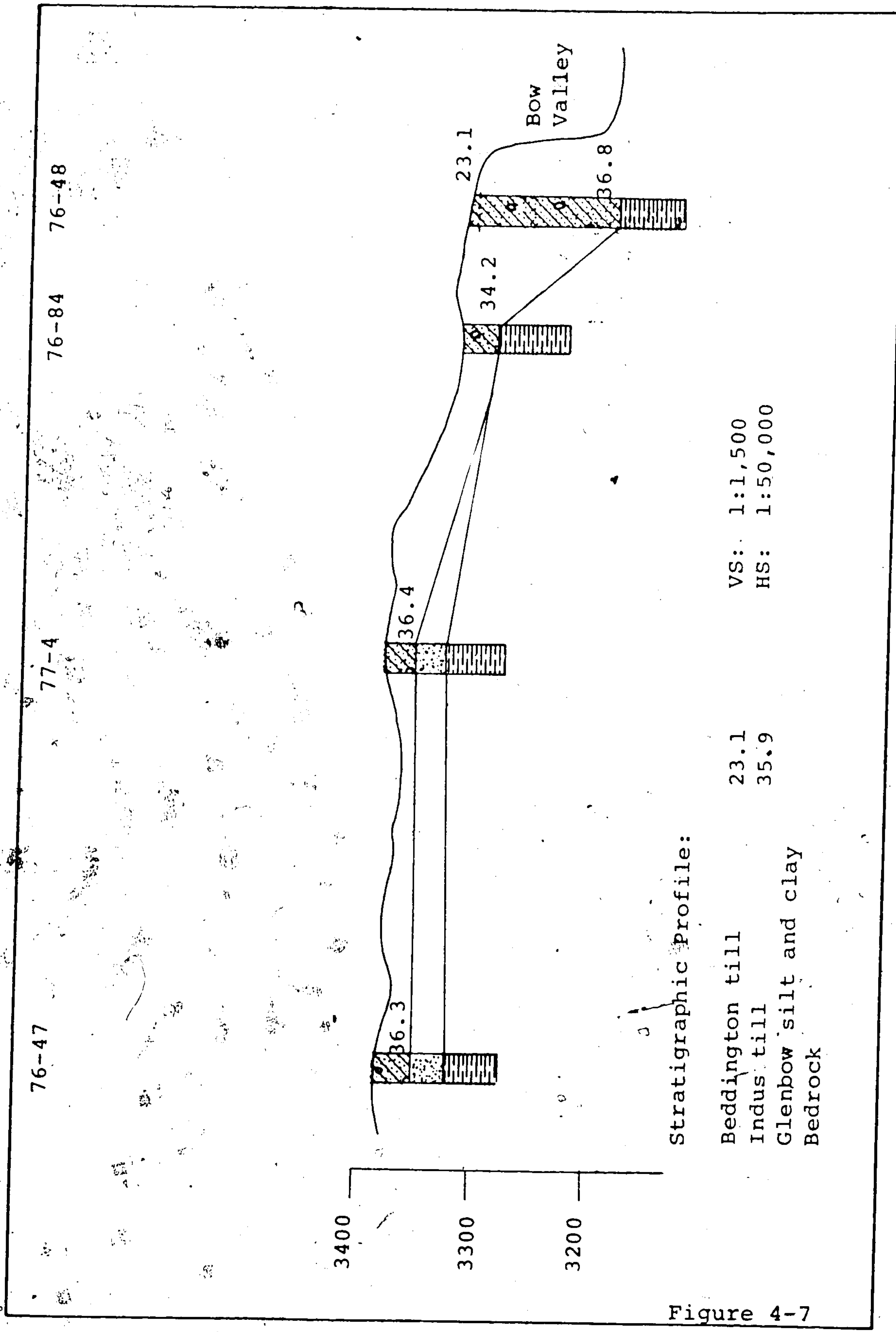
Figure 4-6

Cross-Section Calgary East

sheet, the Indus till occurs as a thick valley fill reaching a maximum thickness of 207 feet at Test Hole 77-29. South of the Bow River, Indus till is absent as the surface rises. Stratigraphic relationships are shown in Figures 4-7 and 4-8.

Indus till is also found along the upper walls of the Highwood River Valley in Test Holes 76-109 and 76-87. A complete stratigraphic section was not penetrated in these test holes. However, it is assumed that a western till (perhaps Glenbow till) underlies this till at depths below river level. While no distinct break in till is observed at 76-109, 8 feet of sand and silt separates two tills in 76-87. Stratigraphic relationships are illustrated in Figure 4-9.

Southwest of Calgary, on the Priddis Sheet, Indus till is confined to the Pine Ridge Upland or its flanks. On the top of the upland, the till occurs as a surface till overlying bedrock. Along the upland flanks, Indus till overlies either sand and gravel (Test Hole 76-107) or bedrock (Test Holes 76-104 and 76-98). In Test Hole 76-106, Indus till overlies 10 feet of silt (possibly Glenbow silt and clay which in turn overlies a thin unoxidized till (Glenbow till?). Stratigraphic relationships for the Indus till on the Pine Ridge Upland are indicated on cross-section Figure 4-10.



Cross-Section South of Shepard

Figure 4-7

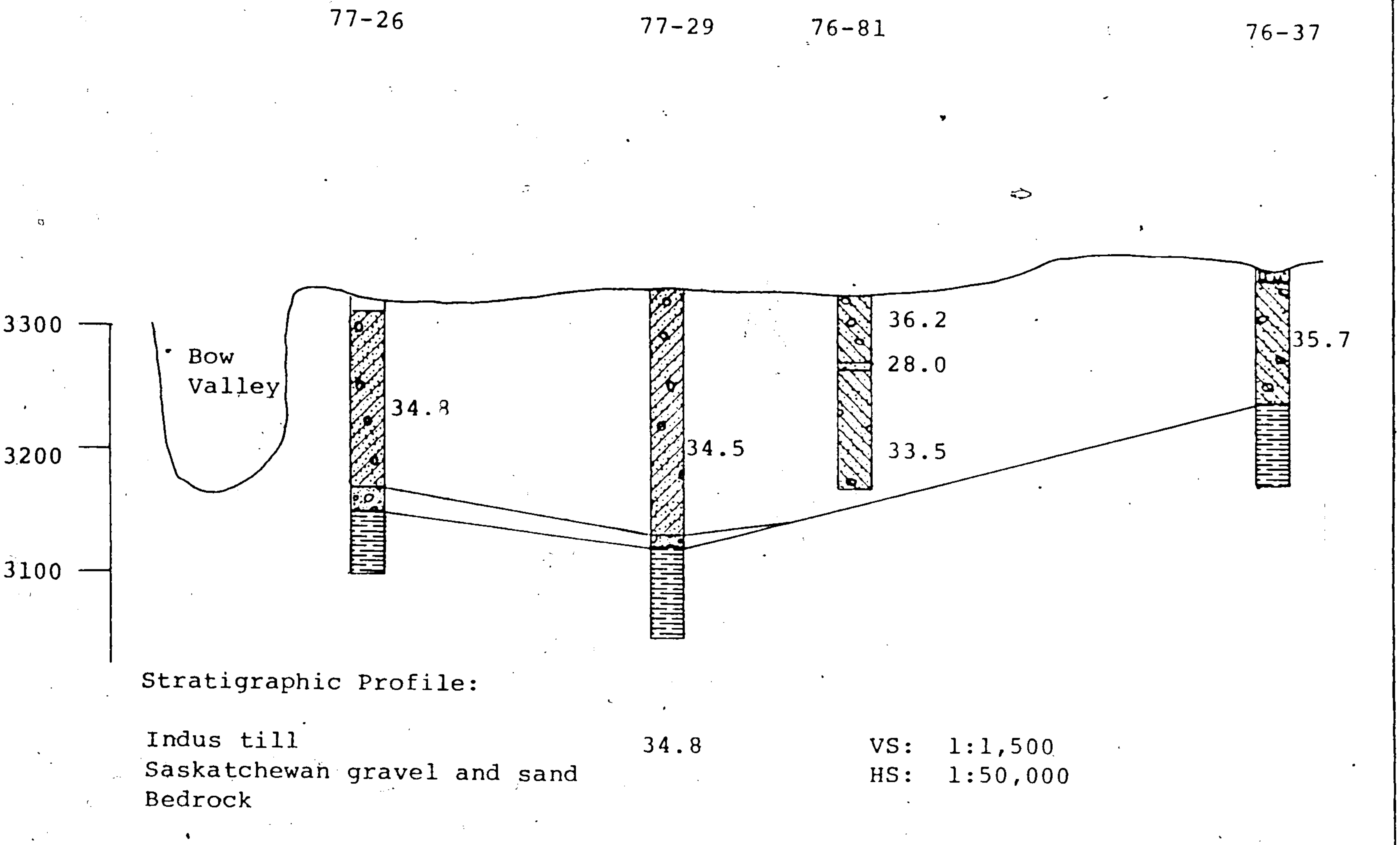
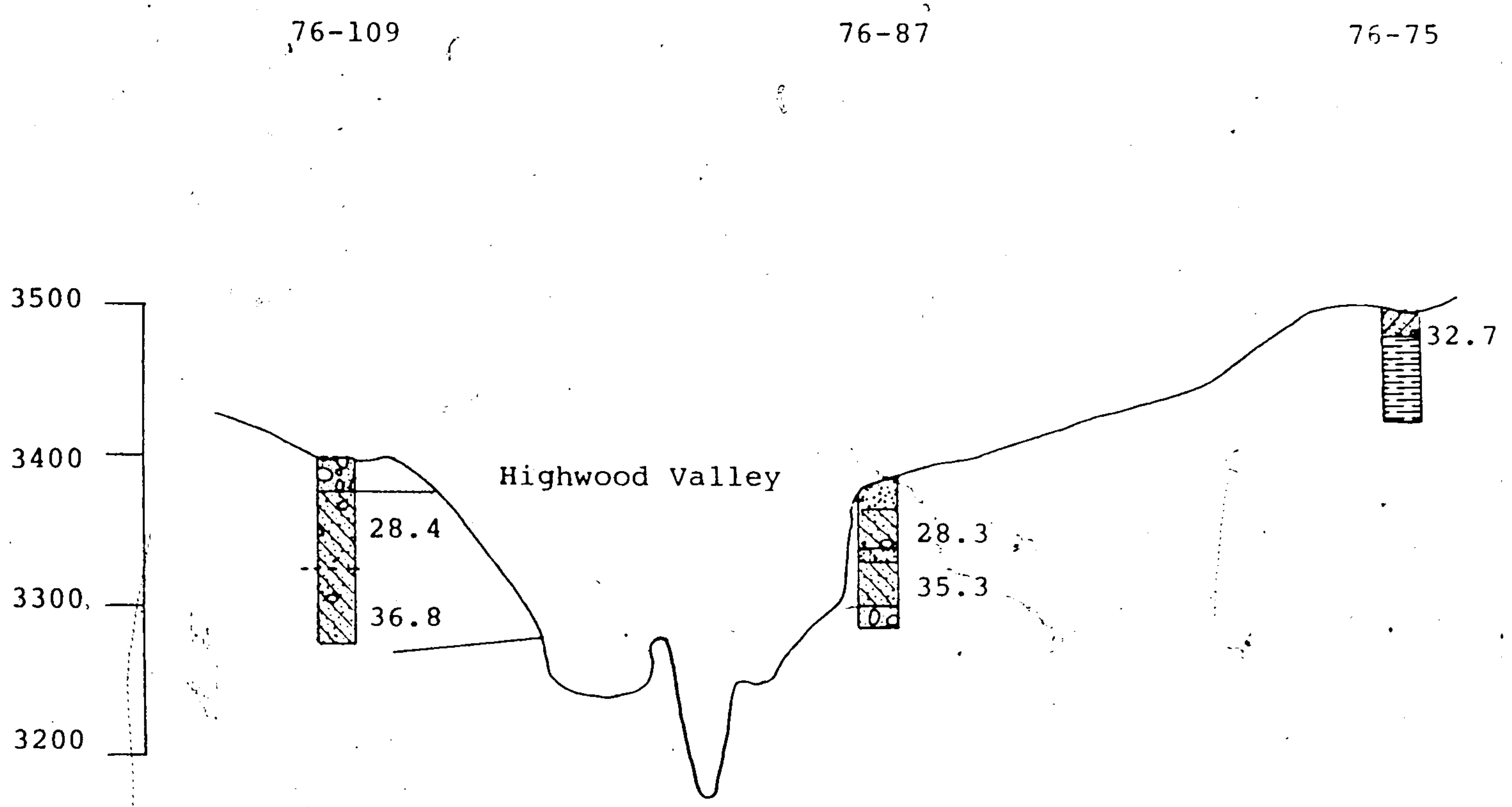


Figure 4-8

Cross-Section South of Indus



Stratigraphic Profile:

DeWinton till	32.7
Beddington silt and clay	
Beddington till	28.3
Indus silt and clay	
Indus till	36.1

VS: 1:1,500
HS: 1:50,000

Figure 4-9

Cross-Section of Highwood Valley

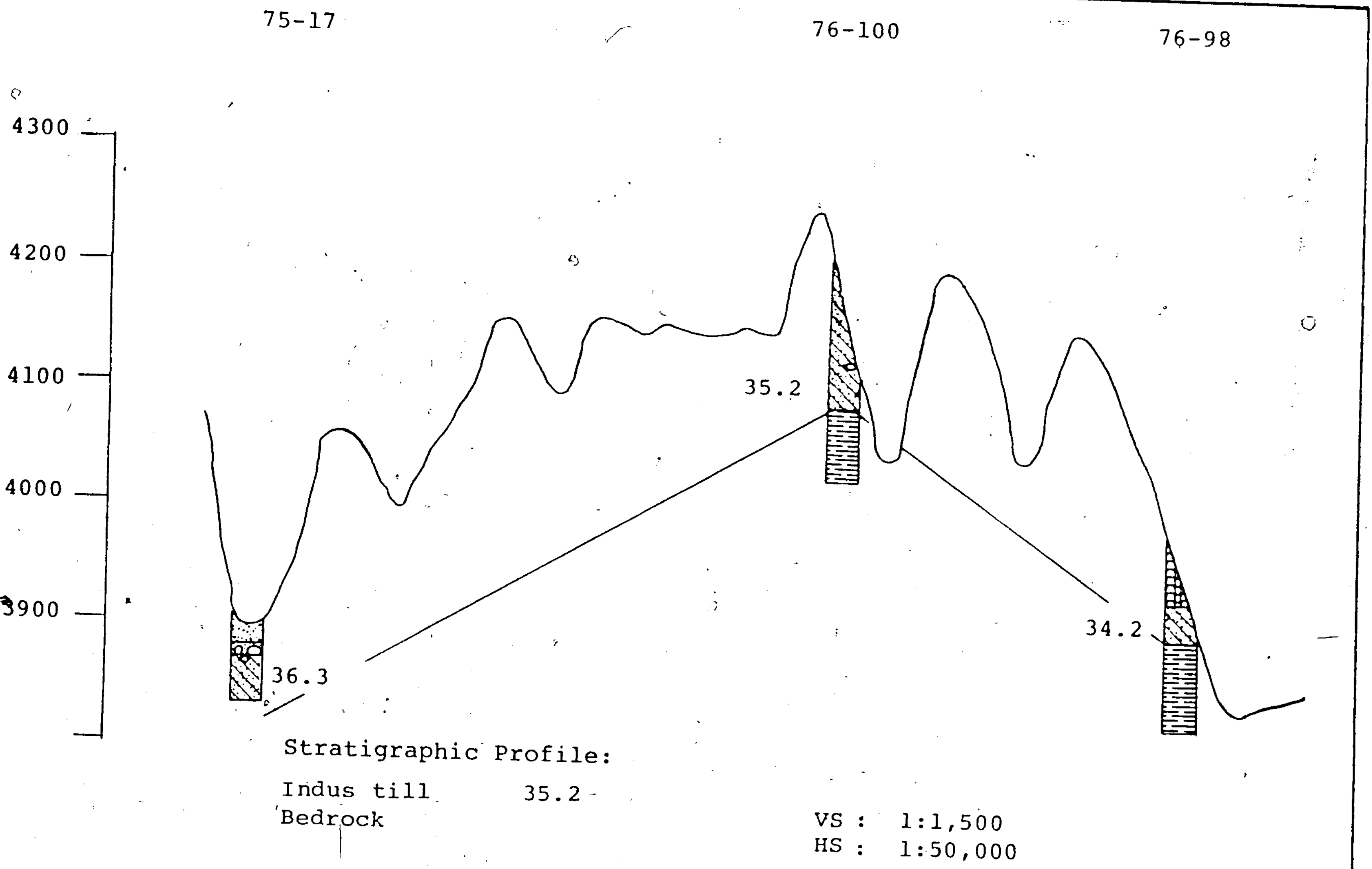


Figure 4-10

Cross-Section Pine Ridge Upland

Physical Attributes

Laboratory analyses conducted on till samples of Indus till have shown the following range of values:

sand/(silt & clay) ratio:

$N = 332$ $\bar{x} = 0.36$ $R = 0.25$ to 0.47

moisture content:

$N = 256$ $\bar{x} = 14.2$ $R = 12.2$ to 16.2

illite/(illite & montmorillonite) ratio:

$N = 174$ $\bar{x} = 0.66$ $R = 0.57$ to 0.75

igneous metamorphic content:

$N = 287$ $\bar{x} = 12.0$ $R = 1.9$ to 22.1

calcium carbonate equivalent:

$N = 178$ $\bar{x} = 16.6$ $R = 11.4$ to 21.8

liquid limit:

$N = 497$ $\bar{x} = 35.6$ $R = 34.0$ to 37.2

Structurally, the Indus till is stiff where it occupies buried valleys, but is often dry and crumbly on the upland areas, most likely in response to post-glacial desiccation.

The igneous/metamorphic content of the Indus till, as determined from the coarse sand fraction, generally exceeds 10 percent where the till occurs as valley fill, while on the upland area, the igneous-metamorphic content is either absent or in trace amounts. The low content of Shield-type fragments on the uplands can be attributed to two factors. One is the englacial position within the ice as it shears up and around bedrock controlled uplands; and the other to the massive volume of western-type lithologies incorporated by the eastern ice. In a continental glacier model, virtually all debris is carried near the base of the ice with minimal sediment carried upward into the ice. When the ice encounters bedrock uplands, it seems reasonable to expect that the incorporated local sediment will dominate.

During examination of the sand and pebble fraction of the various tills, a rather enlightening phenonenon was encountered. Traditionally, studies in glacial stratigraphy in Western Canada use the percentage of Shield stones to distinguish between eastern and western ice. As an experiment, the author examined a number of size fractions for a given till sample. While the pebble fraction was distinctly absent in Shield-type lithologies, the latter was detected in the mid to fine sand fractions. Therefore, on the basis of pebble analysis only, the till has a western source, but the various sand fractions would indicate an eastern source. It would therefore appear that one could in fact be mapping nothing but till lithofacies of a specific size fraction - a somewhat meaningless exercise. In view of this, it should not appear startling that the Indus till could have such a wide variation in igneous-metamorphic fragment content.

The following table which summarizes the physical attributes of both the Indus and Glenbow tills, indicates a significant contrast in their properties:

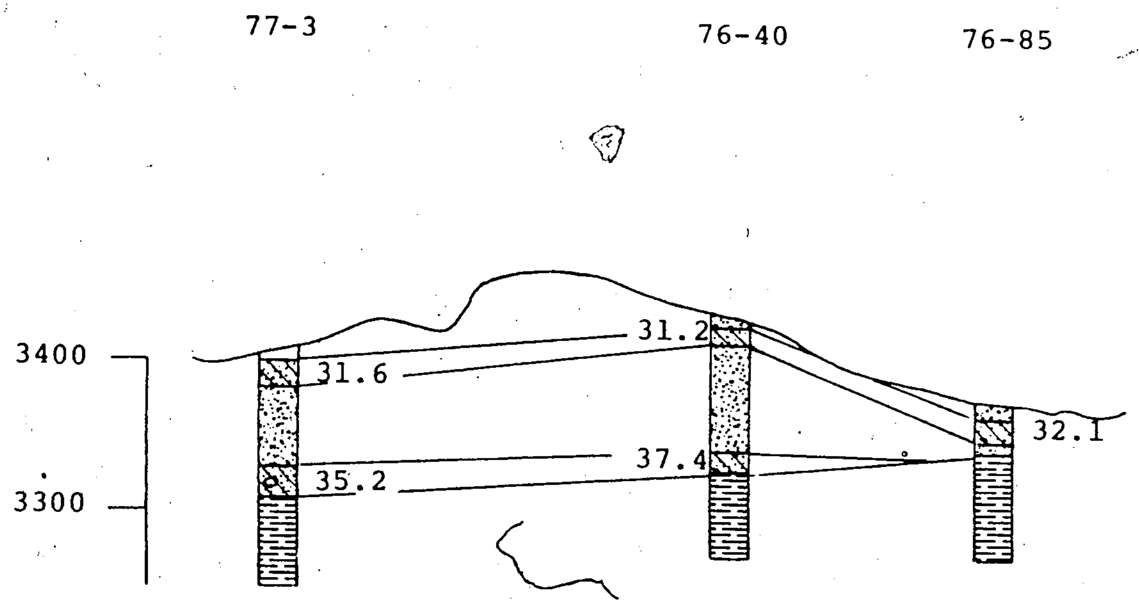
Parameter	Glenbow	Indus
LL	18.3	35.6
S/(M+C)	0.06	0.36
IM	absent	12.0
MC	-	14.2
I/(I+M)	-	0.66
CC	56.0	16.6

Indus Silt and Clay

Stratigraphic Position, Distribution and Thickness

The name Indus silt and clay is proposed for the laminated silts and clays which overlie Indus till. The type reference section is in Test Hole 76-40. The base of the unit is a 35 foot thick, fine to medium sand, dark grey sand which grades upward into a 22 foot zone of interbedded olive brown to olive grey silt and clay. The top of the unit is capped by 15 feet of clean, fine to medium, dark greyish-brown sand of probable dune origin.

The Indus silt and clay is preserved only within pre-Second Glacial Event drainage valleys where it escaped subsequent erosion. As a result, Indus silt and clay is generally found only within the old Calgary Valley drainage system. Two previous cross-sections, Figures 4-5 and 4-9, indicated 65 feet of Indus silt and clay within the Elbow Valley and a thinner 10 foot section of sand within the Highwood Valley, respectively. The thickest section of documented Indus silt and clay occurs in the type section in the area of Bow River bend, Twp. 22, Rge. 29. At this locality, Indus silt and clay overlies Indus till and is overlain by the younger DeWinton till. The stratigraphic relationships at the type section are illustrated in cross-section, Figure 4-11. A fourth occurrence of Indus silt and clay was found within the Lloyd Lake basin where it overlies Indus till and is overlain by sand and gravel



Stratigraphic Profile:

DeWinton silt and clay	
DeWinton till	31.6
Indus silt and clay	
Indus till	36.3
Bedrock	

VS: 1:1,500
HS: 1:50,000

Figure 4-11

Cross-Section Bow River Bend

of probable fluvioglacial origin. Figure 4-12 shows the stratigraphic sequence at the Lloyd Lake locality.

Although drainage channels associated with deglaciation during the Second Glacial Event are no doubt present, only a single fluvioglacial deposit was encountered during the test drilling program. Test Hole 76-59, within the Lloyd Lake basin encountered 30 feet of gravel and medium to coarse sand overlying Indus silt and clay and, in turn, overlain by Beddington silt and clay. The clean nature of the granular deposit as well as its coarse grain size indicates a probable fluvioglacial origin.

Two other drainage channels appear associated with the Second Glacial Event. North of Lloyd Lake a buried channel trending west to east contains younger till overlying bedrock. Similarly, within the Elbow River south of Cairn Hill, this same younger till overlies bedrock. Absence of fluvioglacial deposits within these channels would suggest their original thickness was small or that they have been completely eroded during the Third Glacial Event.

Third Glacial Event

The Third Glacial Event was the last extensive glaciation within the Calgary area and was responsible for generating most of the geomorphic elements now visible in the study area. The ice mass for this event originated in the northeast and

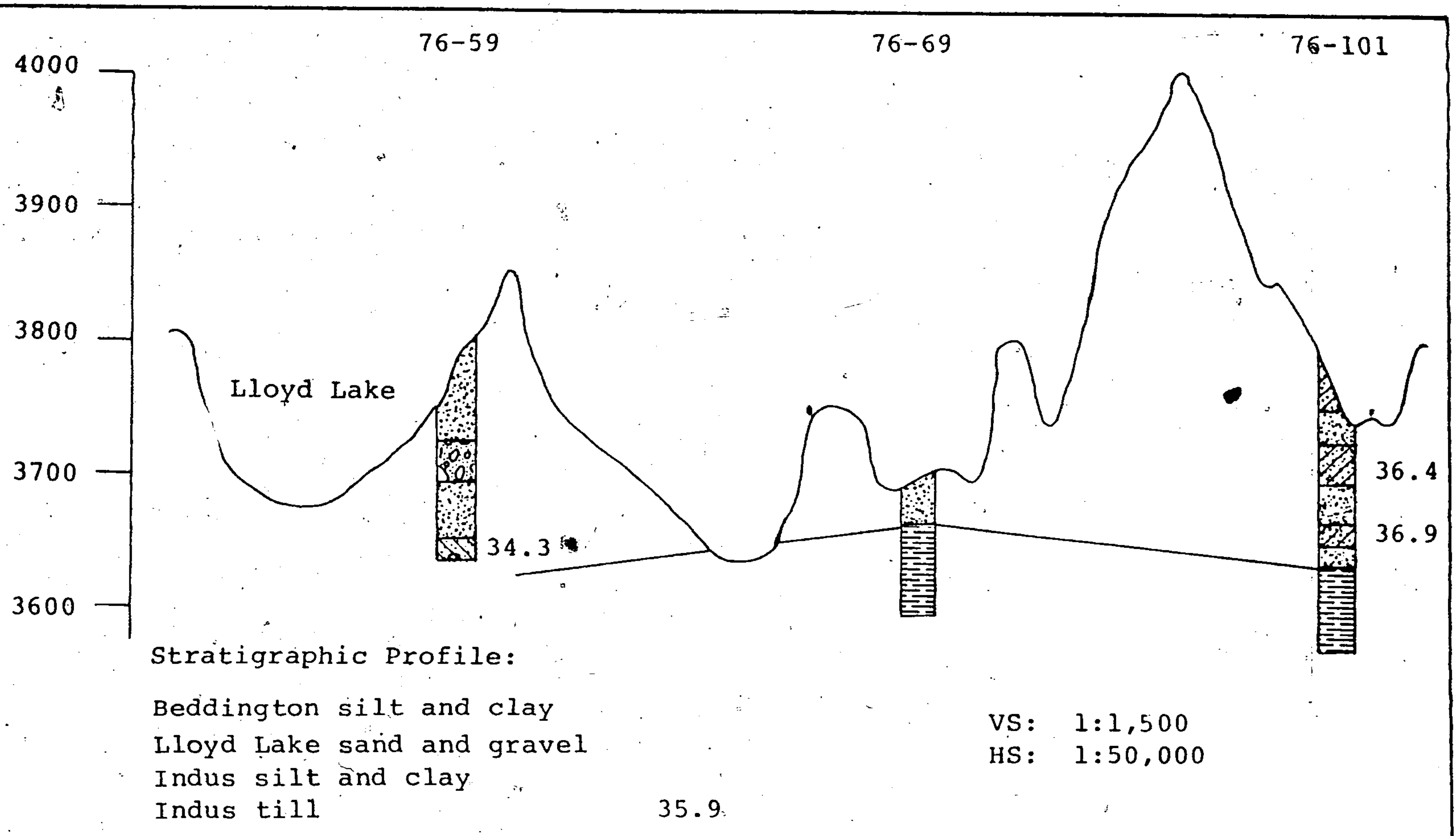


Figure 4-12

Cross-Section Lloyd Lake to Pine Ridge

was responsible for deposition of the well documented quartzite erratics train.

Stratigraphic evidence for this event is provided by the liquid limit parameter and stratigraphic position, aided in part by sand/clay ratios and coarse sand fraction.

The main deposits associated with this event are the Beddington till and the Beddington silt and clay. Numerous meltwater channels associated with deglaciation of the study area are evident on topographic maps and air photographs. These channels and their fluvioglacial sediments are discussed as they relate to deglaciation.

Beddington Till

Stratigraphic Position, Distribution and Thickness

The name Beddington till is proposed for a sandy till which contains numerous scattered quartzite erratics. The name is derived from the historic Beddington Erratic which lies in LSD 13, Section 23, Twp. 25, Rge. 1, W5M. The type reference section is represented by Test Hole 74-6 which is located two miles east of the Beddington Erratic. The type section contains 69 feet of olive brown to grey, sandy silt till, with minor amounts of igneous-metamorphic stones and an average liquid limit of 27.3.

The Beddington till is found to occur in one of four stratigraphic relationships. In the prairie region on the east side of the study area, Beddington till occurs as a surficial unit and overlies bedrock at depth (Test Holes 74-6 and 74-15). Within the old Calgary Valley drainage system, Beddington till is found overlying Indus till, Indus silt and clay, or Saskatchewan gravels. Beddington till overlying Indus till is found on the northeast flank of the Nose Hill Upland in Test Hole 74-29, on the Pine Ridge Upland in Test Holes 76-97 and 76-66, and along the southeast flank of the Cairn Hill Upland in Test Hole 74-40. Albeit thin, ice is inferred to have overrun all the bedrock controlled uplands within the Calgary area. The above stratigraphic relationships are illustrated in two previously sited cross-sections. Figure 4-5 shows the Beddington till overlying Indus silt and clay within the Elbow Valley, while Figure 4-9 shows this till overlying either Indus silt and clay (76-87) or in contact with Indus till (76-109). A third cross-section, Figure 4-13, illustrates the stratigraphic relationship along the northeast flank of the Nose Hill Upland.

Beddington till is found overlying reworked bedrock along the entire length of the Elbow River in Twp. 24, Rge. 2. Likewise, it is found within the Lloyd Lake basin in Test Holes 75-24 and 75-26 where sediment from the Second Glacial Event was eroded.

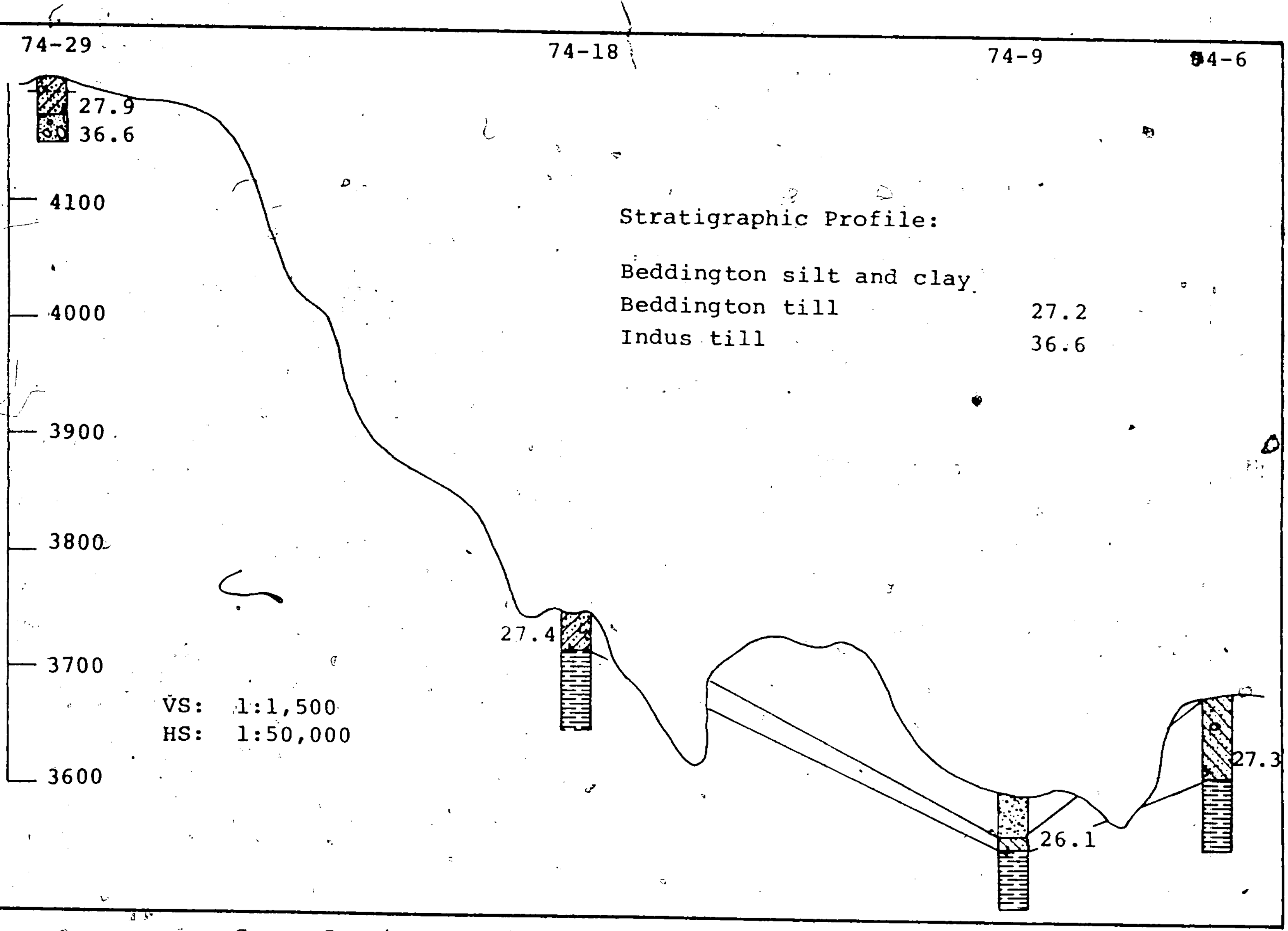


Figure 4-13

Cross-Section Northeast Flank of Nose Hill Upland

The only location where Beddington till has a rather continuous cover on an upland area is Cairn Hill (Test Holes 74-69, 74-61, 74-45, and 74-46 on top, 74-60 and 74-63 on flank). The till occurs as a surficial veneer, usually less than 15 feet thick, on the western part of the upland. On the eastern edge of the upland, the till gives way to Saskatchewan gravel and sand.

On Nose Hill, the Beddington till occurs as a discontinuous veneer except where it locally infills topographic lows in the Indus till, such as in Test Hole 74-77 where the till is 45 feet thick. Other isolated deposits vary in thickness from 10 feet (Test Hole 74-32) to 35 feet (Test Hole 74-28).

Within the Nose Creek area, the Beddington till acquires a thickness of 69 feet at the type reference section. Elsewhere on the gently rolling prairie terrain, the thickness seldom exceeds 35 feet.

On the Pine Ridge Upland, Beddington till was not encountered in any of the test holes. However, it reaches a thickness of some 65 feet in Test Hole 76-97 along the southeast flank. Elsewhere, it is a veneer varying in thickness from 5 feet (Test Hole 76-104) to 15 feet (Test Hole 76-72). In the Lloyd Lake basin, the Beddington till attains a maximum thickness of 37 feet in Test Hole 75-26. The till is generally confined to an east-west channel just north of Lloyd Lake.

Within the Bow Valley and the City of Calgary core, the Inventory Study indicates Beddington till underlying either thick deposits of Beddington silt and clay or post-glacial alluvial gravels within the modern day Bow River Valley. North of the Bow River, Inventory Test Holes 2160 and 960 record a plus 43 foot and 38 foot thickness, respectively, of Beddington till.

The distribution of the Beddington till indicates a minimum elevation of 4,250 feet for advance of the ice mass during the Third Glacial Event. This elevation is determined from a small kame deposit which lies on the western boundary of the Cairn Hill Upland in the northeast quarter of Section 19, Twp. 24, Rge. 2, W5M. A similar, small feature kame occurs on the Nose Hill Upland in the south half of Section 28, Twp. 25, Rge. 2, W5M.

Geomorphic Evidence and Ice Direction

Geomorphologically, the Beddington till forms ground moraine with relief in the order of 10 feet. In the Nose Creek area, the till is characterized by numerous washboard structures and glacial flutings. North-south trending washboard moraine is visible on air photographs in Sections 11, 12, 13, 16 and 25, Twp. 25, Rge. 1, W5M, and Section 36, Twp. 24, Rge. 1, W5M indicating an ice direction from the east. Evidence for a northeast to southwest ice direction is found along the northeast flank of the Nose Hill Upland in

Section 2, Twp. 26, Rge. 2, W5M, and Sections 2 and 3, Twp. 26, Rge. 1, W5M. At the latter location, washboard marks are parallel and flutings normal to the northeast flank of the upland.

Glendinning (1973) has done a till fabric study on surface till south of the Bow River. In the area of Jumping Pound Creek, he indicates an ice flow direction to the east; east of Highway 2 a direction to the west; and between the two areas, particularly on Cairn Hill, and the Sarcee Military Camp, a mixed zone with both westerly and northeasterly ice directions.

Physical Attributes

Laboratory analyses conducted on till samples of Beddington till have shown the following range of values:

sand/(silt & clay) ratio:

N = 193 $\bar{x}$ = 0.32 R = 0.19 to 0.45

moisture content:

N = 231 $\bar{x}$ = 14.2 R = 11.6 to 16.8

illite/(illite & montmorillonite) ratio:

N = 35 $\bar{x}$ = 0.73 R = 0.66 to 0.80

igneous-metamorphic content:

N = 79 $\bar{x}$ = 4.3 R = 0.7 to 7.9

calcium carbonate equivalent:

N = 172 $\bar{x}$ = 4.3 R = 15.7 to 25.5

liquid limit:

N = 288 $\bar{x}$ = 28.4 R = 26.0 to 30.8

The following table compares the results of the physical properties of the tills thus encountered:

Parameter	Glenbow	Indus	Beddington
LL	18.3	35.6	28.4
S/(M+C)	0.06	0.36	0.32
IM	absent	12.0	4.3
MC	-	14.2	14.2
I/(I+M)	-	0.66	0.73
CC	56.0	16.6	20.6

Comparison of the results indicates a contrast for the two eastern versus one western till. However, with the exception of the liquid limit and possibly igneous-metamorphic content, the other parameters do not readily distinguish between the two eastern tills.

Quartzite Erractics

The Beddington Till is characterized by large blocks of quartzite and pebbly quartzite scattered along a narrow belt in the foothills of Alberta. The largest quartzite erratic within the study area is the Beddington Erratic located in LSD 9-26-25-1-W5M.

Considerable work on the Erratics Train has been carried out by Stalker (1956). He comments (p. 10):

> "The blocks rarely show significant weathering aside from frost action... No glacial striae were discovered during careful examination of many of the blocks and it seems probable that none was produced during transportation of the erratics to their present position.....".

Stalker describes the erratics as follows:

> "The rock is very uniform in character over the entire length of the belt studied.....It consists mostly of fine pebble conglomerate and coarse massive to bedded quartzite, cross-bedding being commonly displayed. The coarse quartzite and conglomerate horizons are commonly separated by a siltstone or shaly bed, ¼ to 1 inch wide.

> Quartz veins of about the same thickness also occur in a few of the blocks. The rock commonly breaks along these beds or partings and along the veins".

With respect to the source and mode of transportation, Stalker (1956) concludes :

> "Valley glaciers could have quarried the rock from the valley sides and received the boulders directly on their surfaces.....Had only valley glaciers been present the erratics would have been deposited in lobes opposite the valleys. It seems logical to conclude therefore that mountain glaciation alone could not have effected the present distribution of the boulders.. Regardless of the source of the erratics Laurentide ice was necessary to effect their distribution in a narrow belt controlled on the east by elevation. The large size of many of the erratics and the absence of striae indicate that the blocks were carried on or near the surface of the transporting glacier".

Additional work by Mountjoy (1958) concluded that the Cavell Formation of Lower Cambrian age near Jasper, Alberta was the source of the erratics and an Athabasca valley glacier was the transporting agent. Mountjoy's conclusions were based on the similarity of lithologic descriptions between the rocks of the Cavell Formation and those described by Stalker (1956).

There is unequivocal evidence for ice deflection adjacent to the foothills. Roed (1975) mapped drumlins and other glacial lineaments south of Edson, Alberta. Boydell (1972) also mapped drumlins and glacial flutings indicating a southeastward moving ice mass west of Sylvan Lake. South of the Calgary area, Jackson (1979) mapped a drumlinized terrain with a southeasterly flow from the Bow Valley in the vinicity of Jumping Pound Creek.

Beddington Silt and Clay

Stratigraphic Position, Distribution and Thickness

The name Beddington silt and clay is proposed for an interbedded sequence of silt and clay which overlies Beddington till. The type reference section is in Test Hole 77-22 where 62 feet of glaciolacustrine sediment separates the underlying Beddington till from the overlying DeWinton till. The base of the unit is a 35 foot thick grey clay, which is plastic and occasionally mottled with silt. Except for small interbeds, the clay shows massive bedding. In the upper 27 feet of the unit there is a considerable increase in silt content generating a clay extensively mottled by irregular silt pockets, blebs and lenses.

An extensive glacial lake system is associated with deglaciation of the ice mass for the Third Glacial Event. An upper limit for glaciolacustrine sedimentation is recorded in Test Hole 77-16 at an approximate elevation of 4,340 feet. At this locality, 46 feet of laminated clay overlies a stoney till.

It appears that deglaciation during this event was a progressive retreat with lake levels dropping as the ice retreated eastward. Although lake sediments are found as high as 4,340 feet, the highest drainage outlet is evident only at the 4,000 foot elevation within the study area. Stalker (1968), studying the geology of the Cochrane terraces, described three major deltaic terraces above the townsite. Terraces at 4,000, 3,950, and 3,850 feet were all considered to be the result of deposition of outwash from Bighill Creek into successive stands of a glacial lake. The change in each glacial lake level is marked by a north-south trending meltwater channel, generally with a delta deposit at its southern end.

The Beddington silt and clay is found associated with two major stratigraphic positions. In the northwest part of the study area near Glenbow Lake, Beddington silt and clay overlies Indus till. Throughout the remainder of the area, it exclusively overlies Beddington till. A single occurrence of Beddington silt and clay overlying bedrock, is found on the northeast flank of Pine Ridge Upland in Test Hole 76-69. With the exception of the buried Calgary Valley system, the Beddington silt and clay occurs as a surficial unit. At this latter locality, Beddington silt and clay is overlain by the youngest till in the study area.

On the Nose Hill Upland, Beddington silt and clay is generally quite thin, as in Test Hole 74-55 where it is five feet thick. An exception occurs in Test Hole 74-78 where the silt is 50 feet thick and appears to occupy a low within the post-Second Glacial Event topography.

Within the Bow River valley, east of the Bearspaw Dam, Beddington silt and clay reaches a thickness of 77 feet in Test Hole 74-83. At Test Hole 74-59 on the south side of the Bow River, a minimum thickness of 96 feet was encountered as the base of the unit was not reached.

In the Glenbow Lake area, Beddington silt and clay overlies Indus till. The thickest section of glaciolacustrine was encountered in Test Hole 78-17 at a thickness of 68 feet.

Within the Elbow River valley, Beddington silt and clay outcrops and exclusively overlies Beddington till. Beddington silt and clay reaches a maximum thickness of 87 feet in Test Hole 74-41 and wedges out in a north and south direction as it approaches the Cairn Hill and High Butte, respectively.

At Test Hole 76-59, near Lloyd Lake, Beddington silt and clay is 50 feet thick and overlies fluvioglacial sediments associated with deglaciation during the Indus till glacial event.

Within the City of Calgary proper, Inventory Test Hole 1952 records 108 feet of glaciolacustrine sediment on the north bank of the Bow River. Between the Downtown area and Midnapore, there is a complex interbedding of glacial sediments which appear to include Indus till, Beddington silt and clay, Beddington till and the youngest till and glaciolacustrine sequence. Since depth to bedrock is less than 25 feet in most cases, and the units are less than 6 to 10 feet thick, little confidence is placed on being able to decipher the stratigraphy.

Beddington Silt and Clay Related Drainage Channels

Within the Calgary area, a large number of meltwater channels and spillways are associated with the retreat and deglaciation of the Third Glacial Event. Each channel is related to a drop in water level as the ice retreated eastward. These lake still-stands are described from west to east across the Calgary area and their locations are reflected on Figures 1-3 to 1-6 by the alignment of meltwater channels.

Still-Stand at Elevation 4,000 Feet

The first recorded major still-stand in the history of deglaciation is the 4,000 foot level documented by Stalker (1968) north of the Town of Cochrane. The still-stand is reflected by a flat-topped deltaic terrace. To the south, the 4,000 foot lake level is represented by the Priddis Channel which parallels the southwest flank of the Pine Ridge Upland, and runs northeastward toward the Sarcee Reserve. This part of the channel is presently occupied by Fish Creek. The channel is some 17 miles in lengh and about 2.1 miles at its widest point near the Town of Priddis. Although no visible delta is associated with this channel, it is locally floored by gravel, as seen on the Priddis topographic sheet in Section 13-21-3-W5M.

Still-Stand at Elevation 3,950 Feet

This still-stand is documented by Stalker (1968) from a gravel terrace north of Cochrane. Although no other 3,950 level channels are evident, it is assumed that the large, extensive Priddis Channel complex served to drain water southward at this lake level stage. There is a fairly well defined 3,950 foot elevation lake terrace in Section 34-21-3-W5M and Section 3-22-3-W5M, approximately 3½ miles south of the Town of Priddis.

Still-Stand at Elevation 3,850 Feet

This lake level has also been documented in the Cochrane area by Stalker (1968). A well defined deltaic terrace was formed as Bighill Channel drained into a glacial lake.

North of the Bow River in the east half of Section 19 and the west half of Section 20-24-2-W5M, the Twelve Mile Coulee delta records the 3,850 foot level. It is a narrow channel, about 0.2 miles at its widest point and about 1.3 miles in length.

A second, much larger channel also drained the Nose Hill Upland at the 3,850 level. This channel, called the Reilly

Channel, has a well developed delta lobe which crosses at the intersection of Highway 1A and 85 St. N.W. The delta lobe covers Sections 9, 10, 15 and 16-25-2-W5M. The upper part of the channel is only 0.3 miles wide, but has a minimum depth of 100 feet. Overall, the channel is approximately 1.5 miles in length.

South of the Bow River, this lake level is represented by the Bearspaw Channel which lies along the west flank of the Cairn Hill Upland in Sections 26, 35 and 36-24-2-W5M. The channel is about 2½ miles long, as indicated by the 3,875 contour line on the Calgary Sheet (820/1, Figure 1-3) and 0.6 miles wide at its north end. The southern end of this channel is littered with exposures of gravel and a low relief delta. A water well at S.W.-26-24-3-W5M recorded 99 feet of sand and gravel overlying bedrock.

Within the Priddis Sheet (Figure 1-6), the 3,850 foot level can be traced along the Lott Creek - Six Mile Coulee Channel, which crosses the Sarcee Reserve in a southeasterly direction. The channel is over 13½ miles in length, and in places 0.5 miles wide. It is quite shallow and lacks the well-defined valley sides typical of most meltwater channels. The maximum elevation of the channel floor is approximately 3,820 feet. No gravels are evident anywhere along its length. Based on the shallowness of the channel and lack of gravels, it is concluded that a relatively small flow existed as this channel drained into the Fish Creek basin.

Still-Stand at Elevation 3,750 Feet

A fourth major still-stand is represented approximately by the 3,750 foot elevation. This series of channels can be traced from the southwest flank of Nose Hill southward toward Pine Creek. Along the southwest flank, the upper reach of the Ranchland Channel is outlined by the 4,000 foot countour. The channel is not readily traced southward to elevation 3,750. However, at this latter elevation, the 1:50,000 topographic map indicates a gravel pit in N.E.-2-25-2-W5M and N.W.-1-25-2-W5M with a well defined delta lobe.

South of the Bow River, the Sarcee Channel marks this 3,750 lake level. This channel is located on the east flank of the Cairn Hill Upland in Sections 1, 12, 13, Twp. 24, Rge. 2, E5M. The channel is approximately 3 miles in length and 3/4 miles in width, with an average depth of 60 feet. The west side of the Sarcee Channel is well defined and cut into bedrock. The east side of the channel must have been contained by ice, as the deposits grade gently eastward into glaciolacustrine silt and clay.

The southern end of the channel is marked by the Sarcee Delta, a large continuous lobe of coarse gravel, sand and gravel and cross-bedded sands dipping southward. The north wall of a gravel pit within the delta contains approximately 60 feet of stratified sand and gravel with numerous stacked channel sands grading from sand and gravel at the base to thinly bedded silt and clay at the top.

South of the Elbow River, the Fish Creek - Lloyd Lake Channel marks the 3,750 foot level. The channel starts in a gully southwest of Glenmore Reservoir and fans south to Fish Creek, turns southwest and then south into the Lloyd Lake basin. North of Fish Creek the channel is marked by a north-south slough alignment and a gravel pit in the central part of Section 13-23-2-W5M. From Fish Creek to Lloyd Lake, the channel is shallow and not less than 0.5 miles in width at its narrowest part. The maximum elevation of the channel floor at this northern end is about 3,730 feet. At the lake, the channel widens to about 1.8 miles and bifurcates. North of the existing Lloyd Lake, the northern channel trends east-west. It is some 4 - 5 miles in length with a maximum width of 0.6 miles. The southern channel turns southeast of Lloyd Lake. These two channels, whose sides are marked by the 3,750 foot contour, are both about 1 mile in length and 0.2 to 0.3 miles in maximum width. They both drain southeast into the Pine Creek basin.

No evidence for glaciolacustrine deposits was found above elevation 3,750 in the Lloyd Lake area. It appears that this basin acted as a holding basin to carry flow from the Elbow and Fish Creek Valleys to the southeast.

Still-Stand at Elevation 3,650 Feet

Another still-stand in glacial retreat is represented at the 3,650 foot elevation. Much of this channel is ill-defined due to its shallow nature. It is identified on the topographic map by the presence of elongate sloughs along its course, as well as occasional gravel pits.

On the Calgary Sheet, the still-stand is represented by three well defined and one poorly defined channels. The most prominant channel is the bedrock incised Beddington Channel in the northeast flank of Nose Hill. This channel extends some 25 miles northwest to beyond the study area and is approximately 0.8 miles wide with a maximum depth of 80 feet in N.W.-21-25-1-W5M. Moderately thick gravels overlie weathered bedrock along the channel walls. The Beddington Channel gives rise to a major delta at its southeastern end. The topographic map indicates extensive gravels covering the north half of Section 15 and the south half of Section 22-25-1-W5M.

Another channel, documented by Meyboom (1961) but unnamed, parallels the southern flank of the Nose Hill Upland and is herein called the Highland Channel after the Highland Golf Course which is located within the channel. This channel is approximatel 4 miles in length and about 0.6 miles at its widest point. It covers Sections 28, 29, 31, 32, 33, and 34-25-1-W5M. The presence of gravel pits at the western end of the channel in S.E.-31 and S.W.-32-24-1-W5M suggest that this channel may have been reused by a subsequent advance.

South of the Highland Channel in N.E.-19-24-1-W5M is the North Hill Channel which drains southeastward from McMahon Stadium. It is a short channel, about 1 mile in length and 0.5 miles wide. An Inventory test hole, I 2533 encountered 46 feet of a mixed lithology of gravel, sand, silt and clay overlying bedrock.

South of the Bow River, the 3,625 test level becomes a little obscure but can be traced as a shallow, broad channel from the Alberta Childrens' Provincial General Hospital southwestward through the Mount Royal College campus where a small delta extends eastward off the main Sarcee Delta lobe.

South of Glenmore Reservoir, the channel is traced along an alignment of sloughs in Section 7-23-1-W5M. A gravel pit is visible on airphotos along this alignment of the south bank of Fish Creek in N.W.-31-22-1-W5M. The channel continues to follow depressions marked by the 3,650 foot contour in Section 30-22-1-W5M, then swings easterly to join the northern Lloyd Lake channel before moving southward into the Pine Creek Basin, and then Wilson Coulee.

Still-Stand at Elevation 3,550 Feet

On the Calgary sheet, this still-stand is reflected by the bedrock incised Nose Creek Channel which forms a major geomorphic feature in the east half of Twp. 25, Rge. 1, W5M. It extends some 30 miles in a north-south trend and is approximately 0.5 miles wide with a maximum depth of 40 feet. Most of the channel floor is bedrock with overlying discontinuous, but widespread gravel bars. The extent of gravel deposits is seen on the topographic map in Sections 1, 2 and 10-25-1-W5M and Sections 13 and 35-24-1-W5M.

The southern extension of this channel occurs along the Elbow River where it makes a right angle bend at the Glenmore Reservoir. It is traced further south through an alignment of sloughs on the Canyon Meadows Golf and Country Club, a gravel pit at S.E.-5-23-1-W5M, and another alignment of sloughs in the east half of Section 32-22-1-W5M. The 3,650 and 3,550 foot level changes amalgamate at the northern Lloyd Lake Channel.

Still-Stands At Other Elevations

Three other channels, documented and named by Meyboom (1961) occur in the southeast corner of Twp. 24, Rge. 1, W5M and are traceable as far south as the confluence of the modern-day Pine Creek and Bow River.

The Macleod Channel at an approximate elevation of 3,450 feet, follows Macleod Trail southward through the City of Calgary. It can be traced by extensive gravel pits in the north half of Section 10 and the south half of Section 15-23-1-W5M; gravels pits south of Midnapore in Section 34-24 1-W5M; and along a long, narrow slough and more gravel pits north of Academy.

The Burns Channel represents the 3,325 foot level of deglaciation. This channel starts in the East Manchester Industrial Park and follows a CP spur line southward to the Smelting Plant in the south half of Section 26-23-1-W5M. From here the channel parallels a well-defined gravel terrace, passes near the Bonnybrook Sewage Treatment Plant and joins the Pine Creek Channel at Section 8-22-29-W4M.

The Ogden Channel is the lowermost channel at elevation 3,300 feet and contains the modern-day Bow River. The gravels in these latter two channels are probably a mixture of Beddington fluvioglacial deposits and post-glacial river gravels carried from the west by the Bow River.

Fourth Glacial Event

The Fourth Glacial Event was the least extensive glaciation. All evidence suggests an ice lobe advancing from the north. This ice mass left a thin veneer of till over the lowland areas except where it infilled meltwater channels formed in the previous glacial event. Although the southern extremity of this advance is not identified within the study area, an east-west trending morainal ridge occurs south of the Bow River from Twp. 19, Rge. 23, W4M westward toward the Town of Okotoks. This morainal ridge is broken only by the Highwood River and Arrowwood Creek drainage systems. The ridge is rather well marked by the 3,500 foot contour south of the Bow River on the 1:250,000 Gleichen sheet.

Stratigraphic evidence for this event is provided by the liquid limit parameter, stratigraphic position, and the percentage of igneous-metamorphic components in the coarse sand fraction.

The main deposits associated with this event are the DeWinton till and the DeWinton silt and clay. Meltwater channels associated with deglaciation of this ice mass have reoccupied former channels cut during the Third Glacial Event, in particular, the Glenmore Channel.

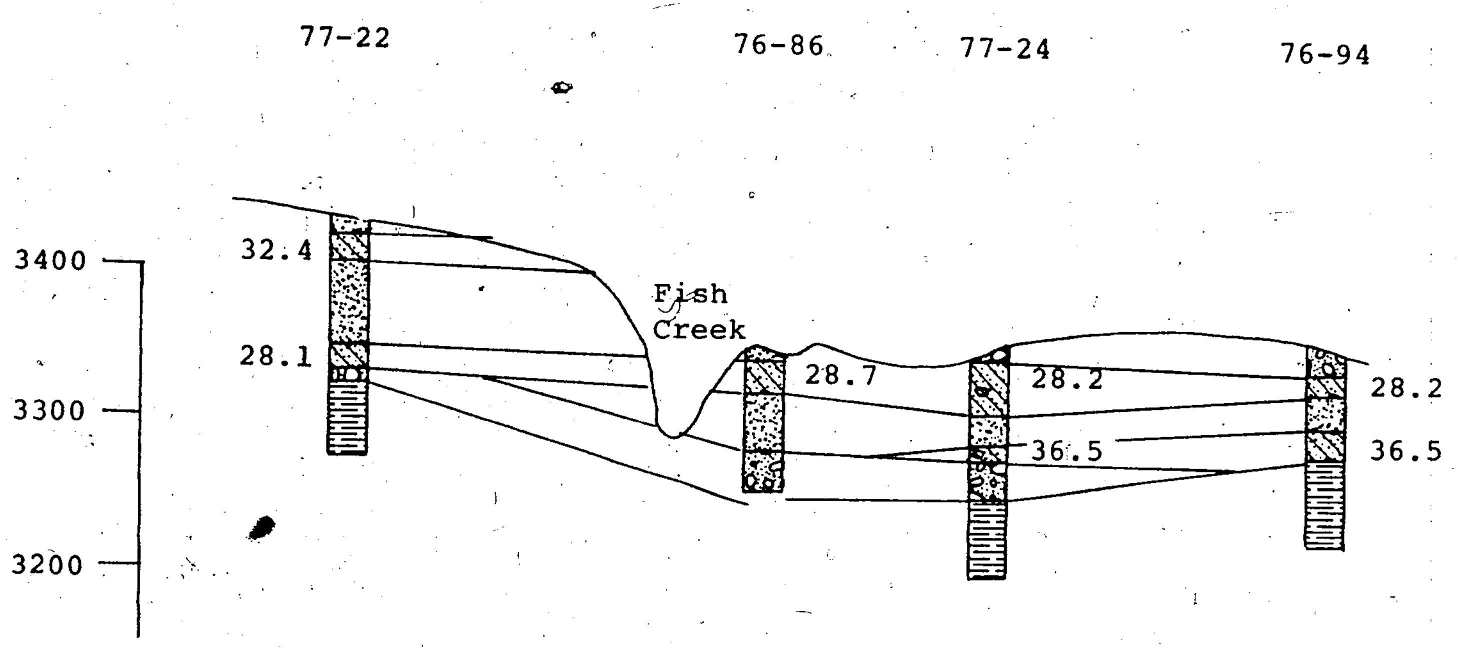
DeWinton Till

Stratigraphic Position, Distribution and Thickness

The name DeWinton till is proposed for a clay silt till found north of DeWinton within the old Calgary Valley drainage system. The type reference section is represented by Test Hole 77-38 which contains 40 feet of till overlying 53 feet of Beddington silt and clay, and underlying 27 feet of clean, stone free, medium to coarse sand of probable fluvioglacial origin.

Although the DeWinton till is found to occur in three different stratigraphic relationships, the most common is DeWinton till overlying Beddington silt and clay. This relationship is encountered in a number of test holes - 76-40, 76-42, 76-74, 76-76, 77-42, 77-22, and 77-38, and is restricted to the Calgary Valley drainage system or to previously eroded meltwater channels. Within these buried channels, DeWinton till varies from 10 to 15 feet with the exception being the type reference section. Stratigraphic relationships within the Calgary Valley are illustrated in cross-section Figure 4-14.

In the northeast part of the study area, till is found as a discontinuous unit overlying Indus till into which it probably grades eastward. Till thicknesses of 15 to 30 feet occur in Test Holes 76-22 and 76-3, respectively.



Stratigraphic Profile:

DeWinton silt and clay	
DeWinton till	32.4
Beddington silt and clay	
Beddington till	28.3
Indus silt and clay	
Indus till	36.5

VS: 1:1,500
HS: 1:50,000

Figure 4-14

North-South Cross-Section Along Bow Valley

Southwest of Calgary near Academy, DeWinton Till occupies another buried channel which occurs at an approximate elevation of 3,625 and 3,650 feet. Three test holes, 76-108, 76-117, and 75-14, are aligned along this channel. Along this alignment, the till approaches 100 feet in thickness. Figure 4-15 is a cross-section along this former channel. The thickness of till in this channel is in sharp contrast to much thinner drift in nearby test holes and water wells.

A second cross-section, Figure 4-16, illustrates the stratigraphic relationships across the channel from the Lloyd Lake area to the east. The Lloyd Lake plateau has Beddington silt and clay overlying Beddington till. East of a ridge through Test Hole 76-54, DeWinton silt and clay overlies DeWinton till.

In the Blizzard Lake Area, DeWinton till is found wedging out against bedrock. It is in the order of 15 - 20 feet thick in Test Holes 75-7 and 76-75.

Limited distribution and/or erosion of the DeWinton till has made it difficult to trace, particularly in the City of Calgary. A number of Inventory test holes (I710, I1660, I2816, I1503, I2461, I2928, I2916, I2898, I180, and I72) all record thin multiple till sections and relatively shallow depths to bedrock. Assuming these multiple till sections represent the two youngest tills, because of the shallow depth to bedrock, it follows that they are probably Beddington and

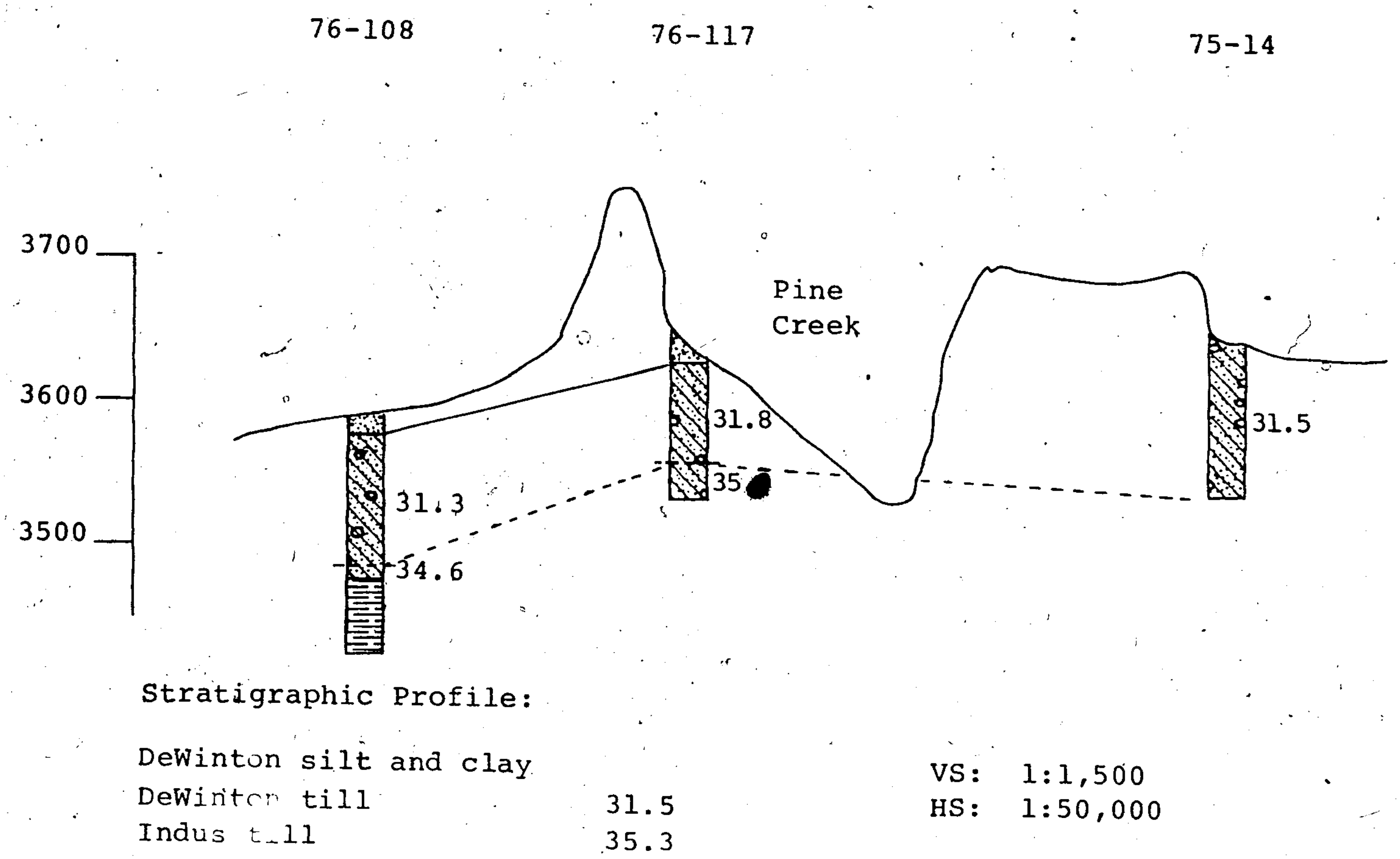
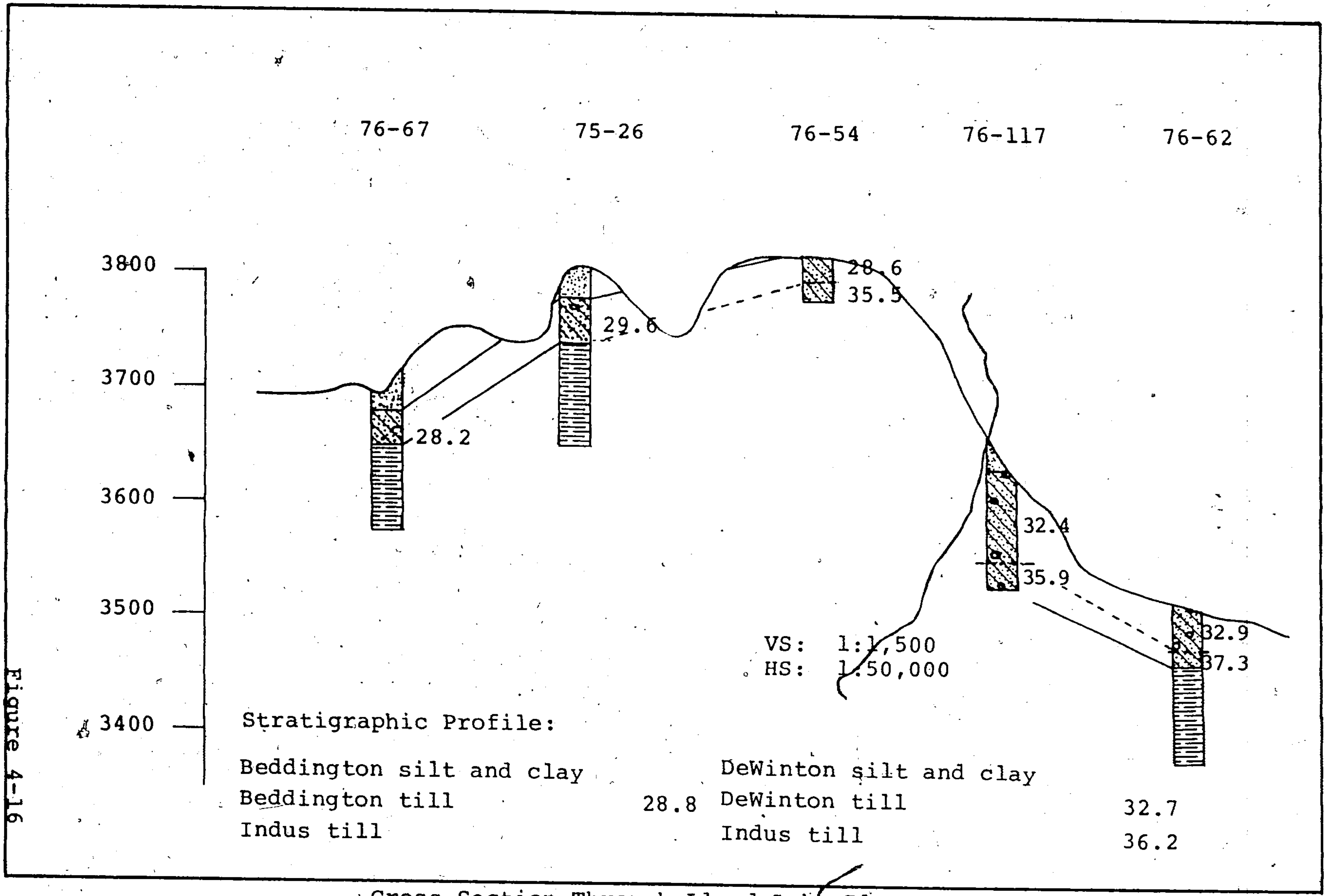


Figure 4-15

Cross-Section Through Pine Creek Channel



Cross-Section Through Lloyd Lake Plateau

Figure 4-16

DeWinton tills. As discussed in Chapter III, the liquid limit approach to correlation is ineffective for till differentiation where units are thin or interbedded.

The relatively thin nature of the DeWinton/Beddington tills and their associated glaciolacustrine or fluvioglacial deposits can be observed in Tharin's (1960) Airport Section and his Incinerator Section. The Airport Section is located in a sewer outfall gully in S.E.-2-25-1-W5M, and contains two tills separated by glaciolacustrine deposits. Liquid limits conducted on the upper and lower tills yielded values of 32.0 and 25.4, respectively. Similarly, at the Incinerator Section located in S.E.-3-24-1-W5M, two tills are separated by lacustrine and glaciofluvial deposits. The upper till yielded a liquid limit value of 30.9 and the lower till a value of 25.3

The distribution of the DeWinton till indicates a minimum elevation in the order of 3,625 to 3,650 feet as the limit of the ice mass during the Fourth Glacial Event. This elevation is determined from channel infill deposits along the approximate Glenmore Channel alignment.

Physical Attributes

Laboratory analyses conducted on till samples of DeWinton till have shown the following range of values:

sand/(silt + clay ratio):

N = 128 $\bar{x}$ = 0.29 R = 0.15 to 0.43

moisture content:

N = 185 $\bar{x}$ = 13.6 R = 11.3 to 15.9

illite/(illite + montmorillonite) ratio:

N = 70 $\bar{x}$ = 0.72 R = 0.66 to 0.78

igneous-metamorphic content:

N = 27 $\bar{x}$ = 8.9 R = 0 to 19.5

calcium carbonate equivalent:

N = 20 $\bar{x}$ = 17.3 R = 15.0 to 20.3

liquid limit:

N = 117 $\bar{x}$ = 31.8 R = 30.4 to 33.2

where N = number of samples analyzed

$\bar{x}$ = mean

R = range of values.

The following table compares the results of the physical properties of the tills thus far described:

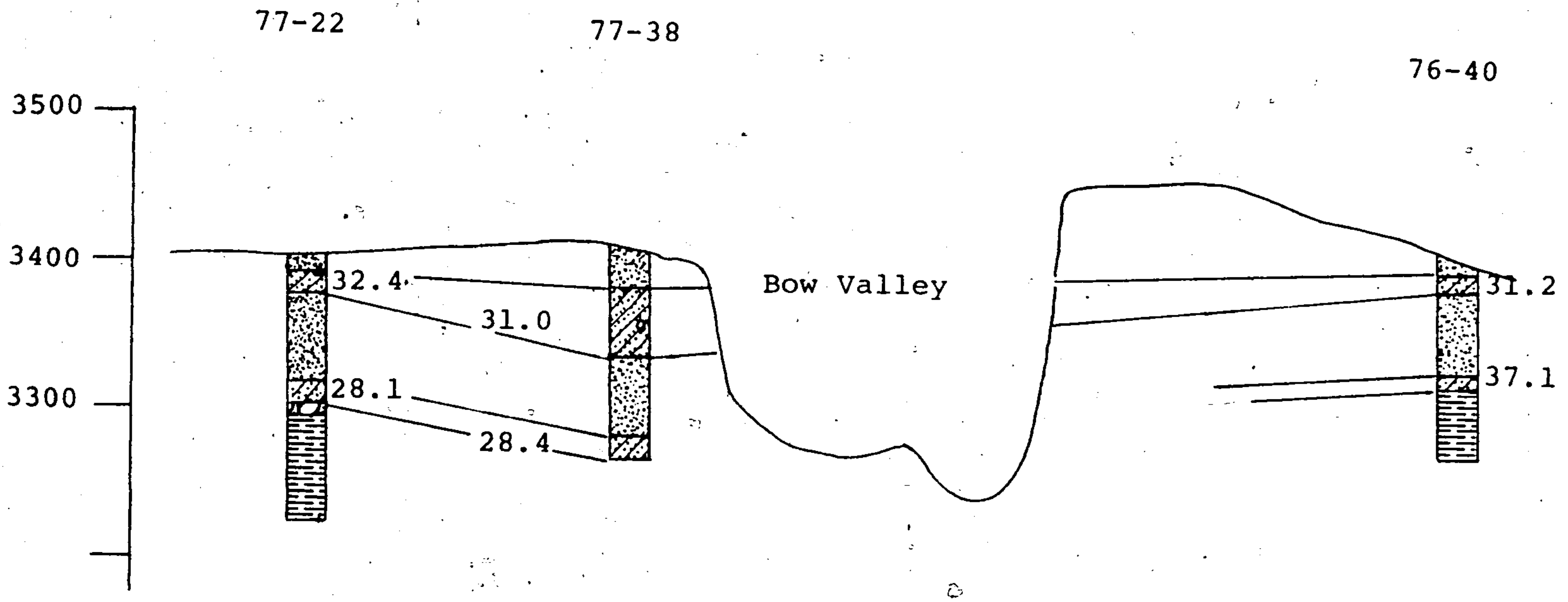
Parameter	Glenbow	Indus	Beddington	DeWinton
LL	18.3	35.6	28.4	31.8
S/(M+C)	0.06	0.36	0.32	0.29
IM	absent	12.0	4.3	8.9
MC	-	14.2	14.2	13.6
I/(I+M)	-	0.66	0.73	0.72
CC	56.0	16.6	20.6	17.3

The data would indicate a contrast for the three eastern tills versus the western till. However, it should be pointed out that only very limited data exists for the western Glenbow till. Among the parameters, only the liquid limit enables a distinction between the three eastern tills.

DeWinton Silt and Clay

The name DeWinton silt and clay is proposed for laminated glaciolacustrine silts and clayey silts of variable thickness within the old Calgary Valley drainage system south of the Midnapore district. The type reference section is represented by Test Hole 77-22. A 10 foot thick unit of DeWinton silt and clay overlies DeWinton till. The upper five feet is a well sorted, clean sand which overlies five feet of silty sand with till-like lenses.

The thickest section of DeWinton silt and clay is encountered in Test Hole 77-38 where 27 feet of medium, stone free sand overlies the youngest till. Elsewhere, the unit seldom exceeds 10 feet in thickness. A stratigraphic section illustrating the geologic relationship is shown on Figure 4-17.



Stratigraphic Profile:

DeWinton silt and clay		DeWinton till	31.5
DeWinton till		Beddington - Indus silt and clay?	
Beddington till	28.3	Indus till	37.1

VS 1:1,500
HS 1:50,000

Figure 4-17

Cross-Section Through Calgary Valley

Other Studies

An examination of over 1,000 water well records in the study area has yielded additional information, particularly with respect to preglacial and interglacial valleys. While there is an inherent danger in accepting lithologic descriptions done by water well drillers, it has been found that changes in lithology are rather well defined.

The pertinent water wells are located on Figures 1-3 to 1-6 and lithologic descriptions are appended to this thesis. A summary of significant data from the water wells is tabulated as follows:

Location	Channel Association	Remarks
NE-7-7-25-2-W5M	Calgary Valley	236 ft. of drift overlying bedrock
NE-8-7-25-2-W5M	Calgary Valley	115 ft. of drift, 83 ft. sand, overlying bedrock
NE-12-7-25-2-W5M	Calgary Valley	222 ft. of drift over bedrock
NE-14-7-25-2-W5M	Calgary Valley	240 ft. of drift over bedrock
NW-4-23-25-w-W5M	Nose Hill	92 ft. of gravels and boulders over bedrock
NE-14-22-25-2-W5M	Nose Hill	47 ft. drift, 92 gravel, over bedrock
NE-15-32-25-2-W5M	Nose Hill	70 ft. drift, 100 gravel & boulders, over bedrock

SE-2-22-29-W4M	Calgary Valley	138 ft. drift, 22' gravel, bedrock
SE-3-22-29-W4M	Calgary Valley	165 ft. drift, 24' gravel, bedrock
SE-4-22-29-W4M	Calgary Valley	136 ft. drift, 31' gravel, bedrock
SE-7-22-29-W4M	Calgary Valley	155 ft. drift, 25' gravel, bedrock
NE-31-21-28-W4M	Calgary Valley	165 ft. drift, 42' gravel, bedrock
SW-6-22-28-W4M	Highwood Valley	205 ft. drift, bedrock
SE-1-22-29-W4M	Calgary Valley	182 ft. drift, 42' gravel, bedrock
SE-34-21-28-W4M	Calgary Valley	126 ft. drift, 9' gravel, bedrock
NW-20-23-1-W5M	Calgary Valley	150 ft. drift, bedrock
NW-1-23-2-W5M	Calgary Valley	27' drift, 112' sand & gravel, bedrock
SE-5-23-2-W5M	Glenmore Chnl.	156 ft. sand & gravel, bedrock
NE-28-22-w-W5M	Fish-Lloyd Chnl.	110 ft. drift, bedrock
NE-30-22-1-W5M	"	100 ft. drift, bedrock
NE-34-21-1-W5M	Wilson Coulee	185 ft. drift, 2' gravel
SE-36-21-1-W5M	Wilson Coulee	160 ft. drift, 25' gravel, bedrock
NW 13-21-1-W5M	Wilson Coulee	84 ft. drift, 66' gravel, bedrock

CHAPTER V

GLACIAL HISTORY

General Remarks

The borehole stratigraphy and geographic distribution of the tills discussed previously, provide evidence for three and possibly four significant glaciations with the Calgary area. Ice margins were reconstructed by examining the stratigraphic sequence and distribution of subsurface units, the liquid limits, and the location and elevations of the various meltwater channels and major spillways. Considerable emphasis has been put on the use of the liquid limit parameter to determine the position and extent of the ice fronts.

Pleistocene Drainage Modifications

The preglacial and/or interglacial drainage patterns of the study area were fundamentally the same as today because of the bedrock controlled uplands, between the valleys, which restricted drainage changes. The drainage, through the glacial period, was undoubtedly modified by subsequent major ice advances. Evidence for this is provided by the number of tills which are present within the valleys.

First Glacial Event

During the First Glacial Event, ice moved eastward out of the Rocky Mountains down pre-existing glacial valleys and coalesced over the foothills to form a piedmont glacier. The eastern extent of this glacier has been traced to at least south of Shepard. Although limited till deposits associated with this advance have been uncovered to date, a number of thick glaciolacustrine sequences are found occupying the incised Calgary Valley system. Based on the data control available, it would appear that preservation of deposits associated with the First Glacial Event are confined exclusively to the ancient Calgary Valley system where they underlie the material deposited from the earliest known eastern advance.

Retreat of this ice left a number of newly created drainage valleys which became infilled by subsequent ice advances.

Second Glacial Event

The time span between the First and Second Glacial Events is unknown. There is no evidence for buried soils between these deposits and those of the preceding advance. However, deep tributary valleys to the main Calgary Valley were incised during the post-glacial period.

During the Second Glacial Event, continental ice moved westward from the Canadian Shield. The glacier associated with this advance was thick and extensive, as it covered old river valleys and all uplands within the Calgary area. The maximum westward extent of this ice mass is not known and presumably lies somewhere to the west (Jumping Pound Creek?) of the study area. The prominent Bighill Creek Valley in the northwest corner of the study area may represent an ice marginal channel for this glacial event. However, borehole data west of this valley was not acquired, so that the origin of the surficial deposits is unknown. Ice from this second event reached a minimum elevation of at least 4,350 feet a.s.l. Deglaciation during the Second Glacial Event is recorded solely by glaciolacustrine deposits within the buried Calgary Valley.

The ice mass must have remained at the eastern edge of the study area for a considerable period of time, for the till deposits are surficial units as well as occupying pre-Second Glacial Event drainage valleys, most notably the Indus Tributary Valley. A low relief morainal ridge is believed to mark a major standstill of the ice mass. The morainal ridge trends northeast - southwest through Twp. 23, Rge. 29, and culminates in a delta complex at its southwest end.

Third Glacial Event

The Third Glacial Event was the last extensive glaciation within the study area. Glacial flutings and push marks record an ice flow direction from the northeast for this event. It appears that a Cordilleran glacier within the Athabasca Valley was responsible for quarrying the quartzite erratic blocks. However, the Laurentide ice sheet was responsible for distributing the blocks as a narrow belt of erratics on the western outskirts of Calgary. The deposition of the quartzite erratics was initiated by changes in elevation, particularly bedrock uplands. As the ice thinned over these uplands, the erratics grounded out.

A small kame deposit on Cairn Hill yields a minimum elevation of 4250 feet for advance of this ice mass. Albeit thin, ice is inferred to have overrun all the bedrock controlled uplands within the Calgary area. The maximum westward limit is not attained within the study area, but probably lies in the vicinity of Jumping Pound Creek (Tharin, 1960).

Almost all the geomorphic features present within the west half of the study area are associated with the deglaciation of this ice mass. Deglaciation is characterized by numerous meltwater channels and extensive glaciolacustrine deposits as the ice mass retreated east and northeast.

An upper limit for glaciolacustrine deposition at elevation 4,340 feet is found within the Whiskey Creek valley in the southwestern part of the Priddis sheet. The assumption is made that the retreat of the Third Glacial Event ice mass was a continuous regression, with lake levels dropping as the ice retreated eastward. Impoundment of glacial waters is believed to have taken place between this ice mass and a western source ice mass further up the modern-day Bow Valley. Although lake sediments are found as high as 4,350 feet, the first major stand-still for the ice mass was at elevation 4,050 feet giving rise to the Bighill Meltwater Channel northeast of Cochrane. Stalker (1968), studying the geology of the Cochrane terraces described three major deltaic terraces above the townsite. Terraces at 4,000 feet, 3,950 feet and 3,850 feet were all considered to be the result of deposition of outwash from Bighill Creek into successive stands of Glacial Lake Calgary.

South of the Bow River, the 4,000 foot lake level is represented by the Priddis Channel trending north from Priddis to the south near Millarville. The 3,950 foot lake level does not appear to be present north of the Bow River. South of the Bow, it is assumed that the lake level dropped accordingly, but still maintained its position within the Priddis Channel.

A second still-stand occurs at elevation 3,875. North of the Bow River, in Section 15, Twp. 25, Rge. 2, the Reilly Meltwater Channel drained into open waters of the Bow Valley. The same channel can be traced south of the Bow River in Section 25, Twp. 25, Rge. 3. This channel enabled water within the Bow Valley to spill southward into the Elbow Valley. The glacial lake impounded within the Elbow Valley apparently existed independently of that occupying the Bow Valley except for the Reilly Channel connection.

The Elbow Valley drained southward at elevation 3,850 through the Lott Creek - Six Mile Coulee Channel and into the Fish Creek Basin.

A third still-stand occurs at an approximate 3,750 foot elevation. South of the Bow River, the Sarcee Meltwater Channel occupies a "side-hill" position on the east side of the Cairn Hill Upland. The south end of the channel contains a raised delta feature in Sections 1 and 2, Twp. 24, Rge. 2. North of the Bow River, the Sarcee Channel can be traced to another short channel which drains Nose Hill. A small gravel deposit, presumably a delta, occurs at the south end of this channel in Section 2, Twp. 25, Rge. 2. This channel, at elevation 3,750, permitted a second connection between the Bow and Elbow Valleys.

No evidence of glaciolacustrine deposits from the Third Glacial Event was found above elevation 3,750. It appears that this basin acted as a holding basin to carry flow from the Elbow and Priddis-Fish Creek Valleys southeastward through two parallel outlet channels into the Wilson Coulee Meltwater Channel.

A fourth still-stand occurs at an approximate elevation of 3,625 to 3,650 feet. This still-stand as well as the next three, are apparently short lived. South of the Bow River the channel crosses the Mount Royal College campus and then swings slightly eastward near Lloyd Lake and continues east until it passes south of DeWinton into Wilson Coulee. North of the Bow, the channel passes through the present area of McMahon Stadium. In addition, two other channels occur at the 3,625 elevation mark on the south and northeast sides of the Nose Hill Upland. The Highland Channel formed in the vicinity of the Highland Golf Course as ice began to stagnate on the Nose Hill Upland. This channel was developed concurrently with the bedrock incised Beddington Meltwater Channel on the northeast flank of the upland. As the ice continued to retreat eastward, continued use of the Beddington

Channel resulted in the formation of a delta as meltwater flowed into the proglacial lake, ponded between the Nose Hill Upland and the main ice mass to the east.

A fifth still-stand occurred at an elevation of 3,525 - 3,550 feet and resulted in the blockage of the interglacial Elbow Valley drainage. The meltwater channel parallels the right angle bend in the river at the Glenmore Reservoir and proceeds southward to tie into the Wilson Coulee Channel. North of the Bow River, this still-stand is reflected by the bedrock incised Nose Creek Channel.

South of Calgary, in the Ogden-Midnapore area, two other shallow channels mark retreatal stages of Glacial Bow Lake. These are the Macleod Channel at elevation 3,450 and the Bonnybrook Channel at elevation 3,350.

The last documented channel is the post-glacial Ogden Channel in which the modern-day Bow River flows. The elevation of the floor of this channel is approximately 3,300 feet.

Fourth Glacial Event

The Fourth Glacial Event was the least extensive glaciation; it reached an elevation of about 3,625 feet. This ice mass advanced from the north leaving a thin till veneer over the lowland areas except where it infilled meltwater channels from the previous glacial event. Although the southern extremity of this advance is not found within the study area, an east-west trending morainal ridge occurs south of Bow River from Twp. 19, Rge. 23, W4M toward the Town of Okotoks. This ridge is broken only by the Highwood River and Arrowwood Creek drainage systems.

An extensive, [illegible]al ridge trending northeast and lying south of [illegible]e of Shepard appears to mark a major recessional moraine in the overall retreat of eastern ice which remained essentially stationary along the eastern boundary of the study area. The south end of this ridge ends in a small delta complex. The ridge is easily traced northward along Chestermere Lake to at least Delacour.

CHAPTER VI

SUMMARY AND CONCLUSIONS

1. The Pleistocene stratigraphy of the Calgary area is recorded by deposits associated with four distinct glacial events. The oldest glacial event is inferred from fragmentary evidence of an early Cordilleran ice source. The other three glacial events are associated with the advance of Laurentide ice. The following composite stratigraphic column, from youngest to oldest, has been determined for the Calgary area:

DeWinton silt and clay	Fourth Glacial Event
DeWinton till	
Beddington silt and clay	Third Glacial Event
Beddington till	
Indus silt and clay	Second Glacial Event
Indus till	
Glenbow silt and clay	First Glacial Event
Glenbow till	
Saskatchewan gravel and sand	
Paskapoo Bedrock.	

The stratigraphic relationships of the proglacial lake sediments and tills to the ice fronts provides evidence that the Cordilleran and Laurentide ice-maxima during each glacial event were not synchronous and that the valley glaciers had receded considerably before the continental ice sheet advanced into the Calgary area.

2. In this study, the stratigraphy has been elucidated by application of a new approach to till differentiation and correlation - namely, utilization of the liquid limit parameter. This technique is strictly a subsurface tool, since it is a prerequisite to minimize weathering and reworking influences in order to successfully apply the method. By means of key test holes containing multiple till sections, a number of till advances have been identified - each associated with a distinct glacial event. The characteristic liquid limit of each basic till unit, from youngest to oldest, is summarized as follows:

DeWinton till	31.8
Beddington till	28.4
Indus till	35.6
Cochrane till	18.3.

3. It has been observed that while other physical properties can vary laterally and vertically, the liquid limit parameter is remarkably consistent. Variations in liquid limit values are relatively easy to interpret in spite of many possible influential factors. Success of the method lies

in the apparent ease by which the well mixed matrix material yields a diagnostic limit value. The contrast in limit value among the various till units is due solely to incorporation of pre-existing drift material and bedrock coupled with rapid mixing within the till matrix.

Experimentation with a limited number of geophysical logs indicates another potentially powerful technique for till differentiation and correlation. In particular, the gamma ray log is an extremely versatile log. It can be used to accurately locate the top and bottom of beds, to define whether the contact is sharp or gradational, and to indicate the relative clay content. The log is very useful in determining depositional characteristics of the various sediments in terms of stable, fining upward or coarsening downward sequences.

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APPENDIX A

LEGEND

▦ Fill

▨ Till

░ Glaciolacustrine silt, sand, clay

▩ Sand and Gravel

▤ Bedrock

◩ Mixed Lithology

☒ No sample recovery

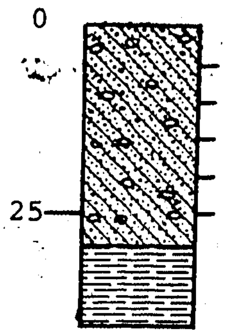
LL = liquid limit (%)
MC = moisture content (%)
S/(M+C) = sand/(sand + silt) ratio
I/(I+M) = illite/(illite + montmorillonite) ratio
CC = calcium carbonate equivalent (%)
IM = igneous-metamorphic content (%)

S.E.-4-16-25-29-W4M = southeast corner, legal subdivision 4, section 16, township 25, range 29, west of the Fourth Meridian

elev. 3560

74-4

S.E.-4-16-25-29-W4M



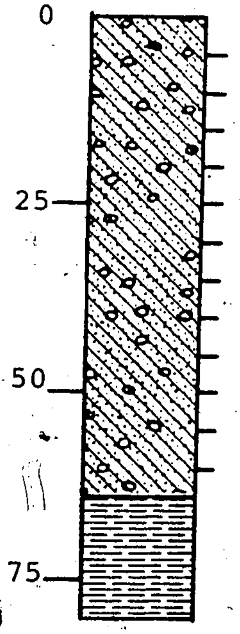
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
33.1	0.30			22.3	31.5?
25.5	0.57	15.2	6.7	20.9	
29.2	0.63	11.5		23.6	
27.4	0.58	12.3	3.2	19.3	27.6 ± 1.5
28.3	0.40	10.5		22.7	

0-26	Till, sandy silt, olive brown, low stone content but stoney 20 - 25 ft.
26-40	Bedrock, shale, grey

elev. 3560

74-6

S.E.-1-26-25-1-W5M



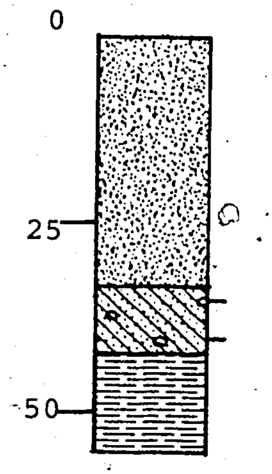
LL	$\frac{S}{M+C}$	MC	CC	IM	Remarks
30.7	0.34	15.8	14.8		
29.8	0.36	12.9	13.0	6.5	
27.8	0.36	15.2	14.3		
29.7	0.36	14.6	15.9	0.6	
26.3	0.36	15.3	13.0	9.2	27.3 ± 2.3
28.6	0.35	14.0	14.8		
25.3	0.38	14.1	16.1		
28.6	0.36	12.8	15.0	3.1	
25.7	0.29	15.1	17.3		
27.0	0.38	14.9	18.0	0.7	
24.7	0.39	16.2	14.5		
23.2	0.31	15.7	15.9		

0-69	Till, sandy silt, olive brown to 55 feet then grey in color; low pebble content and generally small in size; wet at 36 feet, stoney from 56 - 64 feet
69-80	Bedrock, shale, grey, very hard

elev. 3525

74-9

N.E.-16-22-25-1-W5M



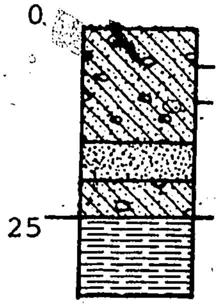
LL	$\frac{S}{M+C}$	MC	Remarks
24.7	0.31	14.2	26.1 ± 1.9
27.5	0.29	13.7	

0-33	Silt and clay, yellow brown, crudely bedded occasional stones
33-42	Till, silty, greyish-yellow, abundant small pebbles, dry
42-55	Bedrock, shale, grey

elev. 3535

74-11

S.W.-1-15-25-1-W5M



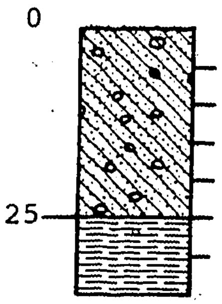
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
31.1	0.19	10.1		22.0	
32.3	0.18	17.2		18.4	31.7 ± 0.8
27.7	0.19	13.7	8.2	20.0	27.7

0-15	Lacustro-Till, yellow brown turning to olive brown at 10 ft., pebbles scarce, crudely bedded, clayey silt
15-20	Sand, yellow, well sorted, some stones
20-25	Till, olive brown, silty sand
25-35	Bedrock, siltstone, brown

elev. 3630

74-15

S.W.-4-34-25-1-W5M



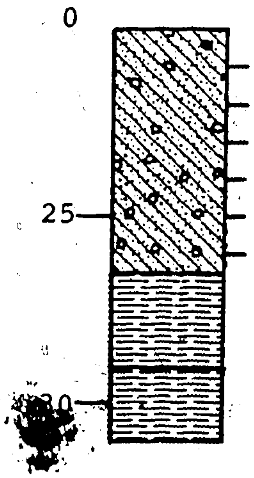
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
37.0	0.17	20.5		28.9	weathered
26.0	0.19	16.5		19.5	28.0 ± 2.7
29.9	0.18	15.1		19.1	
33.8	0.21	13.9		16.4	transitional
32.5					

0-20 Till, sandy silt, olive brown, stoney
20-30 Bedrock, shale, yellow

elev. 3655

74-18

S.E.-1-20-25-1-W5M



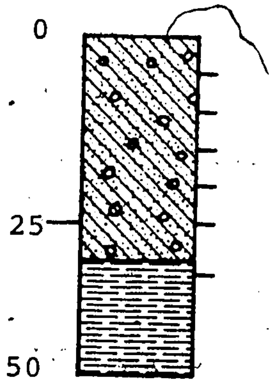
LL	$\frac{S}{M+C}$	MC	IM	C	Remarks
25.4	0.27	10.7		20.0	
26.7	0.21	11.8	6.5	24.5	
27.7	0.23	14.7		24.3	27.4 ± 1.8
29.7		13.0	11.3	28.6	
32.1	0.81	10.8		16.4	transitional?
33.0	0.65	9.9		15.2	bedrock till
34.8	0.56	17.6		30.2	
39.7	0.02	13.6		1.1	
41.4	0.01	12.8		0.9	
37.5	0.08	8.5		0.2	

0-20	Till, sandy silt, olive brown, moderately stoney
20-33	Bedrock-Till, yellow-brown, dry, abundant bedrock fragments
33-55	Bedrock, shale, light yellow

elev. 3775

74-19

S.W.-4-16-25-1-W5M

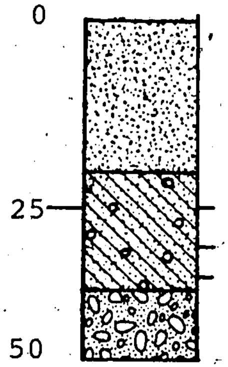


LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
36.2	0.15	16.3		27.5	weathered
29.2	0.35	12.3	7.7	22.0	
27.9	0.48	9.7		23.9	28.5 ± 0.6
28.3	0.31	12.2	0.9	22.9	
37.4	0.08	13.6		14.5	37.4
27.3	0.08	7.1		27.5	

0-26 Till, sandy silt, olive brown, upper 5 ft. is laminated, stoney in part, rocky 22 - 25 ft.
26-45 Bedrock, shale, yellow

elev. 3735

74-24 S.E.-1-36-25-2-W5M



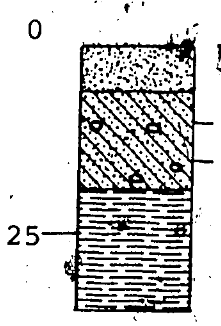
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
31.7	0.20	10.9		18.6	
34.1		11.3		19.3	colluviated
31.7	0.25	13.2		18.9	till
34.4		16.6		15.7	
31.7	0.18	17.7		15.7	
26.3		10.0	0.9		
28.2	0.21	11.5			28.7 ± 2.7
27.3	0.63	0.62		18.	

0-20 Lacustro-Till, silty clay, laminated, occasional pebbles
20-35 Till, silty clay, yellow-brown, stoney
35-45 Gravel, sandy, very coarse, unable to penetrate

elev. 4040

74-28

S.W.-4-18-25-1-W5M



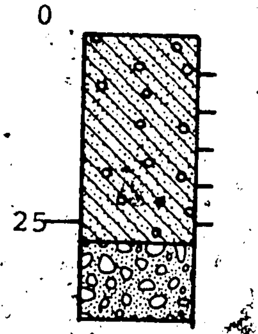
LL	MC	Remarks
28.1	9.9	
27.6	12.2	27.9 ± 0.3

0- 6	Silt and Clay, yellow brown, banded, some pebbles
6-18	Till, sandy silt, olive brown, stoney
18-35	Bedrock, siltstone, dull yellow

elev. 4110

74-29

S.W.-4-24-25-2-W5M



LL	MC	$\frac{S}{M+C}$	CC	Remarks
28.9	13.8	0.27	31.1	27.9 ± 1.4
26.8	15.1		27.4	
38.3	16.3	0.18	15.7	
37.2	15.4		[illegible]	36.6 ± 2.0
34.4	14.6	0.27	20.4	
	7.9		20.9	
	5.8			

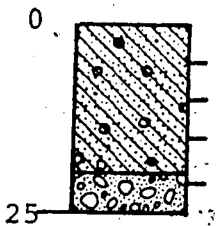
0-27 Till, sandy silt, yellow olive-brown, stoney, some banding, grading to silty clay

27-37 Gravel, sandy, yellow

elev. 4090

74-3(

N.E.-16-23-25-2-W5M



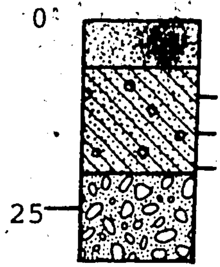
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
33.6	0.22	16.6		19.8	
34.9		12.8		23.6	
36.3	0.24	13.0		15.9	34.9 ± 1.3
24.2	0.84	6.1			

0-17 Till, silty clay, olive brown, stoney, sand stringers
17-30 Gravel, sandy, unable to penetrate

elev. 4105

74-32

N.W.-5-35-25-2-W5M



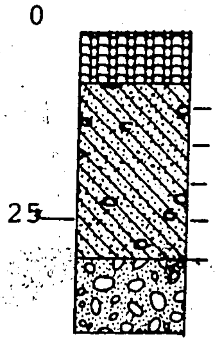
LL	$\frac{S}{M+C}$	MC	CC	Remarks
28.2	0.20	13.4	15.9	27.8 ± 0.6
27.3	0.22	16.5	21.1	
36.8	0.51	14.1		36.8

0- 7	Sand and clay, yellow brown, some rafted pebbles
7-20	Till, clay, greyish yellow grading to olive brown, stoney
20-32	Sand and gravel, yellow, unable to penetrate

elev. 4125

74-33

S.E.-1-27-25-2-W5M



LL	MC	Remarks
36.4	16.8	
35.3	16.8	36.7 ± 1.5
38.4	16.5	
29.8	18.2	transitional
25.3	12.1	gravel influence

0- 7 Fill

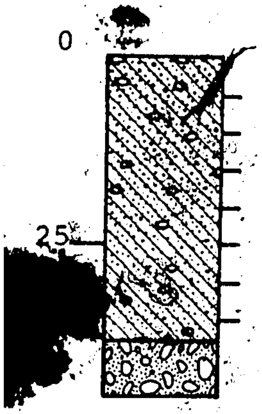
7-30 Till, clayey, olive brown, some sand stringers, stoney

30-40 Sand and gravel, yellow brown, granite pebbles unable to penetrate

elev. 4110

74-34

S.W.-4-23-25-2-W5M



LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
36.5	0.36	15.8		20.5	slump
35.1	0.37	14.0		21.6	till & lake
29.4	0.37	13.3		23.0	mixed?
30.2	0.36	16.8		30.9	
28.9	0.44	15.2		30.5	
29.5	0.32	17.4	2.1	31.4	29.6 ± 0.5
29.5	0.40	16.5		28.6	

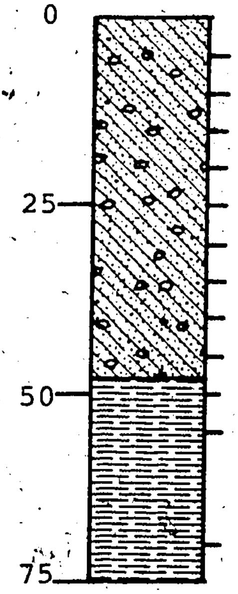
0-39 Till, sandy silt, olive brown, stoney layer 17 - 20 ft.

39-45 Gravel, sandy, unable to penetrate

elev. 3795

74-40

[illegible]W.-13-2-24-2-W5M

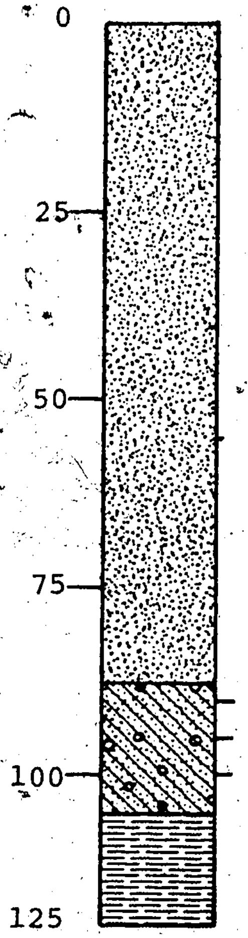


LL	S/M+C	MC	IM	CC	Remarks
29.7	0.28	15.3		17.7	
28.4	0.29	15.6	1.7	17.8	
28.3	0.27	14.7		16.4	29.0 ± 0.7
29.7	0.28	15.0	3.3	17.5	
28.7	0.23	15.7		17.3	-------------
35.0	0.23	14.2		17.5	
35.3	0.25	15.0		17.7	
34.8	[illegible]	14.7		17.5	35.6 ± 1.2
37.5	[illegible]	14.7		20.5	
38.3	[illegible]	14.7		16.1	
39.9	[illegible]	14.3		18.2	
41.4	0.05	12.0			

0-40 Till, clay, greyish-yellow stoney
40-55 Bedrock-Till, yellow brown, numerous clay nodules
55-75 Bedrock, shale, grey

elev. 3640

74-41 S.W.-4-2-24-2-W5M



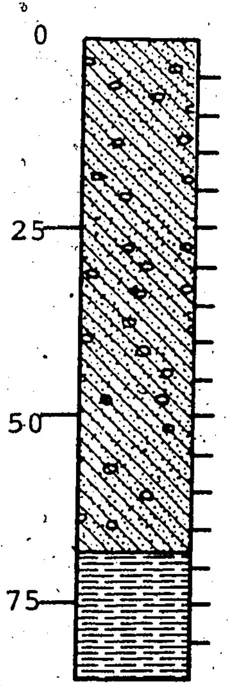
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
27.5	0.16	21.1		24.5	
29.2	0.17	16.1		23.2	28.[illegible] ± 0.8
28.3	0.07	20.9	4.7	26.4	
		14.2		13.9	

0- 85	Clay, silty, yellow-brown, becoming grey at 25 ft., laminated
85-105	Till, sandy silt, moderately stoney
105-120	Bedrock, shale, grey.

elev. 3925

74-44

S.W.-4-15-24-2-W5M



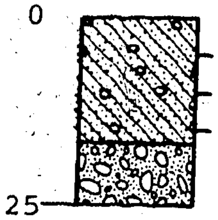
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
31.1	0.25	17.7		20.9	
32.8	0.25	13.5	9.8	15.7	
32.0	0.27	12.5		19.1	
31.7	0.22	13.8		18.0	
30.9	0.35	11.7	[illegible]	21.8	31.4 ± 1.7
33.1	0.28	[illegible]		18.2	
32.3	0.27	14.1	0.8	18.4	
31.9	0.27	13.3	2.6	17.7	
32.2	0.29	14.8	7.1	17.6	
30.2	0.32	15.1		18.2	
26.4	0.31	13.4		18.4	
31.6	0.30	14.4	0.3	18.8	----------------
37.5	0.15	12.5		17.9	
36.5	0.12	21.6		19.5	37.5
38.8	0.05	24.4			
35.2	0.24	14.0		36.4	

0- 3	Silt, sandy, yellow
3-68	Till, clayey silt, olive brown, stoney, sand stringers
68-85	Bedrock-Till, olive brown

elev. 4045

74-45

S.E.-1-21-24-2-W5M



LL	$\frac{S}{M+C}$	MC	CC	Remarks
26.6	0.39	15.0	23.0	
26.6	0.41	10.5	22.7	26.2 ± 0.7
25.3	0.44	9.1	18.9	

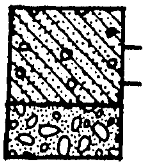
0-17 Till, silty clay, olive brown, stoney
17-25 Gravel, dirty; unable to penetrate

elev. 4060

74-46

S.W.-4-27-24-2-W5M

0



25

LL	$\frac{S}{M+C}$	MC	CC	Remarks
28.1	0.41	8.1	29.5	
27.3	0.49	9.7	26.4	27.7 ± 0.5

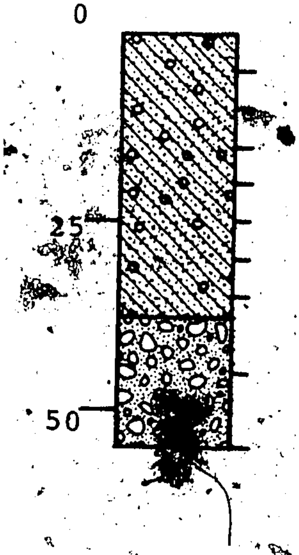
0-13 Till, sandy clay, olive brown, stoney

13-24 Gravel, yellow brown, sandy, unable to penetrate

elev. 4150

74-53

S.W.-4-34-25-2-W5M



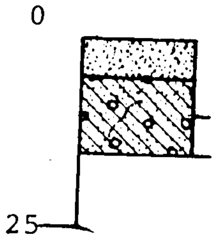
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
37.9	0.20	16.5		20.0	
34.7	0.19	14.3		16.4	
34.1	0.17	15.1		25.2	
36.7	0.18	16.0		24.5	35.4 ± 1.7
35.4	0.20	15.9		16.1	
36.5	0.22	13.9		21.6	
32.6	0.42	12.5		25.2	
		8.8			
25.0	0.72	11.8			
		11.6			
26.6	0.55	8.7			

0-38 Till, silty clay, yellow brown, stoney
38-55 Gravel, sandy, yellow brown, clayey

elev. 4180

74-55

S.E.-1-29-25-2-W5M



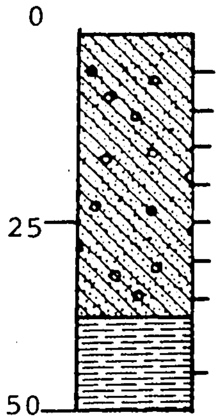
LL	Remarks
28.9	28.3 ± 0.8
27.7	

0- 5 Till with interbeds of silt, lcaustro-till?, yellow-brown, sandy silt

5-15 Till, sandy clay, olive grey, stoney, unable to penetrate

elev. 3875

74-57 S.W.-4-16-25-2-W5M



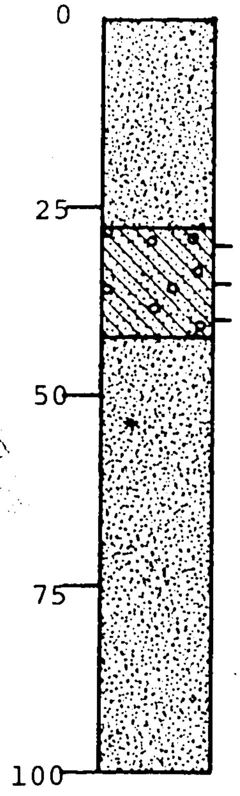
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
35.0	0.27	12.8		20.2	weathered
30.5	0.29	13.2		20.5	
30.4	0.28	13.8		22.0	
35.3	0.24	17.3		20.2	
30.4	0.26	17.8		17.3	29.9 + 1.8
26.8	0.57	15.9		20.0	
31.8	0.27	13.9		18.6	
		8.0			
23.4	0.79	8.0			

0-38	Till, sandy silt, olive brown, stoney layers, some crude local bedding, lacustro-till
38-50	Bedrock, sandstone, yellow-brown

elev. 3745

74-58

S.E.-1-8-25-2-W5M



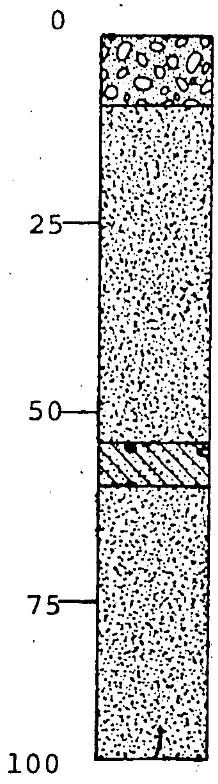
LL	S / M+C	MC	IM	CC	Remarks
36.5	0.18	16.0		24.8	
35.1	0.18	17.4		18.4	35.8 ± 0.9
27.8	0.18	16.2		20.7	transitional
	0.10	17.5		23.2	
46.1	0.01	21.2			

0- 28	Clay, olive brown, laminated, some stones
28- 50	Till, silty clay, olive brown, stoney, granite pebbles
50-100	Clay, brown blue to yellow grey, very plastic, trace stones

elev. 3685

74-59

N.W.-13-33-24-2-W5M

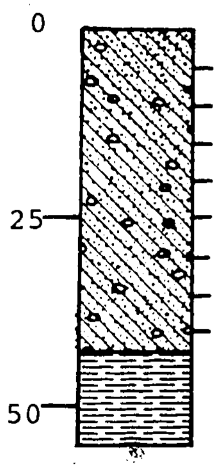


0- 9	Sand and gravel
9-54	Clay, silty olive blue, rare stones, minor sand interbeds
54-59	Till (?), olive blue, stoney, interbedded with sand
59-96	Clay, yellow grey, plastic

elev. 3775

74-60

S.W.-4-33-24-2-W5M



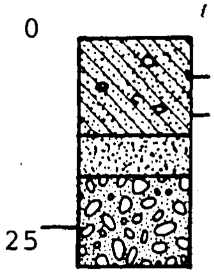
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
26.2	0.69	26.3		22.0	
24.8	0.46	13.7	7.3	28.0	
27.5	0.43	12.7	3.2	23.0	
27.4	0.43	13.4		22.3	26.1 ± 1.3
25.0	0.44	13.7	6.8	37.7	
24.3	0.41	15.1		23.2	
26.1	0.39	16.2		10.9	
27.8	0.28	14.0	1.4	22.3	

0-43 Till, sandy silt, olive brown, stoney
43-55 Bedrock, sandstone, brown

elev. 4095

74-61

S.W.-4-28-24-2-W5M



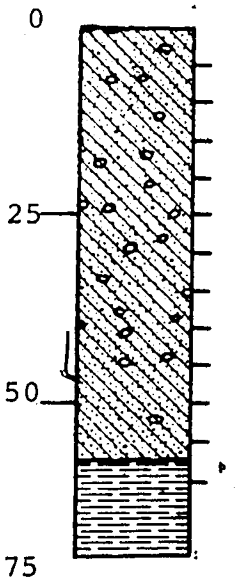
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
26.7	0.39	12.7		21.6	
28.2	0.21	14.9		21.4	27.5 ± 1.1
	0.05			20.9	
31.3		22.4			

0-14	Till, sandy silt, olive brown, stoney at top but decreasing with depth
14-18	Silt, clayey, olive brown, laminated
18-30	Gravel, sandy, brown, unable to penetrate

elev. 3900

74-63

S.E.-1-17-24-2-W5M



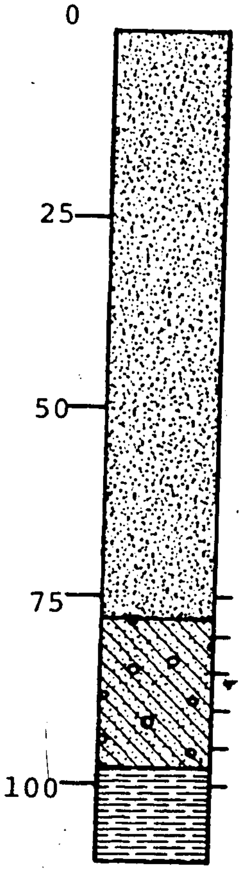
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
31.5	0.29	14.1		21.6	
28.6	0.38	14.0		23.0	
27.2	0.29	14.9	2.9	19.5	
28.4	0.37	13.7		21.4	
29.5	0.33	15.5	3.7	20.5	28.2 ± 1.9
31.2	0.27	15.4	4.8	15.2	
27.9	0.16	16.0		15.7	
26.6	0.17	15.6		14.8	
26.9	0.21	14.3	6.0	16.6	
26.9	0.50	15.2	1.4	24.1	
25.2	0.36	13.5		21.6	
38.3	0.02	21.4			

0-57	Till, sandy silt, olive brown, stoney, sand pockets
57-70	Bedrock, shale, olive brown

elev. 3680

74-64

N.W.-13-4-24-2-W5M



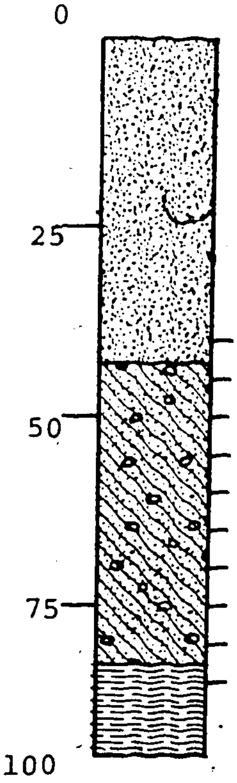
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
	0.13	25.0		18.0	
26.3	0.46	13.7		18.9	
26.7	0.25	17.1		16.8	
29.8	0.24	18.3		15.5	27.4 ± 1.6
26.6	0.23	18.3		17.0	
27.3	0.09	21.1		9.5	

0- 30	Clay, olive brown, laminated, some stones
30- 77	Sand, grey, wet
77- 97	Till, silty clay, grey, stoney
97-110	Bedrock, shale, grey

elev. 3630

74-65

S.W.-4-4-24-2-W5M



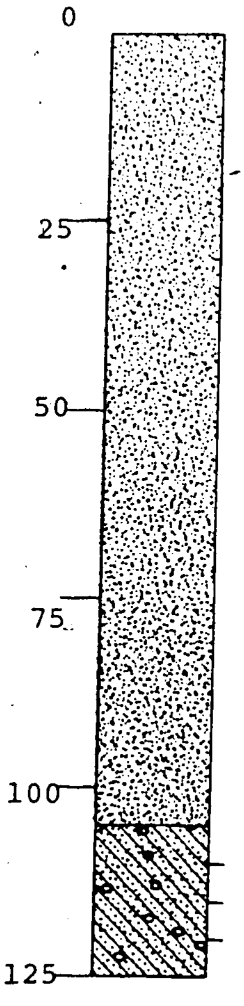
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
35.2	0.13	26.2		16.6	
25.7	0.34	13.1		18.0	
24.9	0.27	11.4	1.2	17.7	
22.6	0.41	10.8		19.5	
23.2	0.44	18.5		19.1	25.7 ± 2.3
29.5	0.18	15.3	3.1	15.0	
26.9	0.28	16.8		14.1	
24.8	0.28	15.2	1.7	16.8	
27.9	0.17	12.6		21.6	
42.2	0.05	12.7		3.0	

0-13	Gravel, sandy
13-43	Clay, olive blue, sandy in part, very plastic
43-83	Till, sandy silt, grey, stoney at top grading to low content within 20 ft.
83-95	Bedrock, shale, olive grey

elev. 3795

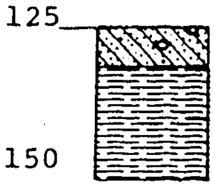
74-68

S.E.-1-18-24-2-W5M



LL	MC	Remarks
28.1	18.1	
27.3	17.6	26.9 ± 1.1
26.8	17.4	
25.4	16.5	

74-68 (cont'd.)

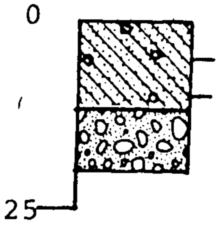


0- 30	Clay, silty, yellow brown, laminated
30- 55	Silt, clayey, olive brown, trace stones
55-105	Sand, clayey, grey, very wet
105-129	Till, grey, stoney layers at 105 - 107, and 122 - 129, sandy silt
129-145	Bedrock, shale, grey

elev. 4155

74-69

S.E.-16-18-24-2-W5M



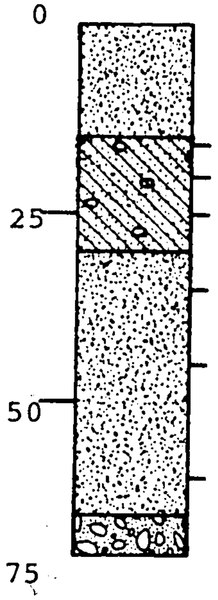
LL	$\frac{S}{M+C}$	MC	CC	Remarks
28.1	0.39	13.9	25.0	27.0 ± 1.5
25.9	0.42	12.7	24.7	

0-12	Till, silty clay, dark greyish-yellow, moderately stoney
12-20	Gravel and sand, brown, coarse, unable to penetrate

elev. 3750

74-73

S.E.-8-7-25-2-W5M



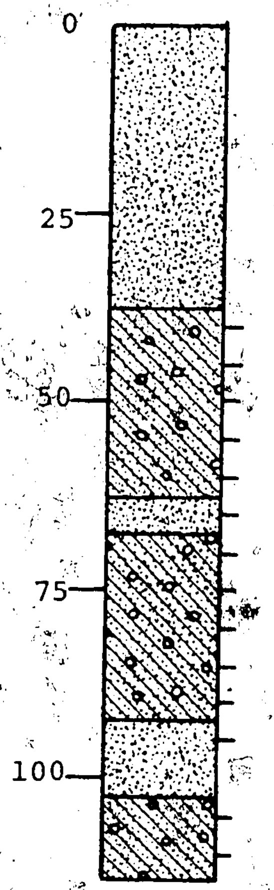
LL	$\frac{S}{M+C}$	MC	Remarks
46.1	0.01		
35.2			
34.6			35.5 ± 1.1
36.8			
46.1	0.01	22.7	
		21.8	
27.3	0.27	11.8	
		11.3	
		8.0	
22.6	0.95	8.2	

0-15	Silt and clay, yellow brown, clay-silt at top grading to sandy silt at base
15-30	Till, silty clay, moderately stoney, olive brown
30-65	Silt and clay, yellow brown, clayey silt grading to clean grey sand at base
65-70	Gravel, sandy

elev. 3830

74-74

N.W.-13-8-25-2-W5M



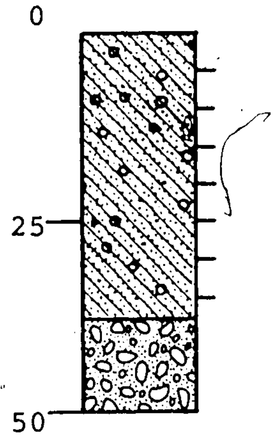
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
31.6	0.11	19.4		20.9	
	0.10	17.0		18.4	
31.6	0.14	16.1		18.0	31.5 ± 0.8
32.0	0.12	16.0		19.1	
32.3	0.11	18.9		20.2	
30.2	0.05	22.6		18.4	
------					-------------
27.7	0.05	19.0		25.5	
28.1	0.23	19.0	8.0	21.6	
28.3	0.24	16.9		20.2	
27.7	0.22	16.5	3.1	19.5	
28.9	0.19	16.0		23.2	28.3 ± 0.8
17.7	0.07	20.3		32.5	
27.7	0.26	17.1		20.2	
29.8	0.30	13.1	7.7	17.7	

0- 37	Clay & silt, olive brown, some stones, quite stoney 20 - 25 ft., lacustro-till?
37- 63	Till (?), clay, low stone content, crudely bedded
63- 68	Clay, olive brown, pebbly
68- 93	Till, sandy silt, olive grey, moderately stoney
93-104	Lacustro-Till (?), yellow grey, stoney but laminated
104-117	Till, sandy silt, yellow grey, stoney, unable to penetrate further, too sticky

elev. 4160

74-76

N.E.-16-19-25-2-W5M



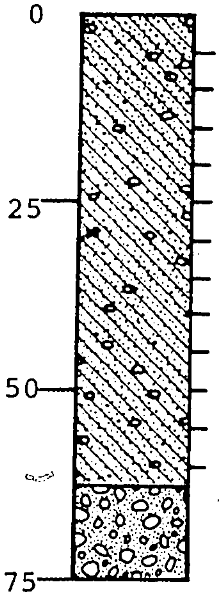
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
39.7	0.18	15.4		18.2	
35.8	0.25	13.1		19.8	
33.5	0.30	12.1		19.3	
34.8	0.28	11.3		17.7	35.6 ± 1.9
35.2	0.27	12.7		18.0	
35.0	0.27	12.3		18.6	
35.3	0.28	13.3			

0-37	Till, silty clay, olive brown, stoney
37-50	Gravel, sandy, unable to penetrate, mostly quartzite, carbonates and sandstone

elev. 4220

74-77

S.E.-1-31-25-2-W5M



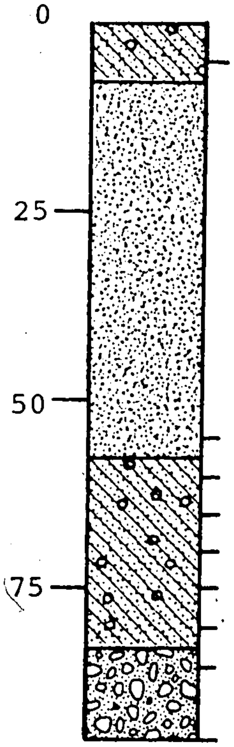
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
35.9	0.18	13.1		27.3	Weathered?
32.7	0.25	15.0		18.0	------------
28.0	0.30	10.3		23.4	
26.3	0.30	11.1		22.7	
27.4	0.33	11.5			28.8
28.8	0.33	9.6		26.4	28.2 ± 1.0
28.4	0.35	11.2		25.7	
29.2	0.32	11.8		27.0	
29.4	0.33	9.8		34.1	
34.1	0.20	14.2		20.9	
35.3	0.18	13.3		18.4	35.4 ± 1.3
36.7	0.30	10.8		25.0	

0-63	Till, sandy silt grading to silty clay, olive brown, stoney
63-75	Gravel, sandy, unable to penetrate

elev. 4255

74-78

S.W.-4-31-25-2-W5M



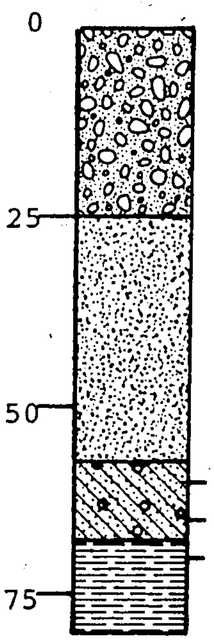
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
31.3	0.01	21.1			
32.8	0.04	21.6			
25.8	0.67	16.9		20.2	
27.4	0.28	15.5	3.1	20.2	27.4 ± 1.6
28.3	0.20	16.4		16.6	
25.9	0.30	16.2	0.5	20.9	
29.8	0.32	18.5	2.0	24.1	
25.8		17.3		24.1	
		9.8			
24.2	0.52	10.8			

0- 8	Till, olive brown, bedded, stoney clay?
8-57	Clay, silty, greyish yellow, plastic, some sand lenses
57-83	Till, sandy silt, grey, low stone content with some stoney layers
83-95	Gravel, sandy, dirty

elev. 3685

74-82

N.W.-13-6-25-2-W5M



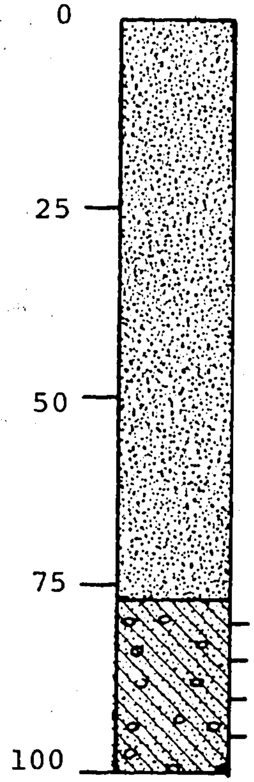
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
25.2	0.27	15.5	3.3	35.9	
27.3	0.39	13.2	1.4	23.6	26.3 ± 1.4
32.8	0.11	30.8		11.1	

0-25	Gravel, sandy, some lenses of yellow clay
25-58	Clay, yellow grey to grey, silty partings, stiff
58-68	Till, sandy silt, yellow grey, stoney
68-80	Bedrock, shale, blue grey

elev. 3835

74-83

S.E.-16-36-24-3-W5M



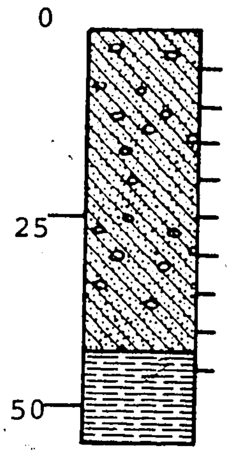
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
32.9	0.28	15.7		20.0	
31.0	0.25	16.1		20.2	
33.2	0.23	16.4		20.7	32.5 ± 1.0
33.0	0.22	18.2		19.8	

0- 77	Clay, silty, interbeds of silt and sand, olive brown, laminated in part
77-100	Till, clayey silt, olive brown, stoney

elev. 4005

74-85

N.W.-13-19-24-2-W5M



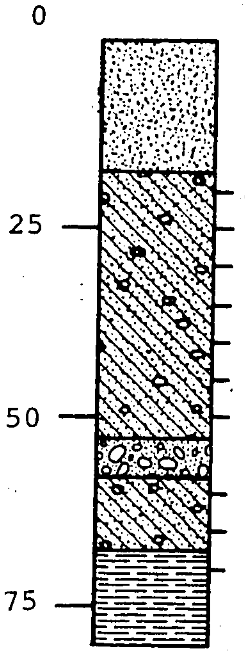
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
32.5	0.23	13.9		22.7	
33.5	0.23	13.6		19.5	
27.1	0.23	13.6	7.7	21.1	
32.8	0.23	13.7	5.4	19.5	
32.9	0.25	13.5	1.3	19.5	31.6 ± 2.2
29.6	0.30	14.7		19.3	
33.5	0.28	14.9	6.8	23.4	
31.1	0.28	12.4		19.3	
28.1	0.15	6.3			

0-43	Till, clayey silt, olive brown, moderately stoney
43-55	Bedrock, shale, yellow

elev. 3890

74-86

S.W.-4-19-24-2-W5M

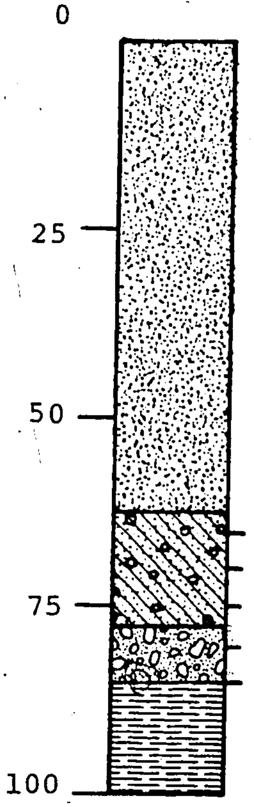


LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
33.3	0.18	20.4		14.1	weathered
33.4	0.18	19.8		14.3	weathered
26.4	0.30	15.1		15.0	
29.1	0.30	16.4	3.7	19.1	
25.9	0.32	15.2		24.3	
27.4	0.30	15.1		17.7	27.7 ± 1.1
28.0	0.35	13.6	2.1	18.0	
29.0	0.28	16.5		18.0	
28.6	0.28	19.1	2.0	17.9	
27.3	0.28	8.1		8.9	

0-17	Lacustro-Till, clay, olive brown, banded, some stones
17-53	Till, sandy silt, olive brown, moderately stoney, sand lenses
53-57	Gravel
57-67	Till, silt, olive brown, low stone content
67-80	Bedrock, shale, yellow

elev. 3785

74-87 S.W.-4-18-24-2-W5M



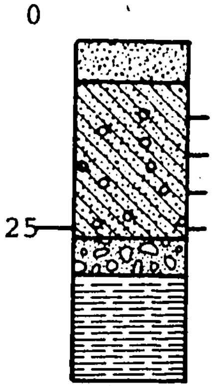
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
22.9	0.32	18.6		18.0	
22.3	0.37	16.8		15.0	22.5 ± 0.3
22.3	0.61	14.1		36.1	
22.6		7.9			
19.7		8.3			

0-62	Clay, silty, greyish-yellow, laminated, sandy in part
62-77	Till, sand, clayey, yellow brown, stoney
77-85	Gravel, clean, wet
85-100	Bedrock, shale, olive grey

elev. 3450

75-1

S.E.-1-1-22-1-W5M



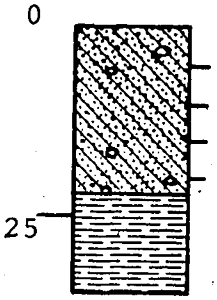
LL	$\frac{S}{M+C}$	MC	IM	CC	Remarks
37.1	0.25				37.2 ± 0.3
37.3	0.30				
36.9	0.28				
37.5	0.41				

0- 2	Silt, pebbly, oxidized
2- 6	Sand and gravel, coarse
6-25	Till, silty clay
25-31	Sand and gravel, coarse
31-	Bedrock, unable to penetrate

elev. 3550

75-7

S.W.-5-1-21-28-W4M



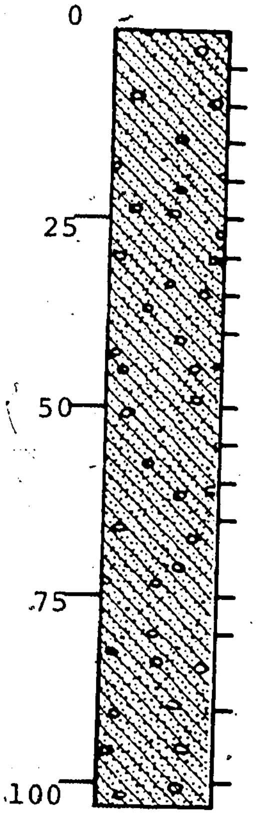
LL	$\frac{S}{M+C}$	Remarks
32.1	0.41	
33.1	0.49	
31.7	0.41	32.2 ± 0.6
31.8	0.41	

0-20	Till, brown, silty clay
20-28	Bedrock, siltstone

elev. 3650

75-14

S.W.-12-34-21-1-W5M



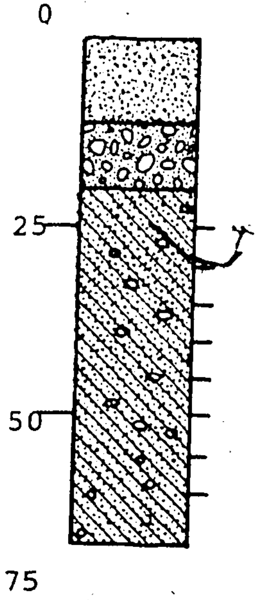
LL	$\frac{S}{M+C}$	IM	Remarks
31.3	0.19		
32.5	0.23	0.4	
32.0	0.23		
31.2	0.25		
32.7	0.23	0.3	
31.0	0.22		
31.5	0.23		
30.7	0.23	0.6	
31.2	0.27	1.1	31.7 ± 0.9
30.7	0.25	0.4	
31.6	0.25	0.3	
31.3	0.27	0.3	
30.2	0.23	0.6	
32.2	0.25	0.7	
32.8	0.25	1.3	
33.6	0.25	0.6	

0-103 Till, grey, clayey silt, 5% pebbles consistent throughout

elev. 3950

75-17

S.E.-3-34-21-2-W5M



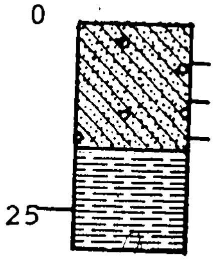
LL	$\frac{S}{M+C}$	Remarks
37.2	0.27	
36.8	0.32	
35.4	0.33	
35.9	0.33	
35.6	0.35	36.3 ± 0.7
37.0	0.33	
36.3		
27.4		sand lens

0-12	Silt, clayey, yellow brown
12-15	Till, brown, sandy
15-20	Gravel, silty, sandy
20-63	Till, black, silty clay
63-	Sand?, hole terminated due to flowing artesian well

elev. 3780

75-24

S.W.-4-27-22-2-W5M



LL

28.0
28.6
29.1

Remarks

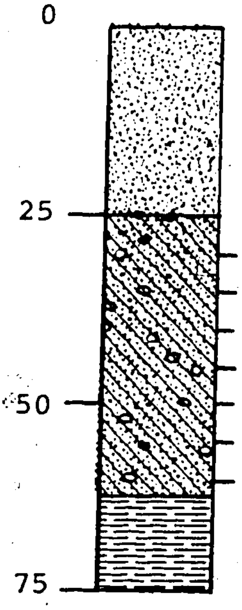
28.6 ± 0.5

0-14	Till, brown, sandy silt
14-23	Bedrock, interbedded sandstone and shale
23-28	Bedrock, shale

elev. 3680

75-26

S.W.-4-19-22-1-W5M



LL

27.7
28.2
29.1
27.9
28.7
26.9
30.4

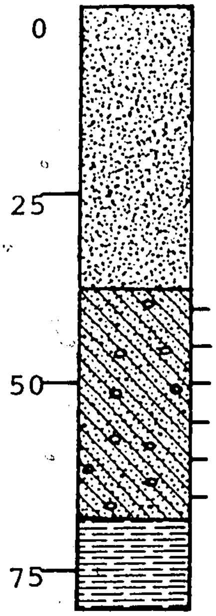
Remarks

28.4 ± 1.1

0-25	Clay, varved, brown
25-62	Till, brown, sandy silt
62-70	Bedrock, interbedded sandstone and shale
70-72	Bedrock, shale

elev. 3600

75-27 S.E.-13-19-23-1-W5M



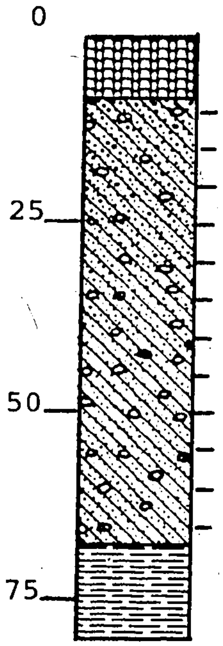
LL	$\frac{S}{M+C}$	$\frac{I}{I+M}$	Remarks
30.2	0.35	0.71	
29.1	0.39		
28.7	0.33		
29.4	0.27		29.8 ± 1.0
29.9	0.28		
31.7	0.23		

0-45	Silt + Clay, interbedded brown, grey sand lenses at 13 - 14 ft. and 28 - 29 ft.
45-70	Till, brown, sandy silt
70-74	Bedrock, sandstone

elev. 3460

76-3

S.W.-4-3-25-28-W4M



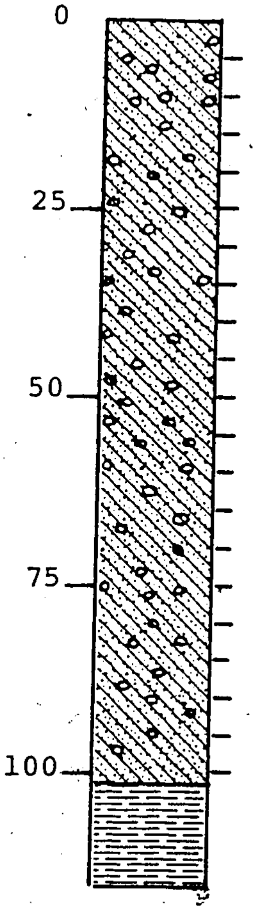
LL	MC	Remarks
36.3	16.4	weathered or fill
33.9	14.3	
30.3	12.5	31.8 ± 0.7
31.8	16.8	
31.3	13.1	----------------------
34.3	14.7	
33.9	15.3	
35.5	16.4	35.7 ± 2.0
34.4	14.7	
36.2	16.0	
35.6		
39.9		

0- 7	Fill & Organics
7-63	Till, silt, greyish brown to 23 ft.; dark grey 23 ft. to base, grading to silty clay
63-68	Bedrock, shale, bluish green

elev. 3470

76-10

S.W.-4-15-25-28-W4M



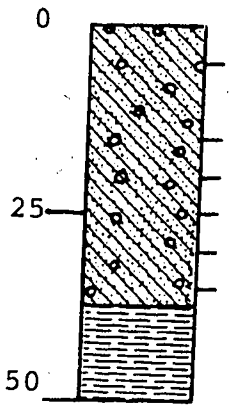
LL	MC	$\frac{I}{I+M}$	Remarks
35.6	14.8	0.83	
35.5	15.3		
32.2	12.0	0.64	
33.3	12.2		
33.3	14.3	0.65	
36.9	14.4	0.73	
38.4	15.2		
33.9	16.8		35.9 ± 2.1
35.2	16.0	0.54	
36.8	16.2		
38.3	16.3		
37.9	16.7	0.65	
36.0	16.3		
36.1			
33.8	16.9	0.62	
35.6	16.4		
33.8	15.7		
39.6	15.0		
39.0	16.3	0.68	
31.9	16.6		

0-100	Till, silty, coal and granite pebbles, greyish brown to 43 ft., dark grey 43 ft. to base
100-101	Bedrock, shale, light green

elev. 3570

76-16

S.E.-1-2-25-29-W4M



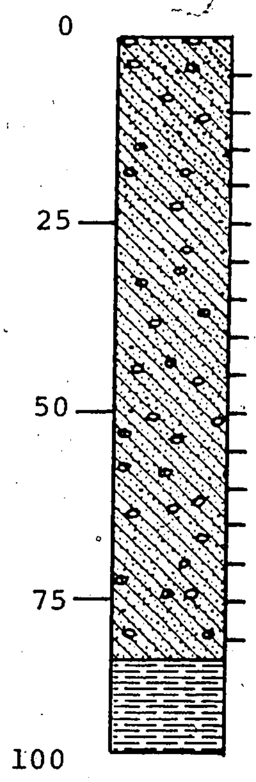
LL	$\frac{S}{M+C}$	MC	IM	Remarks
37.3	0.39	15.2	36.9	
34.9	0.42	14.6	4.5	
34.5	0.23	13.2	5.5	
20.9		13.5	1.4	
35.7	0.18	13.6	11.9	35.4 + 1.1
36.3		12.1	1.5	

0-36	Till, sandy silt, dark greyish-brown
36-50	Bedrock, shale

elev. 3520

76-17

S.E.-1-6-25-29-W4M

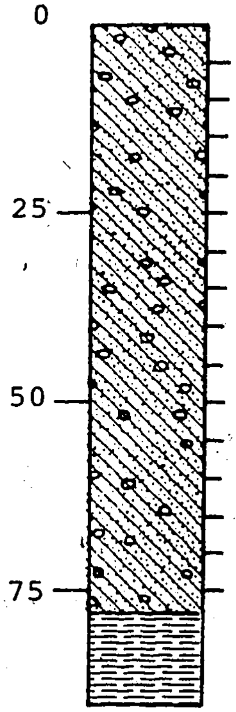


LL	MC	$\frac{I}{I+M}$	Remarks
34.0	16.8	0.74	
32.8	18.3	0.62	
31.9	13.9	0.68	32.3 ± 0.5
32.3	13.7		
34.8	13.3	0.74	
34.0	12.5	0.73	
34.7	13.3	0.72	
35.1	13.1	0.69	
34.4	14.7	0.69	
34.7	14.4	0.75	34.7 ± 0.4
35.6	13.7	0.67	
35.1	14.3	0.77	
34.5	13.9	0.71	
34.8	15.2	0.74	
34.2	14.9	0.71	
35.1	15.4	0.74	

0-83	Till, sandy silt, oxidized dark greyish-brown to 40 ft., dark grey from 40 ft. to base, granites observed to 65 ft.
83-95	Bedrock, shale, light grey

elev. 3480

76-20 S.E.-1-30-24-28-W4M



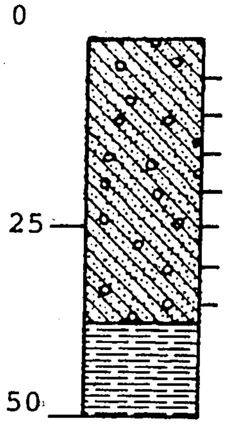
LL	MC	Remarks
35.0	16.9	
35.3	15.2	
27.8	15.4	sand lens
30.3	10.7	sand lens
35.0	13.0	
36.7	13.7	
36.7	14.5	
35.6	13.2	
34.6	13.8	
33.4	13.0	35.1 ± 1.6
34.9	14.5	
34.4	13.5	
35.9	26.0	
34.2	14.8	
34.7		

0-76	Till, silty, oxidized dark greyish-brown to 28 ft., unoxidized dark grey from 28 ft. to base; light and dark rust colored bands observed to 20 ft., granites observed throughout
76-77	Boulders, (driller's comment)
77-90	Bedrock, siltstone, light grey

elev. 3375

76-22

N.E.-16-33-23-28-W4M



LL	$\frac{I}{I+M}$
31.3	0.71
29.6	0.68
32.9	0.64
38.7	0.62
37.5	0.64
35.0	0.69
34.9	0.70

Remarks

31.3 ± 1.6

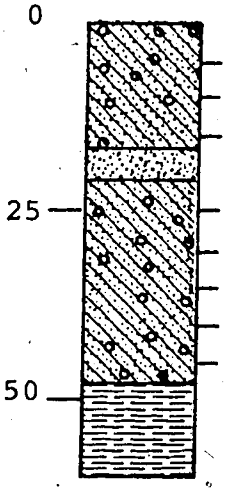
\- - - - - - - - - - - -

36.5 ± 1.8

0- 5	Fill, road fill
5-37	Till, silty, oxidized dark greyish-brown to 28 ft. then unoxidized grey to base
37-50	Bedrock, shale, greyish-blue

elev. 3415

76-23 S.W.-4-5-24-28-W4M



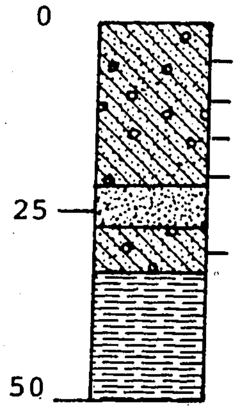
LL	MC	$\frac{I}{I+M}$	Remarks
32.4	17.7	0.74	
30.7	15.8	0.69	
27.0	12.8	0.72	
			31.1 ± 2.0
32.3	12.5	0.72	
32.7	14.2	0.68	
31.6	13.0	0.77	
33.3	11.8	0.71	
33.0	14.3	0.73	

0- 4	Fill
4-16	Till, clayey silt, yellow-brown
16-21	Sand, fine, yellowish-brown, water at 16 ft.
21-48	Till, sandy silt, dark greyish-brown to 25 ft. then grey to base
48-60	Bedrock, shale, greyish-blue, fractured 52-60 ft.

elev. 3425

76-24

S.E.-1-2-24-29-W4M



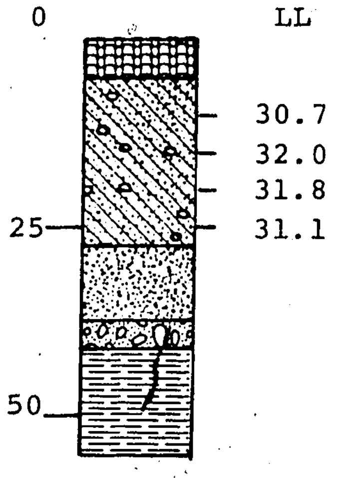
LL	$\frac{S}{M+C}$	MC	IM	$\frac{I}{I+M}$	Remarks
28.3	0.39	14.4	17.5	0.58	
31.3	0.43	14.3	15.5		
25.6	0.45	13.0	9.4	0.73	
24.9	0.33	14.7			26.5 ± 2.9
23.9	0.32	16.4	3.0	0.63	

0-21	Till, clayey silt, yellowish-brown
21-27	Sand, fine with silt, brown
27-33	Till, silty, light grey
33-40	Bedrock, shale, greyish-blue

elev. 3450

76-28

N.W.-13-24-24-29-W4M



Remarks

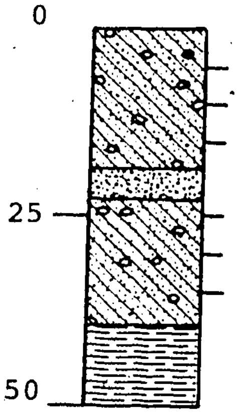
31.4 ± 0.6

0- 5	Fill
5-27	Till, sandy silt, brown
27-37	Sand, fine - medium, brown
37-41	Gravel
41-55	Bedrock ? no sample recovery but very hard drilling

elev. 3385

76-31

N.E.-16-19-23-28-W4M



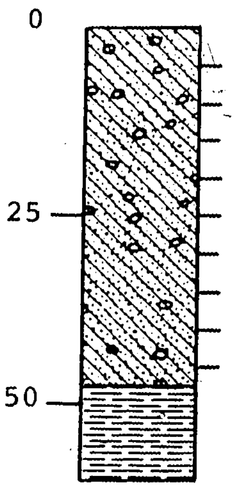
LL	MC	$\frac{I}{I+M}$	Remarks
35.8	15.8		
35.3	15.1	0.71	
34.7	17.0	0.65	
			36.4 ± 1.3
37.7	15.2		
36.9	14.6	0.65	
38.1	13.4		

0-20	Till, silty, dark brown with iron staining to 16 ft., coal, granites and gypsum crystals
20-25	Sand and Gravel, water table at 20 ft.
25-39	Till, clayey, dark grey, granites
39-45	Bedrock, shale, bluish-grey

elev. 3350

76-34

N.W.-4-17-23-28-W4M



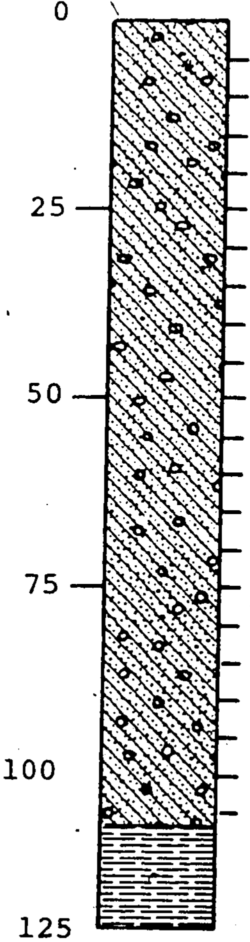
LL	MC	$\frac{I}{I+M}$	Remarks
38.1	16.8		
34.5	10.9	0.72	
35.9	11.7		
36.7	12.8	0.77	
39.8	14.1		36.5 ± 2.1
36.6	15.1	0.70	
37.5	14.4		
36.7	13.9	0.70	
32.4	12.7		

0- 3	Road fill
3-47	Till, silty clay, yellowish-brown to 20 ft. then grey, contains granite pebbles and coal; light and dark banding in till
47-60	Bedrock, shale bluish-grey

elev. 3350

76-37

N.E.-16-23-22-28-W4M



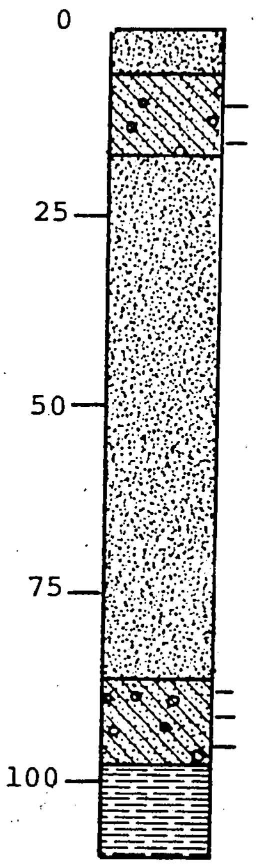
LL	$\frac{S}{M+C}$	MC	IM	Remarks
33.8	0.59	17.3	25.6	
30.3	0.45	15.8	23.4	
36.9	0.41		30.2	
32.3	0.39	13.4	17.2	
34.5	0.37	15.1	16.7	
35.3	0.37		18.6	
35.5	0.33	12.8	9.7	
30.2	0.37	14.7	12.5	
36.1	0.35	15.5	17.4	35.7 ± 1.3
35.8	0.33	15.5	23.0	
35.6	0.33	10.6	17.4	
36.2	0.33	16.5	26.4	
34.2	0.35	16.4	35.4	
37.3	0.32	13.0	23.0	
36.8	0.32	16.4	22.3	
36.9	0.33	15.3	23.6	
37.7	0.32	16.4	29.8	
36.6	0.45	14.8	28.8	
35.1	0.32	15.2	16.0	
36.7	0.33	16.0	17.0	
34.1	0.33	14.1	15.5	

0- 4	Road fill
4-37	Till, yellowish-brown to 20 ft. then grey, granite pebbles, silty clay
37-38	Sand, coarse with some stones
38-106	Till, silty clay, grey
106-120	Bedrock, shale, bluish-grey

elev. 3425

76-40

S.E.-1-29-22-29-W4M



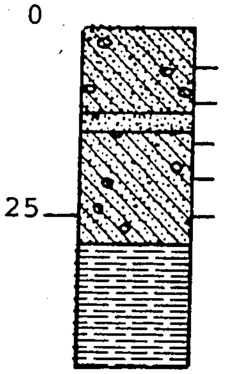
LL	MC	$\frac{I}{I+M}$	Remarks
31.6	14.9	0.67	
30.8	12.8	0.69	31.2 ± 0.5
		0.75	
36.8	14.2		
37.4	13.4	0.78	37.1 ± 0.4

0- 5	Sand, fine, dark, greyish-brown
5-15	Till, sandy, dark greyish-brown, light brown and dark grey bands, granites present
15-30	Sand, fine to medium greyish-brown, wet at 26 ft.
30-52	Silt & clay, interbedded fine sand, silt and clay, olive brown to grey, light and dark grey banding
52-87	Sand, fine to medium, dark grey
87-97	Till, silty clay, dark grey
97-110	Bedrock, siltstone, dark grey

elev. 3350

76-42

S.W.-5-28-22-28-W4M

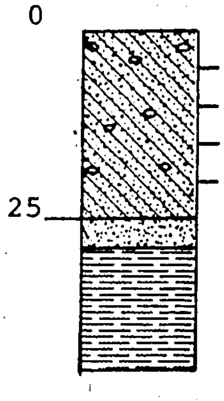


LL	MC	Remarks
35.1	15.9	
32.0	14.1	34.8
35.9		
		35.7 ± 0.6
36.2		

0-10	Till, silty clay, greyish-brown
10-15	Sand, coarse, greyish-brown, water table at 11 ft.
15-28	Till, silty clay, dark grey, granite stones
28-	Bedrock, or boulders?, unable to penetrate

elev. 3350

76-46 N.W.-16-32-22-28-W4M



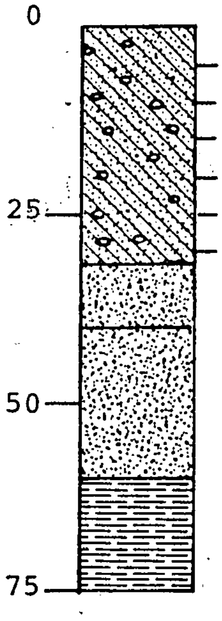
LL	MC	Remarks
34.8	12.3	
35.6	15.2	
35.2	14.0	35.4 ± 0.4
35.8	16.9	

0-25	Till, sandy silt, dark greyish-brown, light and dark brown banding at 15 ft., 3 - 7% pebbles, granites present
25-28	Sand, fine
28-45	Bedrock, shale, light grey

elev. 3365

76-47

S.E.-1-2-23-29-W4M

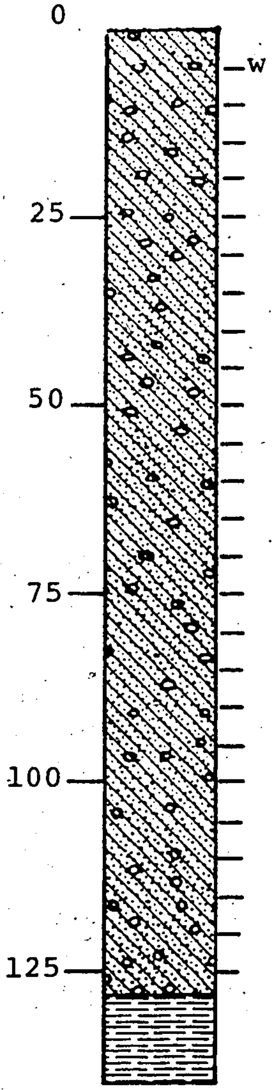


LL	$\frac{S}{M+C}$	MC	IM	$\frac{I}{I+M}$	Remarks
35.5	0.47	17.2	36.7	0.57	
36.3	0.52	19.5	26.8	0.74	36.0 ± 0.5
36.3	0.52	16.1	17.6		
31.8	0.52	14.2	25.2		transitional?
29.3		13.7			transitional?
31.7	0.56	14.5	13.5	0.73	

0-32	Till, silty, very dark greyish-brown to 25 ft. then dark grey, granites present
32-40	Clay, light and dark banding
40-60	Sand, fine to medium, some silt, dark grey
60-75	Bedrock, shale, light grey

elev. 3325

76-48 S.E.-16-7-22-28-W4M



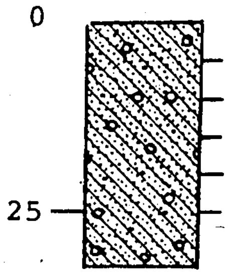
LL	$\frac{S}{M+C}$	MC	IM	Remarks
37.2	0.45	14.2	20.8	
24.9	0.45	11.1	16.3	sand lens ?
21.3	0.45	10.5	2.6	sand lens ?
33.0	0.43	11.7	9.8	
35.5	0.41	12.3	6.6	
41.9	0.20	15.7	12.8	
34.3	0.28	12.4	5.1	
35.9	0.33	12.7		
34.6	0.25	15.5	2.7	
35.9	0.22	14.4	4.1	
35.3	0.27	15.5	5.1	36.8 ± 1.9
36.6	0.28	15.0	6.5	
37.2	0.27	15.2	4.5	
37.9	0.23	13.5	16.8	
37.5	0.27	14.5	4.8	
36.7	0.25	15.2	3.0	
40.3	0.23	15.3	3.6	
36.5	0.23	14.3	6.9	
37.3	0.32	15.8	12.7	
38.1	0.27	14.9	18.8	
35.0	0.28	14.9	9.1	
38.1	0.27	14.2	7.0	
38.6	0.27	14.8	6.8	
37.7	0.22	14.4	21.4	
35.6	0.23	13.8	6.7	

0- 30	Till, silty clay, brown, loose and dry
30-128	Till, silty clay, grey, 5% pebbles, granites present
128-140	Bedrock or boulders?, unable to penetrate

elev. 3800

76-54

S.W.-4-17-22-1-W5M



LL	MC	Remarks
28.9	12.7	
29.2	13.4	
27.6	12.7	28.6 ± 0.7
28.5		
34.2		
36.8		35.5 ± 1.8

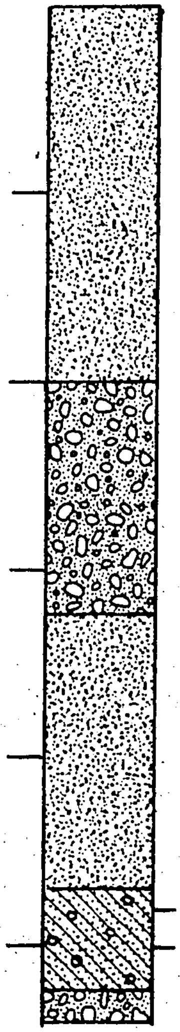
0-19 Till, silty, dark yellowish-brown

19-33 Till, gravelly silt, pale brown, unable to penetrate below 33 ft., to stoney

elev. 3425

76-59

S.E.-1-14-22-2-W5M



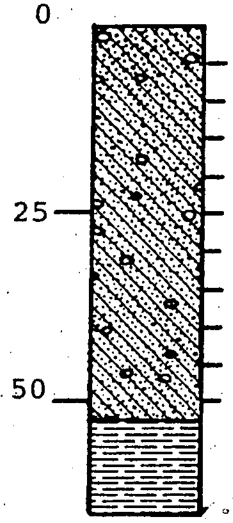
LL	$\frac{S}{M+C}$	MC	$\frac{I}{I+M}$	Remarks
30.8	0.27	19.2	0.80	
34.3	0.25	16.1	0.81	32.6 ± 2.5

0- 51	Clay, silty, olive brown becoming unoxidized olive grey at 14 ft., light and dark brown banding, occasional sand lenses, 1 - 2% pebbles
51- 81	Sand & Gravel, coarse, large boulders
81-118	Clay, silty, dark grey, varved
118-131	Till, silty clay, dark grey, 7-10% pebbles
131-	Boulders (?) unable to penetrate past 131 ft.

elev. 3525

76-62

N.W.-13-10-22-1-W5M



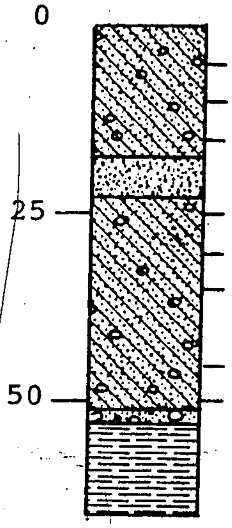
LL	MC	$\frac{I}{I+M}$	Remarks
33.5	17.4	0.65	
32.5	16.6	0.73	
31.4	15.0	0.78	32.7 ± 0.8
32.2	12.9	0.87	
33.5	12.9	0.74	
32.8	12.9	0.77	
33.3	12.7	0.80	
38.1	14.9	76	
37.6		0.71	37.3 ± 0.9
36.3	15.1	0.80	

0-15	Till, silty-clay, olive brown, light and dark brown banding, 3% pebbles
15-51	Till, silty to 40 ft. then clayey, 7% pebbles
51-65	Bedrock, sandtone, olive

elev. 4050

76-66

S.E.-1-1-22-3-W5M



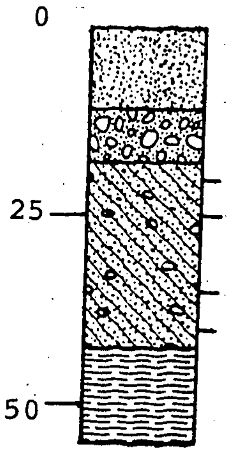
LL	MC	$\frac{I}{I+M}$	Remarks
28.4	8.8	0.79	
	9.4	0.88	
30.6	11.6	0.84	
28.7	26.0	0.90	29.8 ± 1.5
	24.7	0.90	
31.6	15.1	0.84	
33.7	12.2	0.83	transitional?

0-17	Till, sandy silt, dark greyish-brown to 12 ft. then dark olive grey
17-23	Clay
23-51	Till, silty clay, dark grey
51-52	Sand & gravel, wet
52-65	Bedrock, shale, olive

elev. 3700

76-67

S.W.-5-24-22-2-W5M



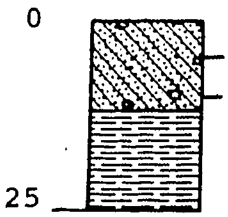
LL	MC	$\frac{I}{I+M}$	Remarks
25.4	20.8	0.74	
28.2	11.6	0.66	
		0.77	28.2 ± 2.0
29.7	13.4	0.74	
29.6	13.0	0.67	

0-12	Clay, silty dark greyish-brown, light and dark banding
12-15	Sand & gravel, fine
15-32	Till, sandy, olive grey, 5 - 7% pebbles
32-42	Till, silty, olive grey, 15% pebbles, wet at 35 ft.
42-55	Bedrock, shale, dark grey

elev. 4025

76-70

S.W.-2-4-22-2-W5M



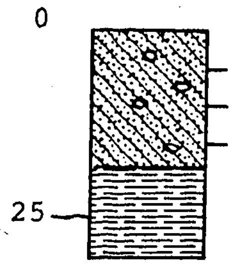
LL	MC	Remarks
36.1	16.2	
37.2	14.7	36.5 ± 0.8

0-11	Till, clayey, brown, loose and friable
11-25	Bedrock, shale, light brownish-grey

elev. 4200

76-71

S.W.-4-18-22-2-W5M



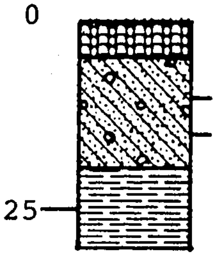
LL	MC	Remarks
39.1	14.5	
32.6	14.4	
39.6	15.7	
		36.9 ± 3.8

0- 3	Fill
3-17	Till, sandy silt, light yellow brown
17-30	Bedrock, shale, light brownish-grey

elev. 3925

76-72

S.W.-2-30-22-2-W5M



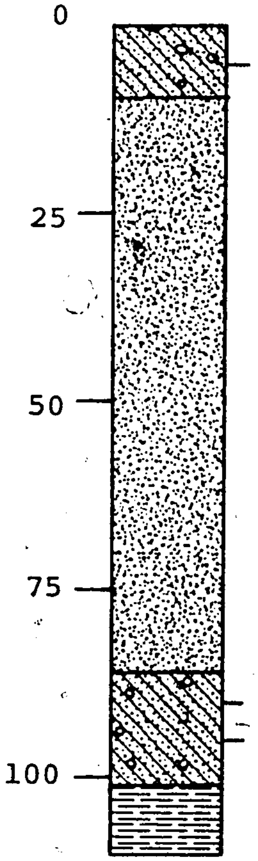
LL	Remarks
27.8	26.6 ± 1.6
25.4	

0- 5	Fill
5-18	Till, sandy silt, yellowish-brown, some sand lenses
18-30	Bedrock, shale, light grey

elev. 3425

76-74

S.W.-4-4-22-29-W4M



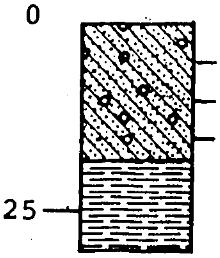
LL	SA	MC	IM	$\frac{I}{I+M}$	Remarks
32.7	0.47	15.2	27.6	0.69	32.7
29.8	0.25	17.6	4.4		
27.9	0.27	12.8	6.5	0.74	28.8 ± 1.3

0- 9	Till, silty sand, yellowish-brown
9- 87	Sand & clay, interbedded fine to medium sand and clay, oxidized yellowish brown to 14 ft. then dark grey, contains granite fragments
87-101	Till, clayey, grey, 6% pebbles
101-110	Bedrock, sandstone, pale olive

elev. 3500

76-75

N.E.-16-11-21-28-W4M



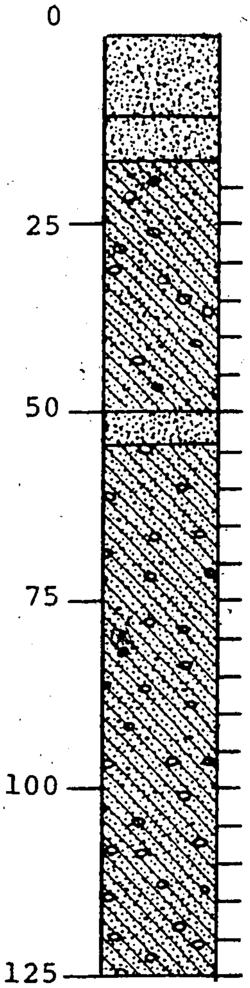
LL	MC	$\frac{I}{I+M}$	Remarks
31.2	12.4	0.60	
32.7	15.6	0.64	32.7 ± 1.5
34.2	12.7	0.69	

0-16	Till, sandy, light olive brown, granites present
16-22	Bedrock, sandstone, yellow
22-30	Bedrock, shale, grey

elev. 3360

76-76

S.E.-1-1-22-29-W4M



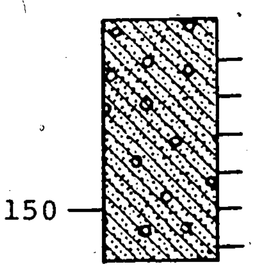
LL	$\frac{S}{M+C}$	MC	IM	Remarks
33.1	0.35	17.2	27.3	
32.3	0.35	16.3		
31.7	0.43	13.7	34.0	32.6 ± 0.7
32.8	0.43	16.1		
33.7	0.35	14.2	24.8	
32.0	0.49	14.3		
33.5	0.27	13.3		
35.1	0.20	15.7	2.4	
34.8	0.27	17.4		
34.8	0.30	16.2	3.8	
33.6	0.27	15.6	2.7	
35.0	0.28	13.4	8.4	
34.5	0.32	16.5	6.5	34.7 ± 1.4
35.4	0.32	14.7	2.9	
35.9	0.30	14.3	9.9	
35.7	0.28	14.6	9.1	
32.7	0.28	15.4	9.2	
38.4	0.23	16.2	6.3	
34.7	0.27	15.9	6.5	
38.1	0.25	15.6	5.0	
34.3	0.25	15.7	6.5	

continued

elev. 3360

76-76 (cont'd.)

S.E.-1-1-22-29-W4M



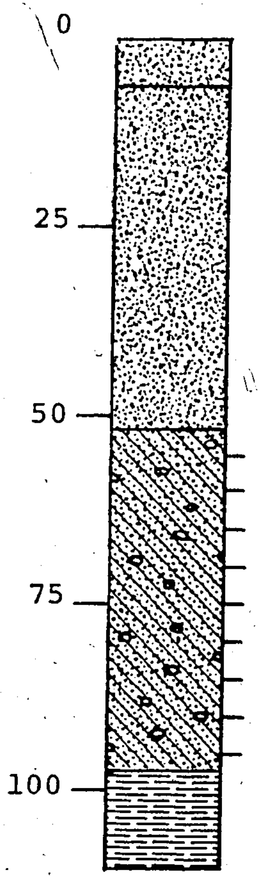
LL	$\frac{S}{M+C}$	MC	IM	Remarks
34.0	0.33	17.5	5.8	
32.8	0.33	18.7	5.4	
33.7	0.32	21.6	1.3	
34.1	0.25	19.3	0	
33.4	0.23	18.6	0	
35.0	0.23	16.0	0	

0- 12	Sand, fine to medium, yellowish brown, wet at 6 ft.
12- 18	Clay, dark olive grey, light & dark banding
18- 49	Till, silty clay, dark olive grey, 3 - 5% pebbles
49- 54	Sand, fine to medium dark grey
54-115	Till, silty clay, abundant granite pebbles 3 - 5% pebbles

elev. 3425

76-79

S.E.-2-34-22-1-W5M



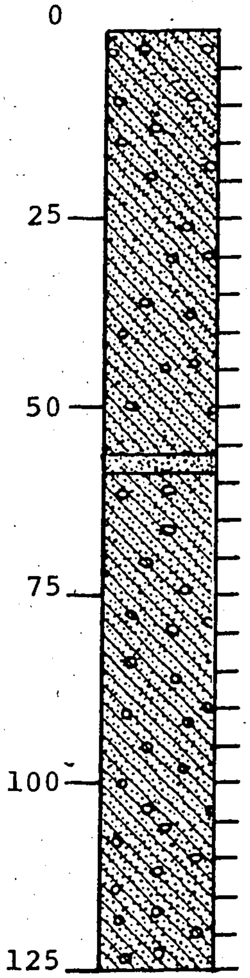
LL	MC	$\frac{I}{I+M}$	Remarks
28.2	16.3	0.77	28.5 ± 0.4
28.8	13.4	0.74	
32.7	14.1		32.5 ± 0.4
32.2	15.9	0.83	
35.3	13.7	0.80	35.1 ± 1.7
34.5	14.1		
32.6	15.2	0.82	
36.1	15.9	0.87	
37.1	15.2	0.80	

0- 7	Sand, medium, greyish-brown
7- 48	Clay, dark olive grey, banded, 1 - 3% pebbles
48- 53	Silt & clay, dark olive grey, pebble free
53- 96	Till, sandy silt, dark olive grey
96-110	Bedrock, sandstone, olive yellow

elev. 3345

76-81

N.W.-13-12-22-28-W4M



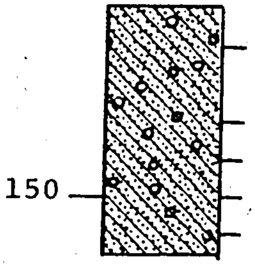
LL	$\frac{S}{M+C}$	MC	IM	Remarks
36.0	0.20	15.3		
33.2	0.45	14.5	27.7	
36.6	0.43	12.6	26.9	
35.6	0.47	12.4	17.0	
36.4	0.45	13.0	19.0	
32.1	0.49	12.6	10.8	
28.6	0.49	12.1	28.0	
27.3	0.64	9.2	22.3	sand lens?
32.4	0.33	11.6	17.9	
31.5	0.32	12.6	10.2	
32.3	0.35	13.0	8.3	
29.5	0.47	13.7	12.2	34.3 ± 1.8
27.5	0.35	12.3	10.5	
32.5	0.33	13.1	9.4	
36.4	0.37	13.3	8.8	
33.9	0.41	13.4	17.2	
30.9	0.43	22.2	11.8	
33.9	0.43	13.9	16.5	
36.3	0.43	13.3	11.0	
32.3	0.43	12.9	15.5	
34.2	0.41	13.5	18.6	
34.7	0.35	13.7	20.8	
34.2	0.35	15.1	22.8	
36.6	0.35	14.2	21.6	
35.7	0.35	13.2	21.1	

continued

elev. 3345

76-81 (cont'd.)

N.W.-13-12-22-28-W4M



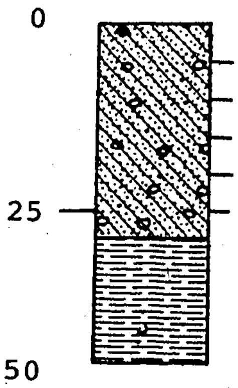
LL	$\frac{S}{M+C}$	MC	IM	Remarks
37.1	0.37	14.4	20.6	
31.9	0.49	14.0	19.9	
35.3	0.39	14.8	22.4	
32.9	0.39	15.3	27.1	
34.2	0.47	15.4	18.3	

0- 38	Till, sandy silt, dark greyish-brown, 5 - 7% pebbles, granites
38- 43	Till, silty sand, olive grey, loose and friable
43- 55	Till, sandy silt, olive grey, moist and plastic
55- 59	Sand, medium to coarse, olive grey, saturated
59-157	Till, sandy silt, dark olive grey, granites present

elev. 3350

76-84

N.E.-16-13-22-29-W4M



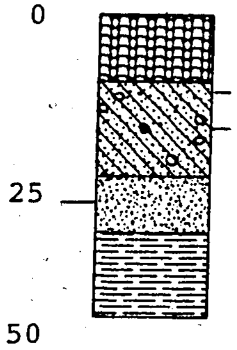
LL	MC	$\frac{I}{I+M}$	Remarks
26.8	6.3	0.73	26.8
33.7	14.3	0.68	
34.1	11.7	0.67	33.9 ± 0.2
	12.6	0.68	
34.0	11.9	0.71	

0-20	Till, sandy silt, dark brown, 7% pebbles
20-28	Till, silty, olive grey, 10-12% pebbles
28-35	Bedrock, sandstone, olive brown
35-45	Bedrock, shale

elev. 3375

76-85

S.W.-12-14-22-29-W4M



LL

31.7
32.5

Remarks

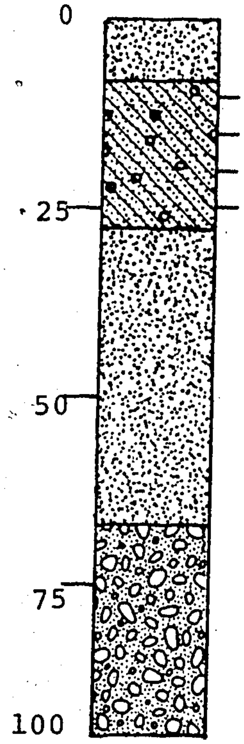
32.1 ± 0.5

0- 8	Road fill
8-22	Till, clayey, yellow-brown, granite pebbles
22-28	Sand, fine to medium, yellow, wet at 24'
28-40	Bedrock, shale, grey

elev. 3350

76-86

S.E.5-36-22-1-W5M



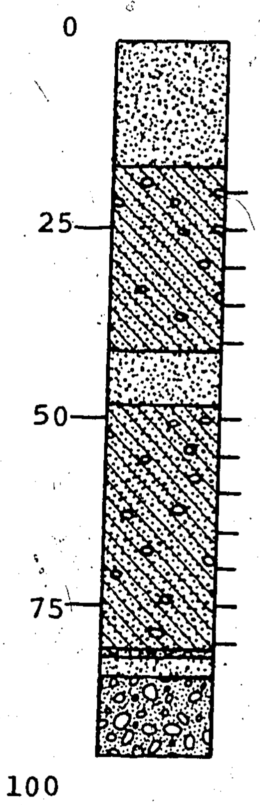
LL	MC	Remarks
28.6	8.8	
29.9	10.7	
30.3	14.0	28.7 ± 1.8
26.1	14.0	

0- 8	Silt, yellowish-brown, some sand
8-28	Till, sandy, light olive brown, contains numerous sand lenses @ 12 - 13 ft.
28-57	Clay & Silt, interbedded, pebble free, dark greyish-brown
57-68	Silt, light grey, 1% pebbles
68-94	Gravel

elev. 3375

76-87

N.E.-1-16-21-28-W4M



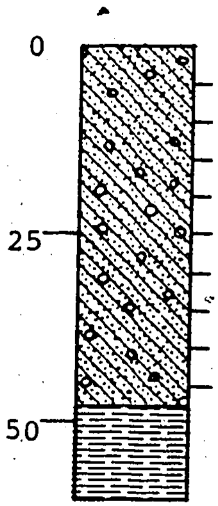
LL	MC	Remarks
30.0	13.2	
28.7	14.0	
27.2	12.6	28.3 ± 1.1
27.5	12.5	
28.0	11.4	
34.4	10.8	
36.0	11.6	
35.8	11.2	
34.2	11.9	35.3 ± 1.9
37.9	11.6	
37.3	11.7	
32.1	12.0	

0-10	Sand and silt, fine, light olive brown
10-17	Clay, silty, sandy, light and dark banding
17-41	Till, silty, very dark grey, 5 - 10% pebbles
41-49	Sand and silt, brown
49-80	Till, silty, very dark grey, 5% pebbles
80-82	Boulders
82-89	Clay, silty, light and dark grey banding
89-95	Sand and gravel, hole terminated due to coarse boulders

elev. 3825

76-90

N.W.-13-31-22-2-W5M



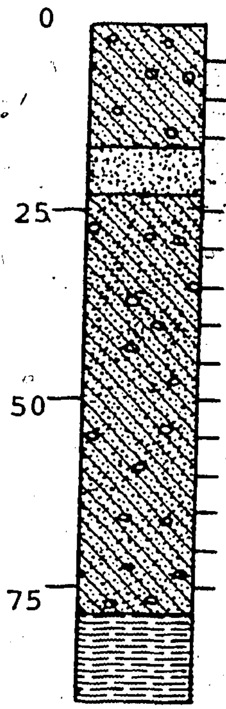
LL	MC	$\frac{I}{I+M}$	Remarks
29.8	13.1	0.68	
31.9	12.0	0.67	
35.2	12.5	0.72	32.3 ± 2.9
35.5	7.0	0.65	
32.9	10.5	0.71	
28.2	9.6	0.85	
37.0	11.3	0.73	
36.1	10.3	0.78	37.0 ± 0.8
37.8	11.7	0.74	

0-47	Till, sandy, greyish-brown, 5 - 7% pebbles increasing to 15 - 20% below 29 ft.
47-60	Bedrock, sandstone

elev. 3825

76-92

S.E.-11-4-21-2-W5M



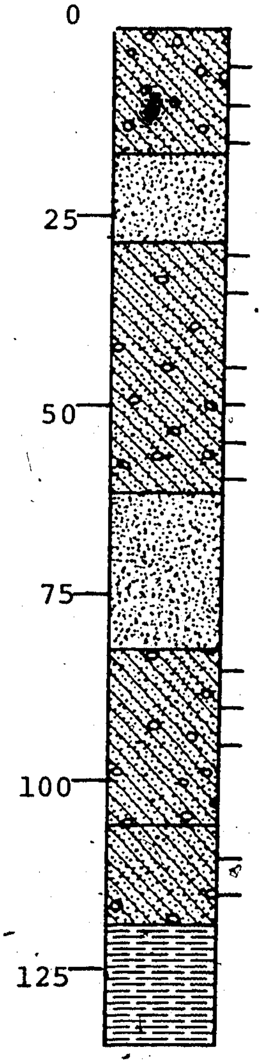
LL	$\frac{S}{M+C}$	MC	IM	Remarks
40.1	[illegible]	[illegible]		weathered?
31.9	[illegible]	[illegible]	6.7	32.2 ± 0.5
32.6	[illegible]	[illegible]		
[illegible]	[illegible]	16.7	0	
32.7	[illegible]	14.2	[illegible]	
28.2		11.8		
32.2		13.1		
27.7		12.4		
25.8	0.33	13.1	0.3	
31.2		14.3		29.7 ± 2.5
28.3		12.1		
28.8		13.3		
28.6		13.2	0	
33.8		13.8		33.8? transitional to bedrock

0-16	Till, silty clay, greyish-brown, 5 - 7% pebbles
16-23	Sand, interbedded with silty clay, dark greyish-brown
23-55	Till, silty clay, dark greyish brown, 10% pebbles increasing to 20 - 30% below 40 ft.
55-78	Till, as above but 10 - 15% pebbles
78-	Bedrock or Boulder?, unable to penetrate

elev. 3500

76-93

S.W.-12-4-23-1-W5M



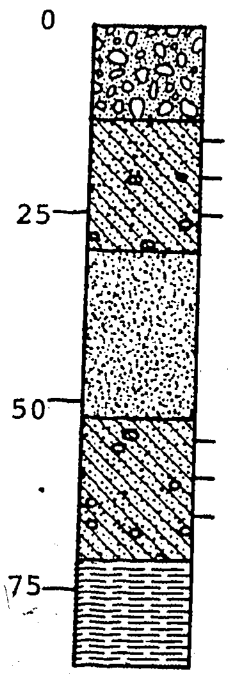
LL	S/M+C	MC	IM	Remarks
25.2		10.4		31.2 ± 5.2?
34.6	0.10	13.2	11.9	lacustro-till
33.8	0.15	13.0	9.5	
			0	
39.2	0.08	14.4	0	
36.2		13.6		
				32.1 ± 4.6?
29.0	0.22	11.4		lacustro-till
31.0		9.5		
30.0		11.2		
27.1		9.9		
23.7		9.4		29.6 ± 5.3?
31.3		11.4	0	lacustro-till
33.8		12.5	2.0	
23.9				
23.9				23.9 ± 0.0

0- 17	Lacustro-Till, silty clay, greyish-brown, occasional light and dark banding, 3% pebbles
17- 28	Sand, Silt-Clay, interbedded, greyish-brown, < 1% pebbles
28- 61	Lacustro-Till, silty clay, greyish-brown, occasional banding, 5 - 10% pebbles
61- 83	Sand, greyish brown, saturated at 68 ft.
83-106	Lacustro-Till, silty clay, dark grey, 3 - 5% pebbles
106-119	Till, dark grey, 2% pebbles, sandy
119-135	Bedrock, sandstone, brownish-yellow

elev. 3350

76-94

S.E.-12-12-23-1-W5M



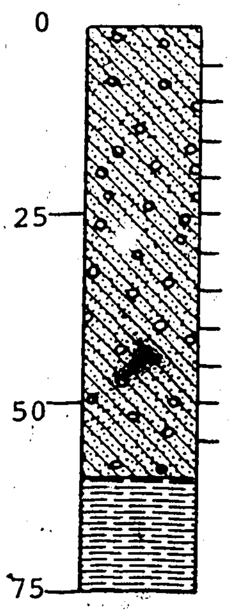
LL	$\frac{S}{M+C}$	MC	IM	Remarks
24.2	0.49	13.3	20.9	
21.6	0.39	11.1	7.3	24.2 ± 2.6
26.8	0.25	12.2	5.7	
37.2				
34.5				35.6 ± 1.4
35.1				

0-13	Gravel, some coarse sand
13-30	Till, silty clay, dark grey, 3% pebbles, granites present
30-39	Clay, dark grey, pebble free
39-52	Silt, grey, pebble free
52-72	Till, silty, grey, 5-15% pebbles, loose and friable
72-85	Bedrock, shale, light grey

elev. 3750

76-96

S.W.-13-14-21-1-W5M



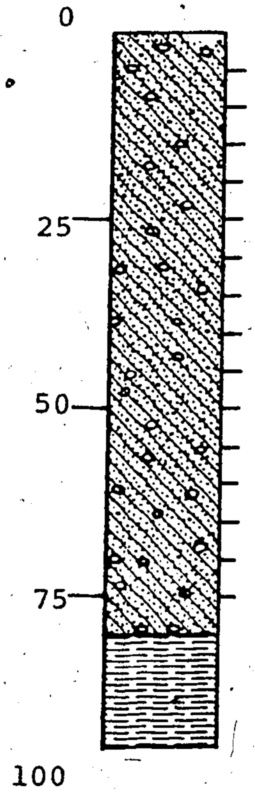
LL	$\frac{S}{M+C}$	MC	$\frac{I}{I+M}$	Remarks
27.9	0.23	13.3	0.71	
29.5		11.0	0.70	
28.7	0.23	11.9	0.71	
30.8		12.6	0.70	30.0 ± 1.6
31.6	0.25	11.8	0.77	
31.9		12.5	0.75	---------------
34.4	0.27	12.4	0.78	
32.1		12.0	0.75	36.3 ± 4.2
33.3	0.19	12.0	0.65	
41.1				
40.8			0.70	

0-60 Till, sandy, yellowish-brown becoming grey at
40 ft., 5% pebbles, grading to silty clay at base
60-75 Bedrock, shale, greyish-brown

elev. 3920

76-97

S.W.-4-16-21-1-W5M



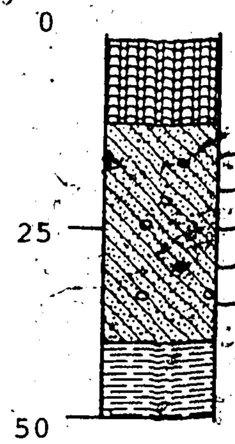
LL	MC	Remarks
30.1	13.4	
28.7	12.1	
29.2	12.0	
28.4	12.0	
27.6	11.8	
28.8	11.1	
28.2	11.3	28.7 ± 0.6
27.6	11.6	
27.9	11.3	
28.1	11.3	
28.3	11.5	
28.8	11.1	
29.3	11.5	
33.9	12.3	33.1 ± 1.1
32.3		

0- 3	Fill
3-80	Till, sandy silt, yellow brown changing to grey at 30 ft., 5% pebbles
80-95	Bedrock, shale, light grey

elev. 3940

76-98

S.W.-13-6-21-1-W5M



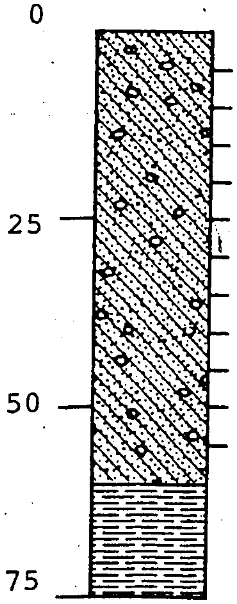
LL	MC	$\frac{I}{I+M}$	Remarks
36.9	13.2	0.68	
33.2	13.7	0.78	34.2 ± 1.6
34.5	14.0	0.72	
33.8	14.5	0.71	
32.6	13.6	0.70	

0-10	Fill
10-40	Till, sandy clay, yellow brown
40-50	Bedrock, shale, grey

elev. 3975

76-100

N.E.-1-14-21-2-W5M



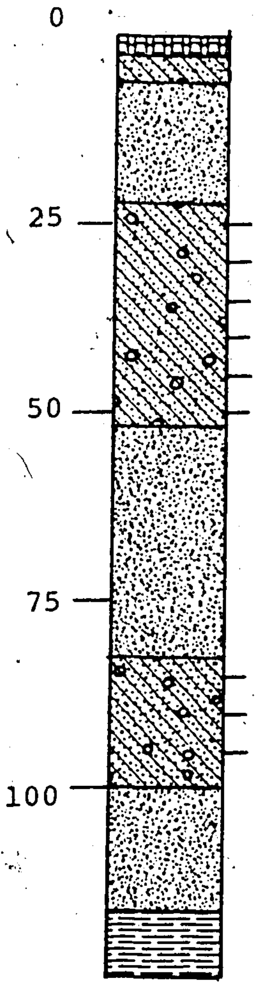
LL	MC	$\frac{I}{I+M}$	Remarks
36.1		0.64	
31.6		0.73	
34.7		0.85	
34.9		0.70	
35.2		0.74	
37.5		0.76	35.2 ± 2.1
39.1		0.71	
33.6		0.78	
35.3		0.80	
32.5		0.75	
36.4		0.70	

0-60	Till, silty, yellow brown becoming olive grey at 40 ft., 5 - 7% pebbles
60-75	Bedrock, shale, light grey

elev. 3750

76-101

S.E.-11-25-21-2-W5M



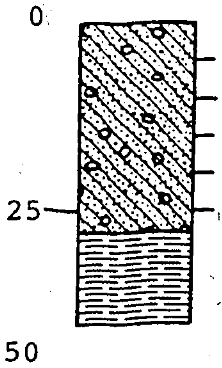
LL	MC	IM	$\frac{I}{I+M}$	Remarks
31.3	12.9	20.7	0.74	31.3?
36.8	15.5	1.6	0.66	
36.6	12.6		0.72	
34.3	12.6		0.74	36.4 ± 1.4
37.8	13.2		0.71	
47.0	16.8		0.69	
				thrust?
36.3	13.7		0.66	
37.4	10.5	0	0.72	37.0 ± 0.6
37.3	11.6		0.73	

0- 3	Fill
3- 7	Colluvial Till, yellow brown
7- 25	Clay, silty, grey-brown, granites in sand fraction, minor till interbeds
25- 55	Till, silty clay, grey-brown, 7 - 10% pebbles
55- 83	Clay, silty with sand and till inclusions, olive brown
83-100	Till, silty clay, grey-brown, 5 - 7% pebbles
100-117	Clay, grey-brown
117-126	Bedrock, sandstone, olive brown, at 120 ft.
*	mixture of till/sandstone

elev. 3800

76-104

S.E.-2-19-21-1-W5M



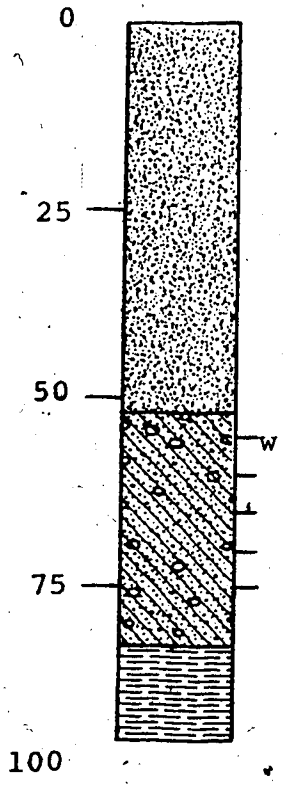
LL	MC	$\frac{I}{I+M}$	Remarks
29.6	12.1	0.61	sandy
35.9	12.5	0.78	
36.2	12.3	0.77	37.1 ± 1.8
39.2	12.8	0.78	
30.0	10.9	0.75	transitional?

0-23	Till, silty clay, yellow-brown, 5 - 7% pebbles
23-28	Till, sandy, light olive brown, 5% pebbles
28-40	Bedrock, sandstone, brown-grey

elev. 3825

76-105

S.E.-15-8-21-2-W5M



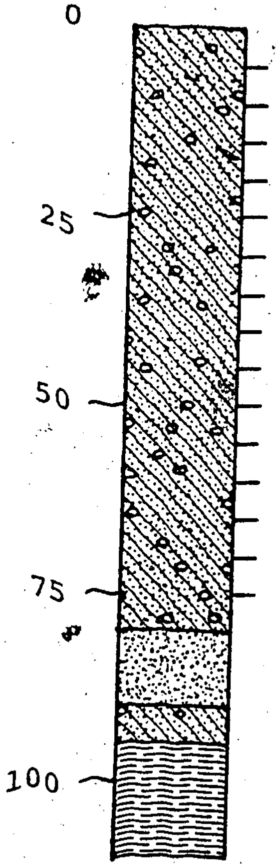
LL	$\frac{S}{M+C}$	MC	IM	Remarks
35.2	0.23	15.1	1.6	clay influence
31.3		14.4		
31.9	0.27	14.2	0.5	32.0 ± 0.7
32.8		15.2		
36.8	0.22	14.2	1.3	36.8

0-50	Clay & Silt, minor sand lenses, pebble free, grey-brown to olive grey
50-83	Till, silty clay, olive grey, 10% pebbles
83-91	Bedrock, sandstone/shale interbedded

elev. 4050

76-106

N.W.-4-21-21-2 W5M



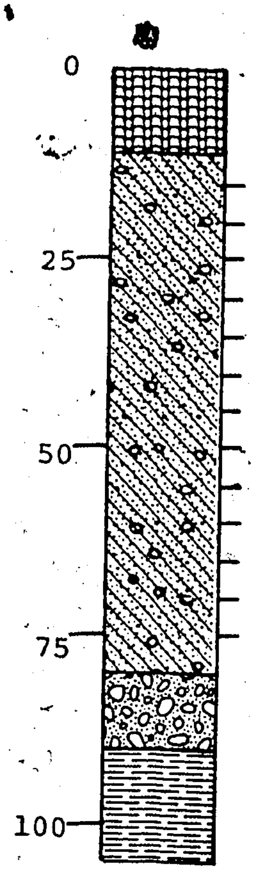
LL	$\frac{S}{M+C}$	MC	Remarks
31.8	0.25	13.6	31.8?
34.6	0.22	12.9	
35.9	0.25	12.8	
	0.25		
35.1		13.0	
35.3		13.0	
34.9	0.19	13.0	
35.6		13.2	34.8 ± 1.1
33.4		12.5	
33.9		12.6	
35.0		12.3	
30.9		11.5	
29.1	0.30	11.1	sandy
32.8		12.5	
36.4	0.27	12.6	
32.2	0.27	12.7	

0- 80 Till, sandy clay, olive grey, 5% pebbles
80- 90 Silt, olive grey with minor sand, pebble free
90- 94 Till, silty, olive grey, 5% pebbles
94-110 Bedrock, shale/sandstone, olive

elev. 3950

76-107

S.E.-3-30-21-2-W5M



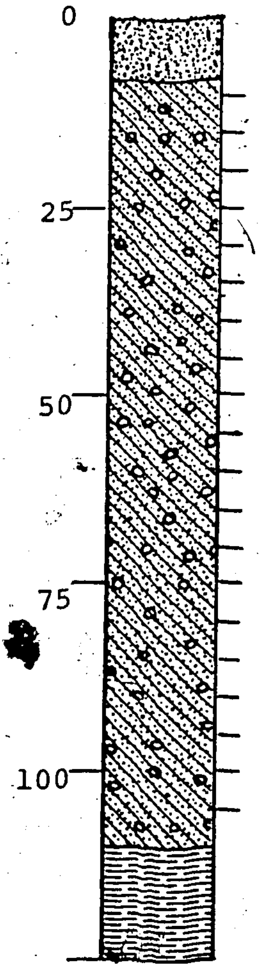
LL	$\frac{S}{M+C}$	MC	$\frac{I}{I+M}$	Remarks
35.5	0.14	18.7	0.71	
37.5	0.35	18.4		
34.1	0.35	12.7		
39.0		13.7	0.79	
36.6	0.39	13.0		35.1 ± 1.7
34.2		12.0	0.83	
34.9	0.39	12.2	0.74	
35.6		12.6		
33.8		12.3	0.75	
34.5		13.1	0.69	
34.7		11.8		
32.4	0.49	12.0		
33.7	0.41	11.0		

0- 12	Fill
12- 80	Till, sandy clay, olive, 5 - 10% pebbles
80- 90	Sand & Gravel, clean
90-105	Bedrock, shale, light grey

elev. 3550

76-108

N.E.-1-20-22-1-W5M



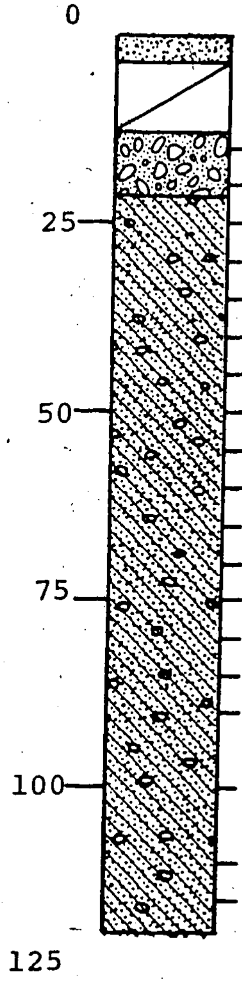
LL	$\frac{S}{M+C}$	MC	IM	$\frac{I}{I+M}$	Remarks
29.0	0.23	14.2		0.73	
29.9	0.23	10.5			
28.9	0.27	10.5	1.3		
30.5		11.9			
30.3		11.6	1.7		
34.6	0.22	11.2			
29.1	0.23	11.0	2.5		31.1 ± 2.5
30.0		11.0	0.4		
31.6	0.25	11.0			
29.2		10.6			
28.2		11.9			
27.9		11.5	1.9		
34.0	0.27	12.5			clayey?
36.7		12.4	2.1		
34.8	0.27	11.7			
31.6	0.30	12.5	3.1		
32.3		12.2	0.3		
33.3		12.9			
30.1	0.39	11.2			--------------
34.1	0.37	11.3			
35.2					34.6 ± 0.7

0- 10	Clay, sandy, yellow brown, pebble free
10-110	Till, clayey to 40 ft. then silty, light olive brown to 40 ft. then grey, 10% pebbles
110-125	Bedrock, sandstone, light olive brown

elev. 3400

76-109

N.W.-13-5-21-28-W4M



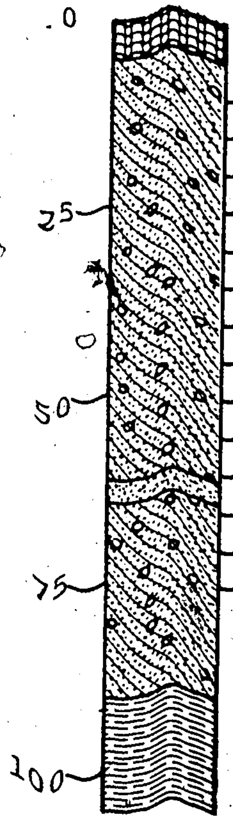
LL	MC	$\frac{I}{I+M}$	Remarks
26.8	9.0		
28.9	14.8		
28.6	12.1		
28.6	12.1	0.72	
29.0	12.0		29.0 ± 1.3
28.9	12.2		
27.2	12.5	0.69	
29.2	13.2		
27.6	13.1		
28.7	11.6		
31.3	13.9		
31.1	15.0		
36.8	13.1	0.70	
36.8	11.3		
37.5			
38.2			
35.9			37.0 ± 0.8

0- 3	Sand, fine, light olive brown
3- 13	Till/Sand/Gravel, mixed
13- 20	Gravel, some sand, water table at 12.5 feet
20-120	Till, silty, 5% pebbles to 55 ft. then increasing to 10%

elev. 3350

76-110

N.E.-4-33-21-28-W4M



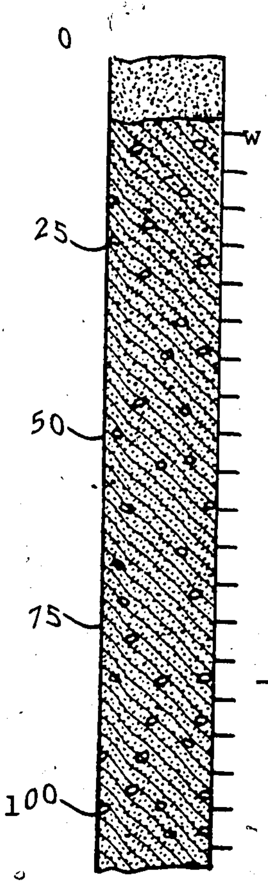
LL	MC	$\frac{I}{I+M}$	Remarks
32.8	17.6	0.63	
36.1	14.0	0.63	
35.1	13.2	0.70	
	13.6	0.69	
35.4	13.2	0.72	34.8 ± 1.1
	13.3	0.67	
33.9	12.6	0.65	
35.9	10.5	0.69	
	11.0	0.79	
34.1	11.6	0.73	
29.0	13.3	0.63	
29.3	11.3	0.68	sand influence
34.2	14.3	0.72	
36.2	13.4	0.75	

0- 5	Fill
5- 41	Till, sandy clay, grey-brown, 5% pebbles
41- 61	Till, sandy silt, olive, dry and friable, 5% pebbles
61- 64	Sand, coarse, grey, saturated
64- 90	Till, sandy silt, olive grey, 5% pebbles
90-105	Bedrock, shale, grey

elev. 3650

76-117

N.W.-12-9-22-1-W5M



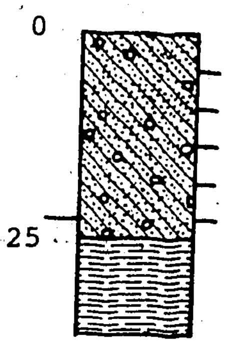
LL	MC	Remarks
34.9	11.9	
31.6	11.9	
32.8	12.0	
32.1	11.5	
31.3	11.6	
32.4	11.4	
32.1	11.0	31.8 ± 0.9
31.3	11.7	
31.3	12.3	
32.3	12.4	
31.7	12.7	
30.6	12.2	
29.6	9.8	
33.1	12.1	
32.4	12.0	
35.8	12.3	
36.0	12.8	35.9 ± 0.2
35.6	12.1	
36.2	11.7	
35.8	11.3	

0- 10	Silt, sandy, light yellow brown
10-106	Till, silty, olive grey, 7% pebbles, loose, dry

elev. 3850

76-118

S.W.-4-36-22-2-W5M



LL

32.0
35.7
33.2
39.4
40.1

Remarks

32.0

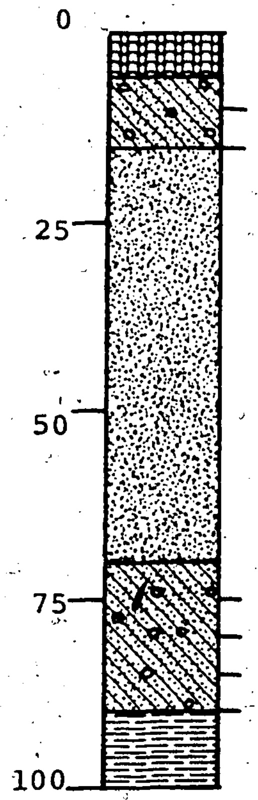
37.1 ± 3.2

0-26 Till, sandy clay, grey-brown
26-40 Bedrock, sandstone, yellow

elev. 3415

77-3

S.W.-1-29-22-29-W4M



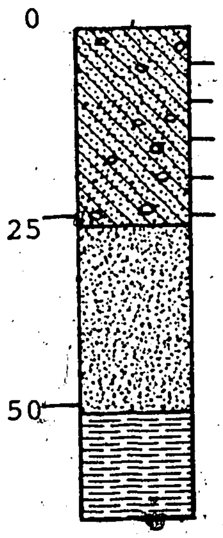
LL	$\frac{I}{I+M}$	Remarks
31.2		31.6 ± 0.6
32.0		
33.9	0.72	
36.4	0.67	
35.8	0.75	35.2 ± 1.1
34.7		

0- 3	Fill
3- 15	Till, silty, clayey, olive, unoxidized
15- 42	Silt, sandy, thinly laminated, heavily oxidized stains at base, occasional clay beds 1 - 3 cm thick
42- 47	Clay, silty, thinly laminated, unoxidized, grey
47- 71	Silt, thinly laminated, organics on bedding planes, grey
71- 90	Till, silty, abundant carbonate pebbles, grey
90-100	Bedrock, sandstone

elev. 3375

77-4

S.W.-2-26-22-29-W4M



LL	$\frac{I}{I+M}$	Remarks
36.3	0.65	
38.7	0.70	
		36.6 ± 2.2
34.2	0.72	
31.0		
33.0		

0-26 Till, silty clay, brown, mottled in parts, contains granite pebbles

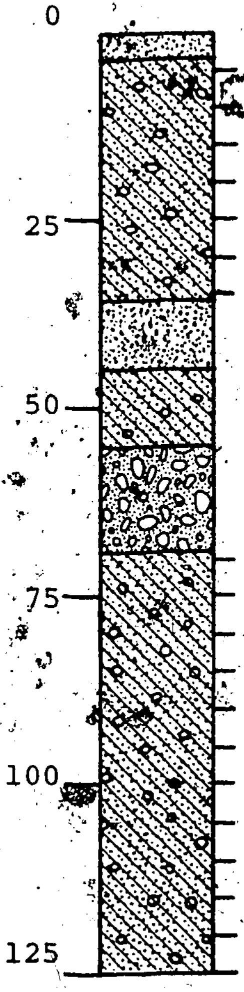
26-51 Silt, some find sand, some clay beds up to 12 cm thick, saturated at 33 ft., grey, laminated

51-65 Bedrock, sandstone, brown

elev. 3345

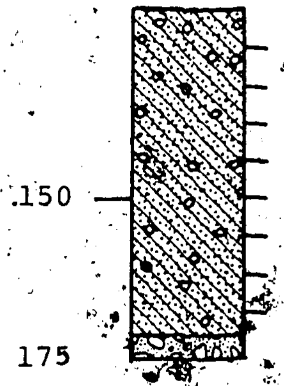
N.E.-7-5-22-28-W4M

77-8



LL	$\frac{S}{M+C}$	IM	CC	Remarks
	0.41		12.3	3-36'
32.8	0.37	25.2	11.7	banded
35.1	0.43	23.9	9.5	lacustro-till?
36.1	0.47	16.7	8.6	
34.9	0.23	19.2	18.5	34.2 ± 1.7
31.9	0.25	3.8	19.5	
	0.72	2.8	22.2	
	–	2.2	–	
24.2	0.69	7.0	21.1	25.5 ± 1.1
25.9	0.52	7.0	18.4	
26.3	0.64	5.7	16.9	
32.1	0.59	4.5	18.8	
34.6	0.35	5.1	[illegible]	
33.4	0.28	7.8	14.5	
32.4	0.49	3.2	17.2	
	0.25		13.8	
34.1	0.33	9.8	16.2	34.5 ± 1.5
34.6	0.30	15.9	16.0	
33.0	0.27	4.6	16.3	
34.8	0.28	9.1	15.9	

77-8 (cont'd.)



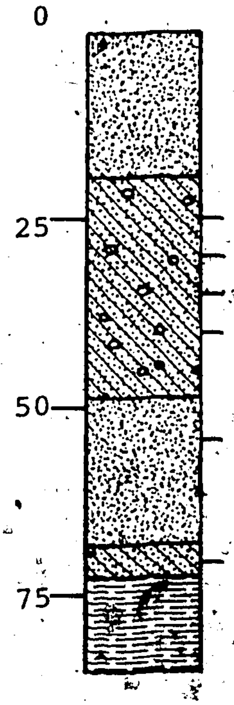
LL	$\frac{S}{M+C}$	IM	CC	Remarks
	0.27		16.2	
36.1	0.27	3.6	16.3	
35.5	0.27	2.7	15.6	
37.8	0.23	5.1	16.8	
35.6	0.28	2.9	[illegible]	
29.3	0.32	0.4	21.7	sandy
34.2	0.23	7.6	17.5	
	0.33		18.3	

0- 3	Silt, loess, brown-grey
3- 36	Till, olive brown, dry, crumbly, granites present, appears streaked, gypsum crystals, numerous sand inclusions
36- 45	Sand, very fine, few pebbles, olive grey, laminated, organic laminae
45- 58	Till, silty sand, grey, loose, dry, crumbles easily, granites present
58- 69	Gravel, pea size, granites present, well sorted, grey
69-167	Till, silty clay, very stoney, interbeds of silt and very fine sand, silty 70 - 72 ft., dark grey granites
167-	Boulders?, unable to penetrate further

elev. 3950

77-15 —

N.E.-4-34-21-[illegible]-W5M



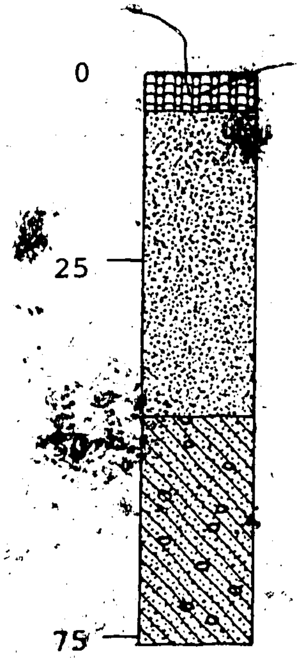
LL	$\frac{S}{M+C}$	$\frac{I}{I+M}$	Remarks
31.8	0.27	0.77	32.1 ± 0.3
32.3	0.27	0.81	
34.9	0.30	0.84	34.8 ± 1.4
34.7	0.30	0.77	clay influence?
42.0			
27.2	0.67	0.79	27.2

0-19'	Clay, varved, silty, pebbly
19-48	Till, clayey, 5% pebbles, grey-brown to 22 ft. then unoxidized olive grey, stonier at 42 ft.
48-69	Clay-Silt, sandy beds up to 4 ft. thick, olive grey, pebbly, saturated at 54 ft.
69-73	Till, sandy silt, olive grey

elev. 4340

77-16

S.W.-1-4-22-4-W5M

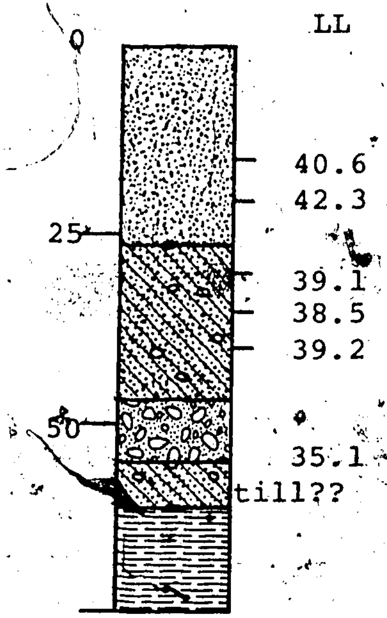


0- 5	Road fill
5-46	Clay, banded, slightly silty, olive grey
46-76	Till, dark grey, clayey, stoney

elev. 3880

77-20

S.W.-2-27-22-3-W5M



Remarks

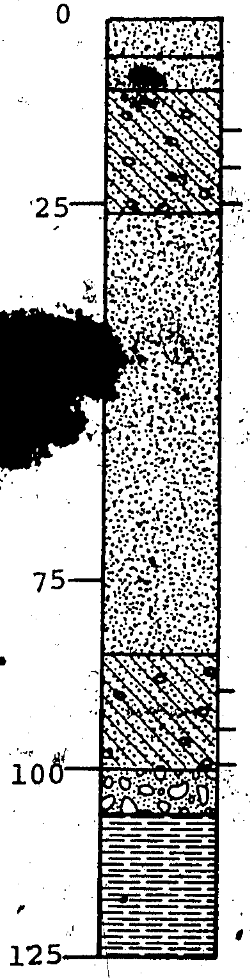
37.9 ± 1.9

0- 2	Clay & Organics
2-26	Clay, pebbly, olive grey, some banding
26-47	Till, olive grey, dry and crumbly, silty clay
47-55	Gravel, very dirty, saturated
55-62	Till, silty clay, very hard, same as till above
62-75	Bedrock, sandstone, grey

elev. 3430

77-22

S.E.-3-26-22-1-W4M



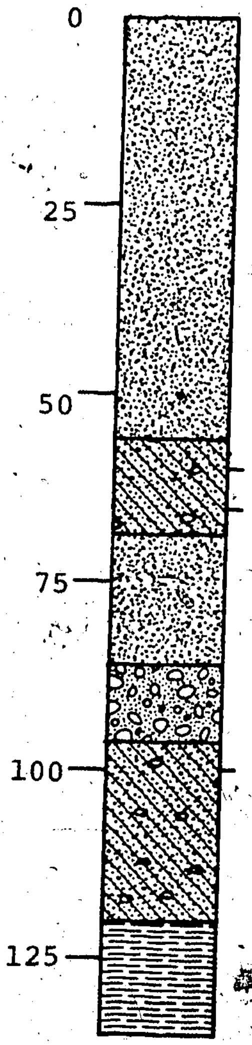
LL	MC	CC	IM	$\frac{S}{M+C}$	Remarks
32.4					
31 5	17.2	15.9	13.7	0.22	32.4 ± 0.6
32.8	15.8	15.2	18.9	0.20	
33.0	15.0	15.7	12.8	0.22	
28.5	10.4	14.1	3.4	0.32	
27.6	10.4	13.0	6.0	0.30	28.1 ± 0.4
28.1	10.2	13.2	0.9	0.35	

0- 5	Loess
5- 10	Till, interbedded with sand, silty, few pebbles
10- 25	Till, silty clay, few pebbles, grey
25- 87	Interbedded clay and silt, laminated, grey
87- 95	Till, silty, few pebbles
95- 97	Sand
97-100	Till, sandy silt
100-107	Sand & Gravel, one granite fragment, mostly carbonate and quartzite
107-149	Bedrock, shale, grey

elev. 3510

77-23

N.W.-9-20-23-1-W5M



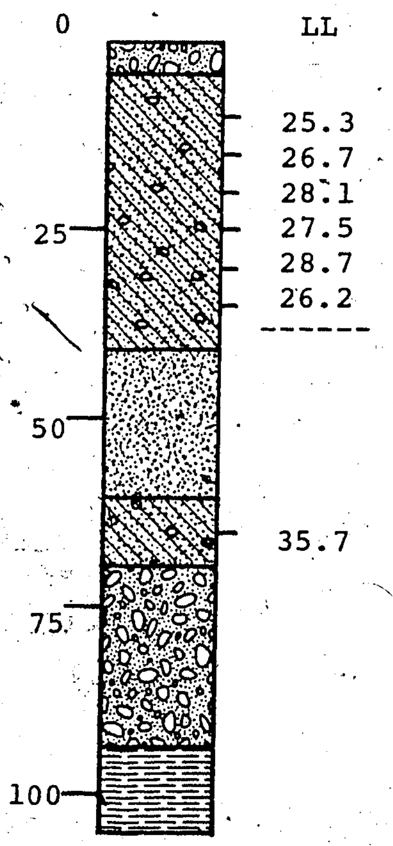
LL	$\frac{S}{M+C}$	IM	CC	$\frac{I}{I+M}$	Remarks
28.8	0.08	[illegible]6	31.9	0.73	silty
28.6	0.04	7.1	34.1	0.66	28.7 ± 1.4?
	0.23		19.2	0.72	sandy
	0.23	0	20.6	0.75	28.5?
	0.09	0.6	16.2	0.68	
	0.09	0.4		0.70	silty
	0.19	0		0.68	

0- 57	Silt & Clay, minor stones bedded
57- 67	Till (?), very hard, silty, very few pebbles
67- 87	Silt, grey, trace pebbles
87- 97	Gravel, well rounded, no granites
97-120	Till, very hard, sandy, light brown to 109 ft. then grey
120-135	Bedrock, shale, dark grey

elev. 3350

77-24

S.W.-6-1-23-1-W5M



Remarks

27.1 ± 1.2

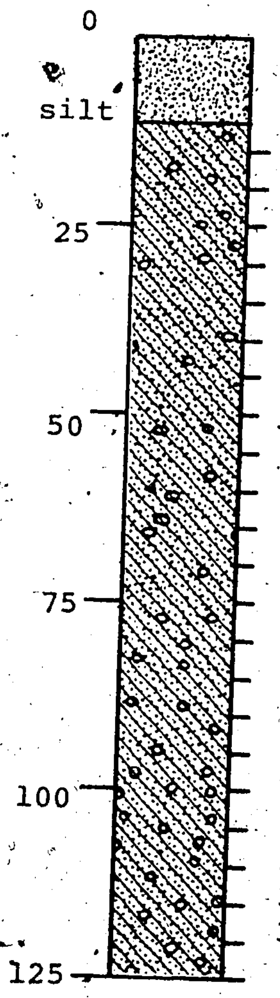
35.7

0- 4	Sand and Gravel, stones up to 3" size
4- 40	Till, silty, iron stained, granite pebbles
40- 62	Silt & Clay, minor grit
62- 69	Till, silty clay, dark grey
69- 93	Gravel, trace clay lense, no granites
93-105	Bedrock, siltstone, grey

elev. 3365

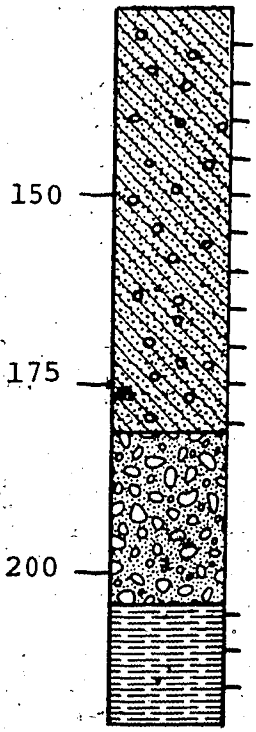
77-25

N.W.-13-22-22-28-W4M



LL	$\frac{S}{M+C}$	IM	CC	$\frac{I}{I+M}$	Remarks
34.8	0.49		8.2	0.58	
35.6	0.47	24.9	10.1	0.59	35.8 ± 1.2
37.2	0.52	26.6	12.3	0.58	
28.4	0.49	26.0	15.2	0.63	
29.2	0.61	27.7	17.2	0.58	sandy zone
25.1	0.52	7.8	19.6	0.57	27.6 ± 1.5
27.4	0.47	9.8	16.3	0.63	
28.2	0.25	[illegible]	17.9	0.61	
33.5	0.32	[illegible]	14.5	0.59	
32.7	0.43	[illegible]	14.5	0.59	
35.9			12.2	0.58	
32.1	0.30	15.9	14.5	0.59	
36.4	0.33	15.3			
34.9	0.18	14.8	11.7	0.56	
35.2	0.32	12.6			35.3 ± 1.7
33.8	0.43	13.8			
34.7	0.43	17.1	14.2	0.58	
35.8	0.43	22.6	12.4	0.56	
36.9			14.5	0.61	
38.2	0.20	17.5	17.0	0.57	
38.1	0.43	17.8	15.2	0.60	
37.6	0.20	17.0	15.3	0.58	
	0.25	12.3	14.9	0.57	

77-25 (cont'd.)



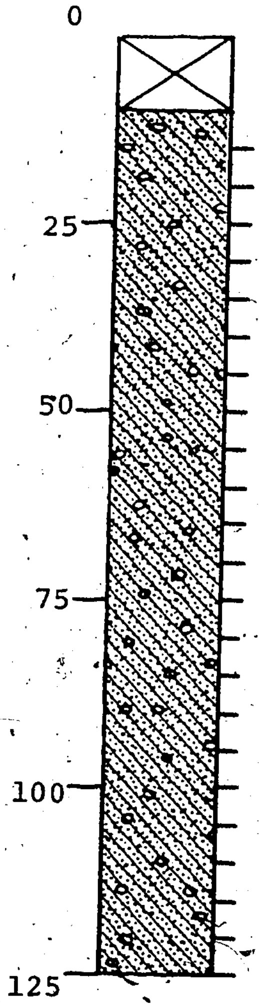
LL	S/M+C	IM	CC	I/I+M	Remarks
35.6	0.19	12.3	15.3	0.64	
35.4	0.22	12.4	15.6	0.61	
31.2	0.36	22.5	15.8	0.63	
36.2	0.36	13.9	15.6	0.63	
35.0	0.22	21.9	15.0	0.62	
35.8	0.30	11.9	15.9	0.65	
36.7	0.14	9.1	15.7	0.64	
35.9	0.33	16.9	17.1	0.63	
34.1	0.18	12.2	13.9	0.65	
34.8	0.30	10.6	15.0	0.61	
35.2	0.25	8.3			
	0.64	3.8			
34.6					
35.2					
34.8					

0- 11	Silt, brown, with fine sand
11- 23	Till, silty clay, oxidized brown with bands of oxidized/unoxidized, gypsum crystals, granite pebbles
23-182	Till, silty clay, grey, hard
182-204	Gravel, contains granite fragments
204-220	Bedrock, siltstone

elev. 3330

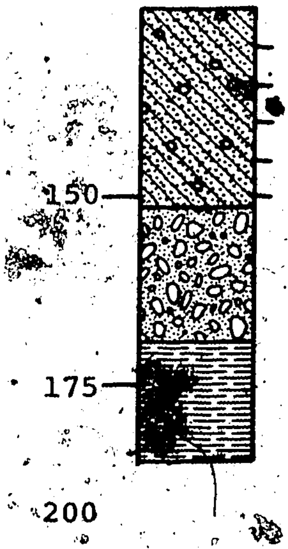
77-26

S.E.-9-35-21-28-W4M



LL	$\frac{S}{M+C}$	IM	CC	$\frac{I}{I+M}$	Remarks
34.4	0.47	18.0	9.8	0.56	
33.9	0.47	22.2	8.7	0.57	
34.8	0.47	26.4	8.1	0.59	
35.3	0.47	25.8	9.0	0.58	
34.1	0.47	23.4	14.4	0.59	
35.8	0.39	30.4	12.6	0.57	
36.7	0.33	25.9	12.5	0.56	
36.1	0.35	23.6	12.0	0.52	
35.1	0.35	15.1	12.1	0.55	
36.0	0.37	20.3	12.1	0.56	
35.4	0.39	21.0		0.57	
37.3	0.37	21.0	10.6	0.54	
36.8	0.37	21.7	10.9	0.56	
36.0	0.39	20.7	10.7	0.56	
36.4	0.37	22.6	10.2	0.50	
35.8	0.39	18.8	12.5	0.53	
35.9	0.37	26.1	12.0	0.58	
35.1	0.39	44.8	11.9	0.55	
36.3	0.45	48.4	19.1	0.56	
34.3	0.49	40.6	12.0	0.59	
34.1	0.39	37.7			
32.9	0.41	34.2	11.2	0.59	
34.4	0.43	22.6	14.7	0.57	

77-26 (cont'd.)



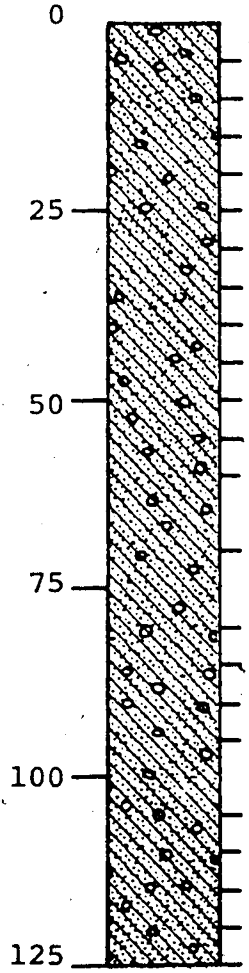
LL	$\frac{S}{M+C}$	IM	CC	$\frac{I}{I+M}$	Remarks
35.9		28.8	14.0	0.57	
35.7		21.4	11.4	0.50	
35.8		29.9	13.3	0.53	35.4 ± 1.0
36.4			13.2	0.53	
35.1		33.1	13.1	0.55	
				0.56	
				0.53	

0- 9	Poor samples
9- 95	Till, silty clay, oxidized, granite pebbles, banding 15 - 20 ft. and 65 - 95 ft. hard drilling
95- 99	Gravel (?), "chattering"
99-151	Till, silty clay, dark grey, granites
151-167	Gravel with sand interbeds, smooth drilling
167-185	Bedrock, siltstone, yellow brown

elev. 3340

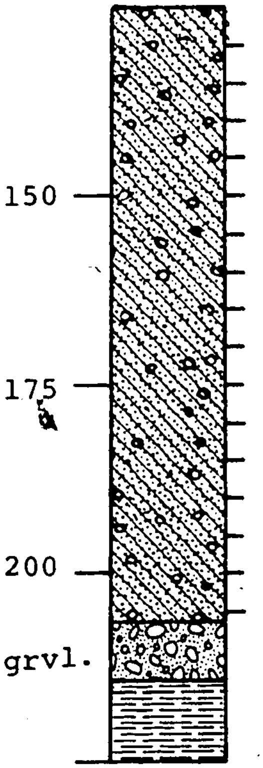
77-29

S.W.-13-1-22-28-W4M



LL	$\frac{S}{M+C}$	IM	CC	$\frac{I}{I+M}$	Remarks
35.7	0.39		13.6	0.56	
36.8	0.47	24.9		0.57	
36.4	0.49	22.2	22.3	0.61	
36.3	0.49	20.5	8.8	0.54	
35.0	0.49	33.9	7.8	0.58	
35.8	0.47	25.0	9.3	0.55	
35.3	0.49	22.8	9.5	0.57	
36.2	0.49	15.3	11.3	0.59	
33.4	0.47	17.4	14.5	0.56	
31.9	0.43	11.8	13.9	0.63	
35.4	0.33	9.0	17.2	0.64	
30.5	0.33	7.2	16.0	0.63	
32.6	0.35	8.7	16.2	0.58	
30.7	0.32	9.4	15.4		
34.8	0.30	7.8	17.9	0.66	
30.4	0.30	14.9	18.[illegible]	0.60	
33.1	0.37	8.8	11.5	0.58	
34.5	0.28	11.0	8.4	0.67	
35.3	0.28	8.2	10.6		
36.7	0.41	14.6	12.7	0.61	
36.0	0.39	15.5	10.6	0.55	
36.8	0.33	12.6	12.2	0.55	
37.1	0.35	14.7	12.7	0.54	
36.0	0.35	20.8	11.9	0.55	
36.2	0.33	22.0	11.9	0.55	

7-29 (cont'd.)



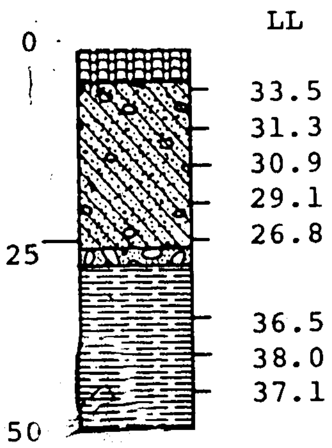
LL	$\frac{S}{M+C}$	IM	CC	$\frac{I}{I+M}$	Remarks
	0.37	16.6	13.1	0.53	
36.3	0.35	12.3	13.5	0.59	
36.1	0.41	22.3	14.1		
35.8	0.37	12.2	14.2		
35.3	0.37	14.3	13.0		
34.2	0.35	8.4	16.5		35.2 ± 1.8
35.5	0.33	7.7	15.2		
29.4	0.33	14.9	15.1		sandy
36.2	0.37	13.3	15.9		
35.8	0.37	7.8	13.4		
37.0	0.37	9.1	16.5		
36.9	0.35	13.3	15.6		
37.2	0.30	7.8	15.3		
36.7	0.37	9.1	14.6		
35.4	0.33	8.1	16.3		
36.8	0.27		20.9	0.93	

0- 20	Till, silty clay, grey-brown, granite pebbles
20-207	Till, silty clay, grey, very stoney 37 - 40 ft. granites and abundant local bedrock, firm
207-214	Gravel
214-225	Bedrock, siltstone

elev. 3395

77-31

S.W.-4-15-23-29 W4M



Remarks

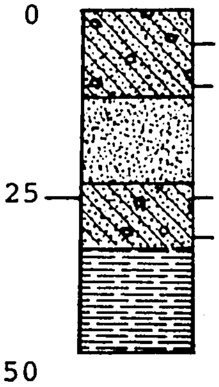
30.3 ± 2.5

0- 5 Fill
5-25 Till, silty, stoney
25-27 Gravel
27-50 Bedrock, sandstone/shale, grey

elev. 4250

77-34

S.W.-15-25-22-4-W5M

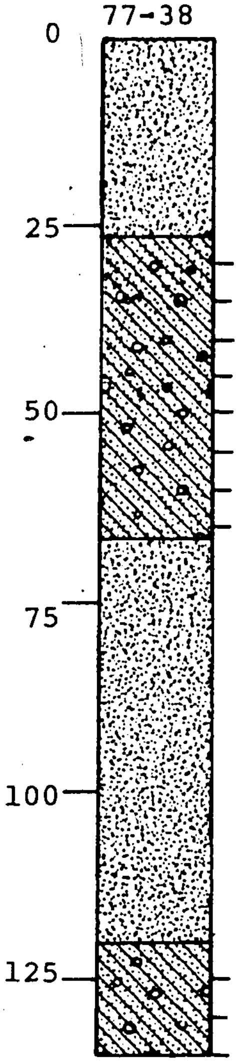


LL	$\frac{S}{M+C}$	IM	Remarks
38.4	0.93	1.4	weathered
33.9	0.85	0.7	
33.4	0.75	-	33.6 ± 0.3
32.1	1.00	-	
32.4	0.79	-	32.2 ± 0.2
34.9	0.91	-	

0- 7	Till, few pebbles
7-12	Till as above, very stoney
12-24	Sand, silty, laminated, stone free
24-31	Till, brown-grey, very hard, stoney
31-45	Bedrock, siltstone, light brown

elev. 3435

N.E.-16-14-22-1-W5M



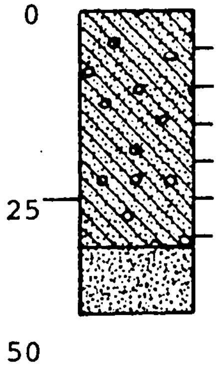
LL	$\frac{S}{M+C}$	IM	$\frac{I}{I+M}$	Remarks
32.1	0.17	13.9	0.77	
30.2	0.51	11.4		
31.5	0.48			
31.0	0.19	13.6		
31.0	0.45	13.5		31.1 ± 0.8
31.7	0.40			
29.7	0.28	6.5		
32.2	0.24	8.6		
28.0	0.21	3.2		27.8 ± 1.1
28.9	0.26	0.5		
26.7	0.22	1.2		

0- 27	Sand, medium to coarse, stone free, unoxidized at 18 ft.
27- 67	Till, silty clay, granite pebbles, clay beds up to 1 ft. thick throughout
67-120	Silt, laminated to massive, blue-grey, sticky below 80 ft.
120-136	Till, silty, dry, hard drilling, dark grey, few small pebbles

elev. 3570

77-41

N.E.-16-36-25-1-W5M



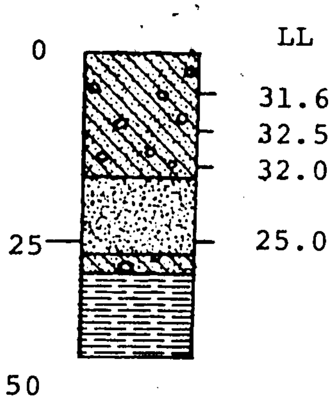
LL	$\frac{S}{M+C}$	IM	Remarks
25.6	0.21	2.1	
25.8	0.22	1.9	
24.5	0.22	1.6	
			24.6 ± 1.4
25.4	0.53	1.2	
22.3	0.51	0.3	

0-33	Till, very few pebbles, laminated silt, predominantly silt to 12 ft., below 12 ft. stoney, hard drilling with sand interbeds, sandy silt
33-40	Bedrock, siltstone, light grey, dry

elev. 3550

77-42

S.W.-12-1-26-1-W5M



Remarks

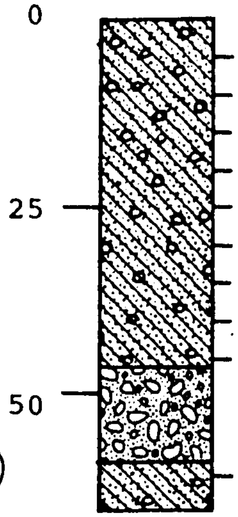
32.0 ± 0.5

0-16	Till, silty, few stones, includes silt lamination
16-22	Silt, wet.
22-27	Sand, fine, organic matter
27-29	Till, fairly stoney
29-40	Bedrock, siltstone, grey

elev. 3760

77-45

S.W.-12-11-26-2-W5M



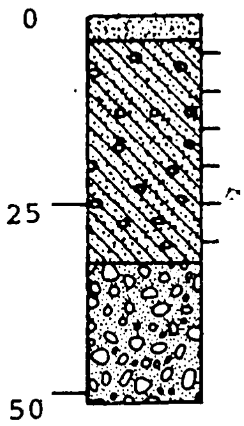
LL	$\frac{S}{M+C}$	IM	Remarks
41.0	0.31	3.3	
35.4	0.30	2.5	
39.5	0.35	0.7	
36.9	0.38		37.2 ± 1.9
36.2	0.41	0.2	
38.4	0.40	-	
35.8	0.38	-	
35.9	0.46	-	
35.7	0.41	1.4	
30.4	0.59	1.3	

0-46	Till, silty clay, pebbles few to moderate, unoxidized at 35 ft.
46-59	Gravel
59-65	Till (?), very hard

elev. 4165

77-46

S.E.-1-13-26-3-W5M



LL	$\frac{S}{M+C}$	IM
40.4	0.33	16.8
35.6	0.66	5.9
38.4	0.65	3.1
37.1	0.45	0.8
33.5	0.79	-
32.9	1.10	1.0

Remarks

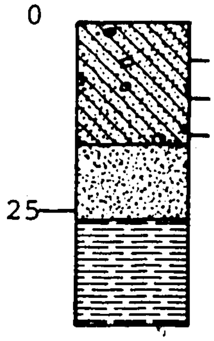
36.5 ± 2.8

0- 4	Silt, clayey, pebbly
4-33	Till, silty clay, grey-brown, very rocky 28 - 33 ft.
33-51	Gravel

elev. 4275

77-47

N.W.-13-8-26-3-W5M



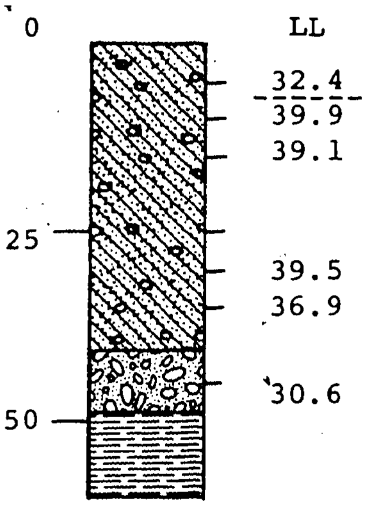
LL	$\frac{S_\ell}{M+C}$	IM	Remarks
36.0	0.36	0.2	
34.1	0.42	-	
34.9	0.33	0.6	35.0 ± 0.9

0-16	Till, silty clay, very stoney
16-26	Silt, light tan, dry, stoney, organic matter
26-30	Bedrock, siltstone

elev. 4245

78-2

N.W. 4-35-25-3-W5M



Remarks

32.4

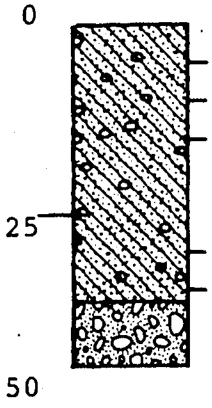
38.8 ± 1.3

0-44	Till, silty, banded upper 6 ft., abundant black carbonate pebbles, olive brown, unoxidized at 16 ft., very stoney 31 - 33 ft.
44-49	Gravel, dry, light tan
49-60	Bedrock (?)

elev. 4320

78-3

N.W.-13-35-25-3-W5M



LL	$\frac{S}{M+C}$
37.9	0.52
39.2	0.46
31.4	0.68
36.2	0.63
33.0	0.49

Remarks

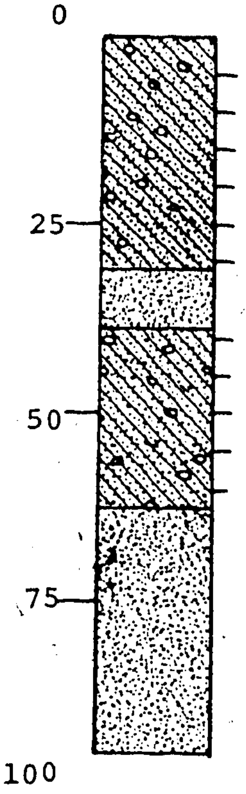
35.5 ± 3.2

0-36	Till, silty clay, grey, carbonate pebbles, stoney to 26 ft., fewer stones 26 - 36 ft.
36-44	Gravel

elev. 4150

78-6

S.E.-1-22-26-3-W5M



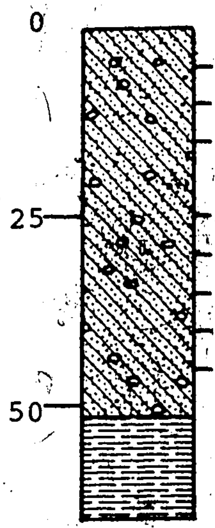
LL	$\frac{S}{M+C}$	CC	Remarks
33.0	0.30	30.4	
34.1	0.25	27.0	
33.8	0.68	23.5	
34.2	0.30	25.6	33.5 ± 0.6
32.7	0.23	24.4	
44.4	0.04	21.4	
37.3	0.04	21.3	
38.7	0.06	21.0	39.9 ± 2.9
42.0	0.06	22.9	
43.9	0.08	22.4	
37.6	0.06	21.8	

0- 8	Till, silty clay, stoney, black carbonate pebbles, yellow-brown
8-10	Silt, light tan, laminated
10-27	Till as above, few stones
27-31	Till, clay, grey, some laminated clay
31-38	Clay, grey, laminated, plastic, some stones
38-63	Till, silty clay, stoney
63-80	Clay, grey, some stones
80-95	Silt, olive brown dry

elev. 3950

78-7

S.E.-9-25-26-3-W5M



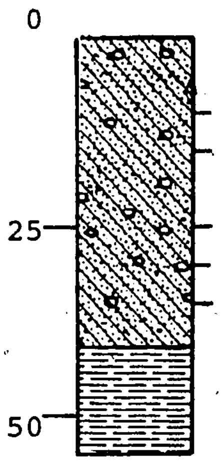
	LL	$\frac{S}{M+C}$	Remarks
w	35.2	0.65	weathered?
	31.0	0.82	
	31.8	0.65	
	27.2	1.03	
	34.0	0.73	
	31.4	0.82	31.9 ± 2.2
	32.5	0.70	
	33.9	0.39	
	33.4	0.64	

0-51	Till, silty, small pebbles, mostly carbonate pebbles, silty 22 - 24 ft. with no pebbles, unoxidized at 44 ft.
51-65	Bedrock, siltstone, yellow-brown

elev. 4025

78-8

N.W.-4-23-25-4-W5M



LL

33.8
36.3
35.5
31.8
32.3

Remarks

35.2 ± 1.2

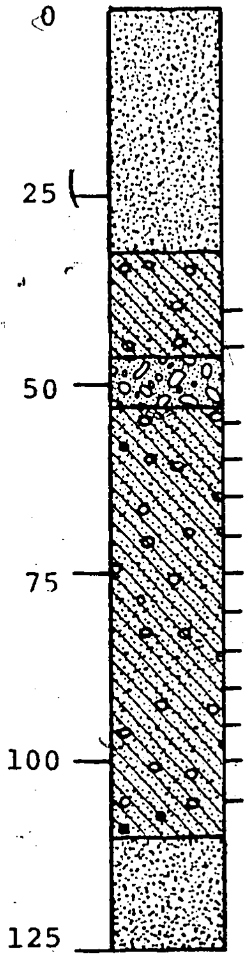
32.0 ± 0.3
transitional?

0-29 Till, silty, firm, oxidized
29-42 Till, silty, grey, dry, crumbly appearance, mostly carbonate and quartzite pebbles
42-55 Bedrock, shale

elev. 3935

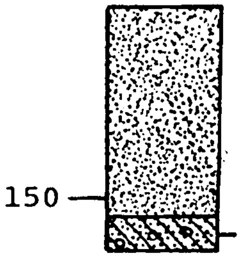
78-9

S.W.-16-27-25-4-W5M



LL	$\frac{S}{M+C}$	CC	Remarks
37.1	0.20	23.6	
35.9	0.28	21.0	
35.3	0.32	24.6	
32.6	0.37	22.4	
33.3	0.37	23.5	
34.6	0.39	23.0	
35.8	0.37	22.5	34.4 ± 1.5
33.0	0.37	22.3	
34.3	0.39	21.9	
34.8	0.37	21.8	
36.2	0.45	22.5	
32.4	0.33	22.4	
32.5	0.35	23.2	

78-9 (cont'd.)



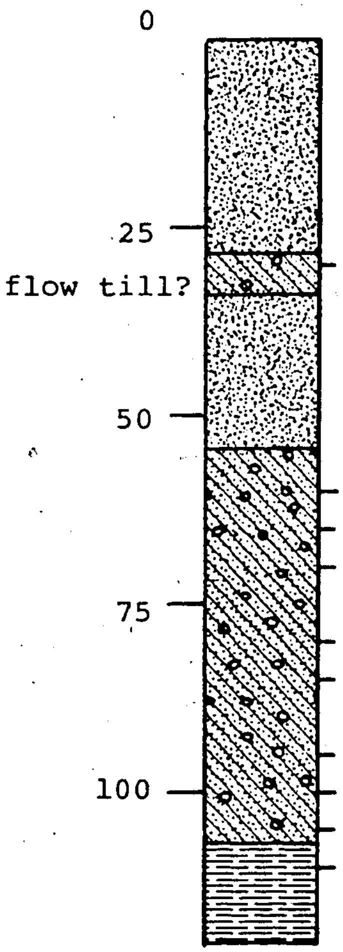
LL	$\frac{S}{M+C}$	CC	Remarks
18.3	0.06	56.0	18.3?

0- 37	Clay & Silt, laminated, pebbly, stiff
37- 47	Till, olive brown, abundant black carbonate pebbles, silty clay
47- 54	Gravel, or very rocky till
54-110	Till, grey-brown, becoming unoxidized at 75 ft., abundant local bedrock and carbonate pebbles
110-154	Silt and sand, silt laminated, dry
154-157	Till, grey, abundant carbonate pebbles

elev. 3875

78-10

N.E.-8-24-25-4-W5M



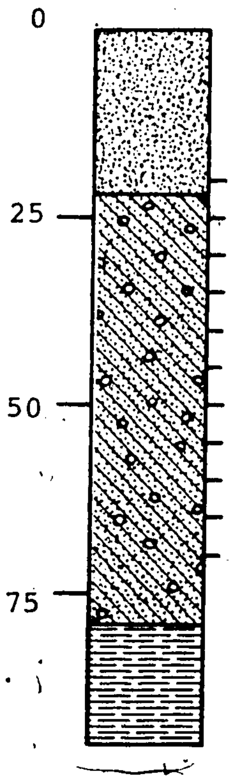
LL	$\frac{S}{M+C}$	CC	Remarks
37.7	0.12	25.5	36.5 ± 1.6
35.4		23.6	
37.2		27.7	
36.8	0.04	27.4	
36.9	0.05	27.3	
34.8	0.06	27.6	
31.0	0.06	27.9	34.8 ± 2.1
34.3	0.06	30.6	
34.5	0.08	28.5	
33.4	0.05	30.7	
33.5			

0- 30	Clay & Silt, laminated, yellow-brown
30- 32	Till, silty, some pebbles, oxidized, flow till?
32- 54	Silt, clayey, some small pebbles, yellow-brown, dry
54-106	Till, silty, massive, low pebble content, dry, crumbly, yellow-brown
106-120	Bedrock, siltstone

elev. 3925

78-11

N.W.-4-7-25-3-W5M



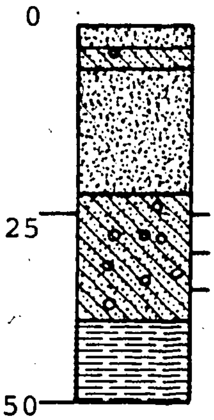
LL	$\frac{S}{M+C}$	CC	Remarks
40.0	0.19		
36.5	0.12	21.1	
42.8	0.16	24.1	
31.1	0.15	23.7	
34.0	0.15	24.5	
35.9	0.16	25.0	
34.8	0.18	25.0	35.4 ± 2.9
34.5	0.12	26.1	
35.4	0.14	25.7	
34.0	0.16	30.7	
35.4	0.14	30.3	

0-23	Clay, silty, oxidized, stone free
23-78	Till, clayey silt, oxidized, becomes unoxidized at 41 ft. and dry
78-95	Bedrock, sandstone, oxidized

elev. 3950

78-14

N.W.-13-34-24-3-W5M



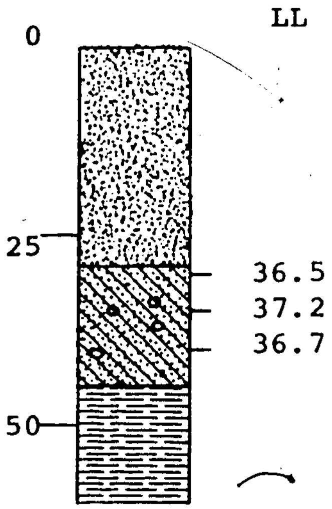
LL	$\frac{S}{M+C}$	CC	Remarks
36.0	0.19	20.8	38.1 ± 2.0
38.3	0.19	20.9	
40.0	0.18	19.3	

0- 2	Silt, clayey, black, organic, soft, stone free
2- 6	Till, clayey, silt, highly organic black
6-23	Clay, silty, light olive brown, stone free
23-38	Till, silty, dry, crumbly, mostly dark carbonate pebbles, unoxidized
38-50	Bedrock, sandstone

elev. 3890

78-16

S.E.-4-16-25-3-W5M



Remarks

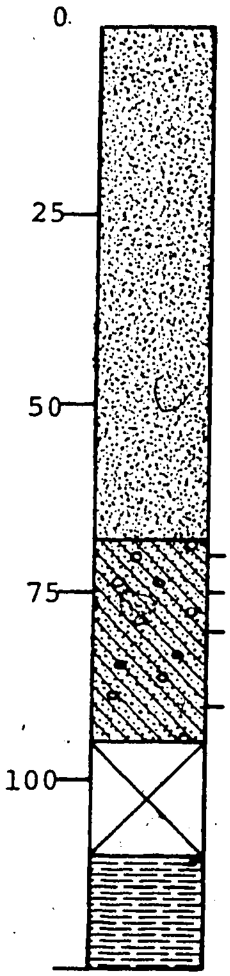
36.8 ± 0.4

0-28	Clay, silty, crumbly, pebble free in upper 15 ft., banded
28-44	Till, silty, massive, dry, yellow-brown
44-60	Bedrock, sandstone

elev. 3865

78-17

S.W.-12-11-25-3-W5M



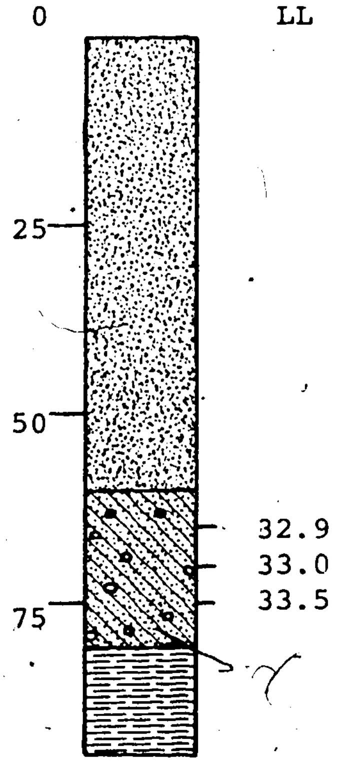
LL	$\frac{S}{M+C}$	CC	Remarks
34.3	0.16	30.1	35.1 ± 1.7
34.0	0.18	29.0	
37.7	0.10	30.8	
34.3	0.12	36.9	

0- 68	Silt & Clay, light olive brown, stone free
68- 95	Till, sandy silt, oxidized to 76 ft., very pebbly
95-108	No recovery
108-125	Bedrock, sandstone

elev. 3850

78-18

S.E.-4-23-24-3-W5M



Remarks

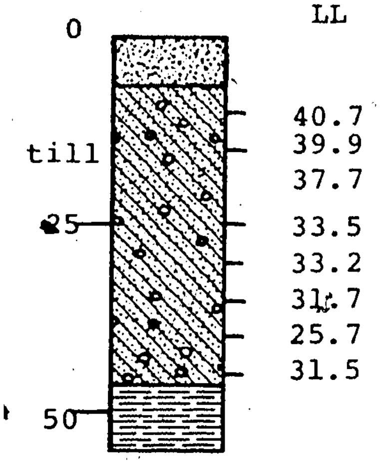
33.1 ± 0.3

0-60	Clay & Silt, stone free, plastic, unoxidized at 32 ft.
60-81	Till, silty, massive, dry
81-95	Bedrock, sandstone, grey

elev. 3850

78-19

N.W.-13-3-24-3-W5M



Remarks

37.0 ± 3.5

----

transitional to
sandy bedrock

0- 6	Silt & Clay, very dry, stone free, olive
6-45	Till, clayey silt, olive, quite stoney, sandy from 30 ft., very hard
45-55	Bedrock, sandstone, grey

APPENDIX B

ADDITIONAL TEST HOLE INFORMATION

Water Wells

S.W.-22-21-28-W4M: 0-86 clay, 86-130 gravel

S.W.-27-21-28-W4M: 0-10 sand and clay, 10-11 sand, 11-127 till, 127-133 gravel

S.E.-27-21-28-W4M: 0-125 clay, 125-140 gravel, 140 - bedrock

S.W.-29-21-28-W4M: 0-42 sand, 42 - bedrock

N.W.-30-21-28-W4M: 0-30 sand, 30 - 60 gravel, 60 - bedrock

S.W.-31-21-28-W4M: 0-36 boulder till, 36 - 46 sandy silt, 46-100 till, 100 - bedrock

N.E.-31-21-28-W4M: 0-60 clay and silt, 60-63 sand, 63-166 clay, 166-188 gravel, 188 - bedrock

S.E.-34-21-28-W4M: 0-126 blue clay, 126-135 gravel, 135 - bedrock

N.E.-5-21-29-W4M: 0-92 till, 92 - bedrock

S.E.-28-21-29-W4M: 0-15 clay, 15-91 till, 91 - bedrock

N.W.-33-21-29-W4M: 0-100 sand and gravel, 100 - bedrock

S.E.-36-21-29-W4M: 0-12 till, 12-29 sand and gravel, 29-79 clay and gravel (till), 79 - bedrock

N.W.-13-21-1-W5M: 0-84 clay, 84-150 sand and gravel, 150 - bedrock

S.W.-31-21-1-W5M: 0-193 overburden, 193 - bedrock

N.E.-34-21-1-W5M: 0-48 till, 48-185 clay, 185-187 gravel

S.E.-36-21-1-W5M: 0-160 clay, 160-185 gravel, 185 - bedrock

S.W.-6-22-28-W4M: 0-26 clay, 26-36 sand, 36-124 till, 124-138 sand and gravel, 138-201 till, 201 - bedrock

N.W.-6-22-28-W4M: 0-25 clay, 25-167 grey clay and rocks (till), 167-205 cemented gravel, 205 - bedrock

N.W.-10-22-28-W4M: 0-175 till, 175-199 gravel

S.E.-1-22-29-W4M: 0-40 clay, 41-50 boulder clay (till), 50-174 clay and pebbles (till), 174-195 gravel and boulders, 195 - bedrock

S.E.-2-22-29-W4M: 0-18 brown till, 18-27 sand, 27-124 grey boulder till, 124-129 gravel and boulders, 129-138 grey boulder till, 138-160 gravel, 160 - bedrock

S.E.-3-22-29-W4M: 0-30 clay, 30-40 sand, 40-140 till, 140-143 gravel, 143-165 till, 165-189 gravel, 189 - bedrock

S.E.-4-22-29-W4M: 0-29 brown sand, 29-110 grey clay and rocks (till), 110-150 gravel and boulders, 150 - bedrock

N.E.-24-22-29-W4M: 0-20 till, 20-60 sand and gravel, 60 - bedrock

S.W.-28-22-29-W4M: 0-81 clay and sand, 81-84 sand and gravel, 84-100 clay and gravel (till)

N.E.-2-22-1-W5M: 0-15 till, 15-54 gravel, 54-64 till, 64-74 gravel, 74-95 till, 95 - bedrock

N.E.-7-22-1-W5M: 0-19 clay, 19-36 gravel, 36-65 till, 65 - bedrock

N.E.-17-22-1-W5M: 0-12 clay, 12-55 sand and gravel, 55 - bedrock

N.E.-17-22-1-W5M: 0-6 clay, 6-35 gravel and boulders, 35-65 till, 65 - bedrock

N.E.-18-22-1-W5M: 0-100 till, 100 - bedrock

S.E.-18-22-1-W5M: 0-20 clay and rock (till), 20-50 gravel, 50-65 clay and rock (till), 65 - bedrock

N.W.-23-22-2-W5M: 0-90 till, 90 - bedrock

N.E.-28-22-2-W5M: 0-110 till, 110 - bedrock

N.W.-8-22-3-W5M: 0-30 clay, 30-99 silt, 99 - bedrock

S.E.-15-22-3-W5M: 0-21 clay, 21-57 till, 57-73 gravel, 73 - bedrock

N.E.-21-22-3-W5M: 0-20 clay, 20-40 till, 40-66 gravel, 66 - bedrock

N.E.-28-22-3-W5M: 0-34 gravel, 34 - bedrock

N.W.-29-22-3-W5M: 0-40 till, 40-53 gravel, 53-55 till

S.W.-30-22-3-W5M: 0-55 clay and boulders (till), 55-103 silt, 103 - bedrock

N.E.-36-22-3-W5M: 0-95 clay and boulders (till), 95 - bedrock

S.E.-5-23-1-W5M: 0-10 sand, 10-60 sand and clay, 60-73 fine sand, 73-158 silty sand and gravel, 158 - bedrock

N.W.-20-23-1-W5M: 0-30 clay, 30-35 sand, 35-100 brown clay and gravel (till), 100-150 sandy clay and gravel (till), 150 - bedrock

N.W.1-23-2-W5M: 0-11 clay, 11-13 gravel, 13-27 clay, 27-69 sand, 69-106 gravel, 106-139 sand, 139 - bedrock

N.W.-1-23-2-W5M: 0-24 till, 24-82 clay, 82-116 gravel, 116-134 sand, 134 - bedrock

S.E.-12-23-2-W5M: 0-103 clay, 103-128 sand, 128 - bedrock

N.W.-13-23-3-W5M: 0-16 clay and boulders (till), 16-92 gravel and boulders, 92 - bedrock

Inventory of Calgary Data

N.W.-15-23-1-W5M: 0-6 silt and sand, 6-9 brown till, 9-11 sand, 11-19 till

S.E.-20-23-1-W5M: 0-6 silt, 6-11 till (LL 35)*, 11-17 sand, 17-20 till

S.E.-21-23-1-W5M: 0-3 silt, 3-13 till, 13-28 clay and sand, 28-31 till

S.E.-21-23-1-W5M: 0-13 silt, 13-34 till, 34-36 gravel, 36-40 till

N.E.-28-23-1-W5M: 0-7 silt and clay, 7-11 till (LL 32), 11-13 clay, 13-18 till

*LL = liquid limit

N.E.-28-23-1-W5M:	0-5 silt, 5-14 till, 14-17 gravel, 17-20 silt, 20-24 till (LL 27), 24-30 gravel
S.W.-33-23-1-W5M:	0-5 silt, 5-15 till (LL 28), 15-19 silt, 19-24 till
S.E.-33-23-1-W5M:	0-4 silt, 4-7 till (LL 28), 7-19 sand and silt, 19-21 till
N.W.-2-24-1-W5M:	0-4 fill, 4-22 sand, silt and clay, 22-40 till (LL 25)
N.W.-3-24-1-W5M:	0-18 silt and sand, 18-22 till (LL 27), 22-87 silt and sand, 87-104 till (LL 37)
N.W.-4-24-1-W5M:	0-6 silt, 6-36 till, 36-47 silt and sand, 47-97 till
S.E.-6-24-1-W5M:	0-6 silt, 6-18 till (LL 33), 18-25 sand and silt, 25-36 till (LL 35), 36 - bedrock
S.W.-8-24-1-W5M:	0-14 till (LL 27)
S.W.-9-24-1-W5M:	0-7 sand, 7-25 till (LL 27)
N.E.-21-24-1-W5M:	0-99 sand, silt and clay, 99-137 till (LL 22), 137 - bedrock

N.E.-21-24-1-W5M: 0-108 sand, silt and clay, 108-132 till (LL 26), 132 - bedrock

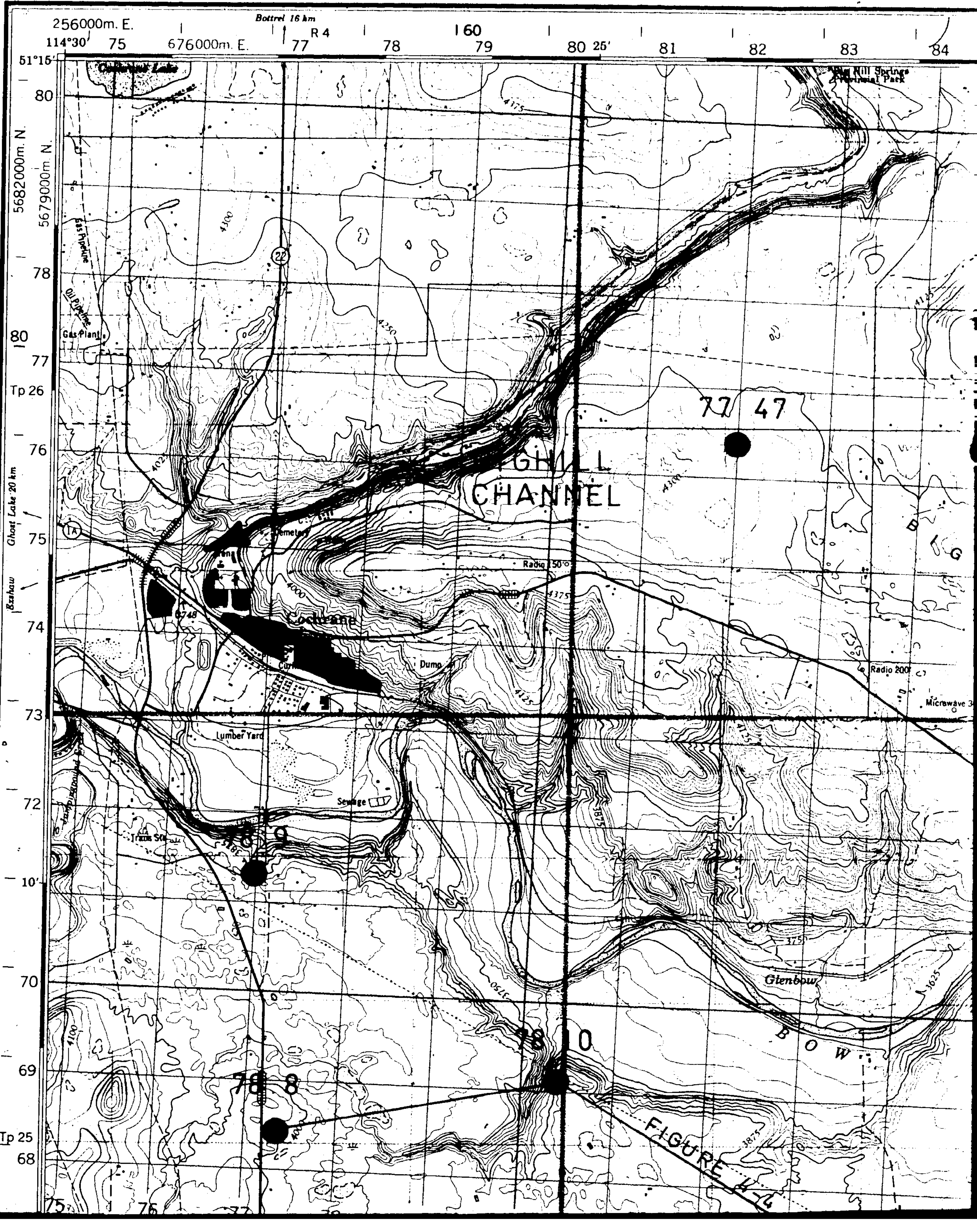
S.E.-30-24-1-W5M: 0-46 sand, silt, clay and gravel, 46 - bedrock

N.E.-30-24-1-W5M: 0-28 silt and sand, 28-71 till (LL 28)

1 of

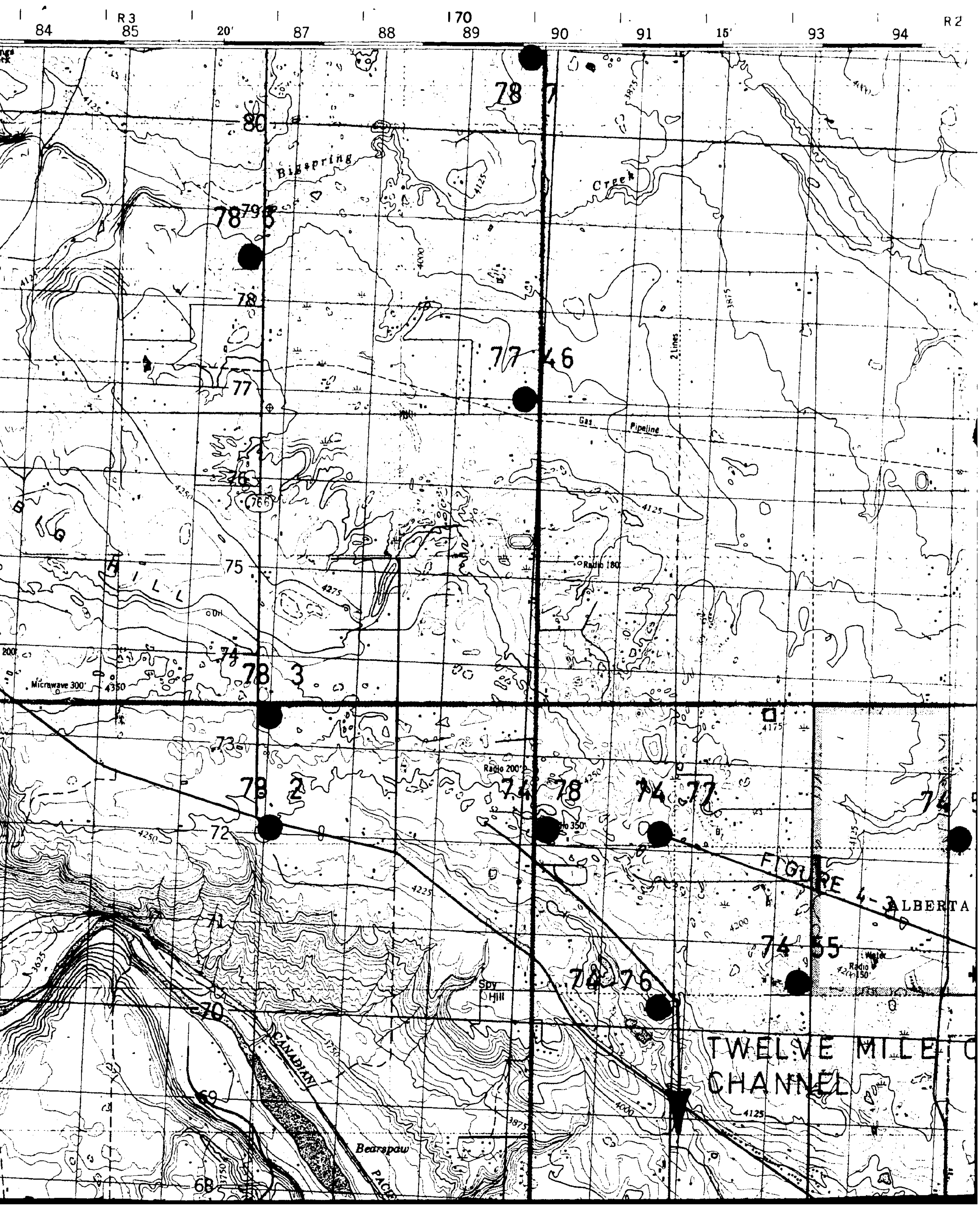
82-O/1

1:50 000



2 of

CANADA



R 3
R 2
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85
20′
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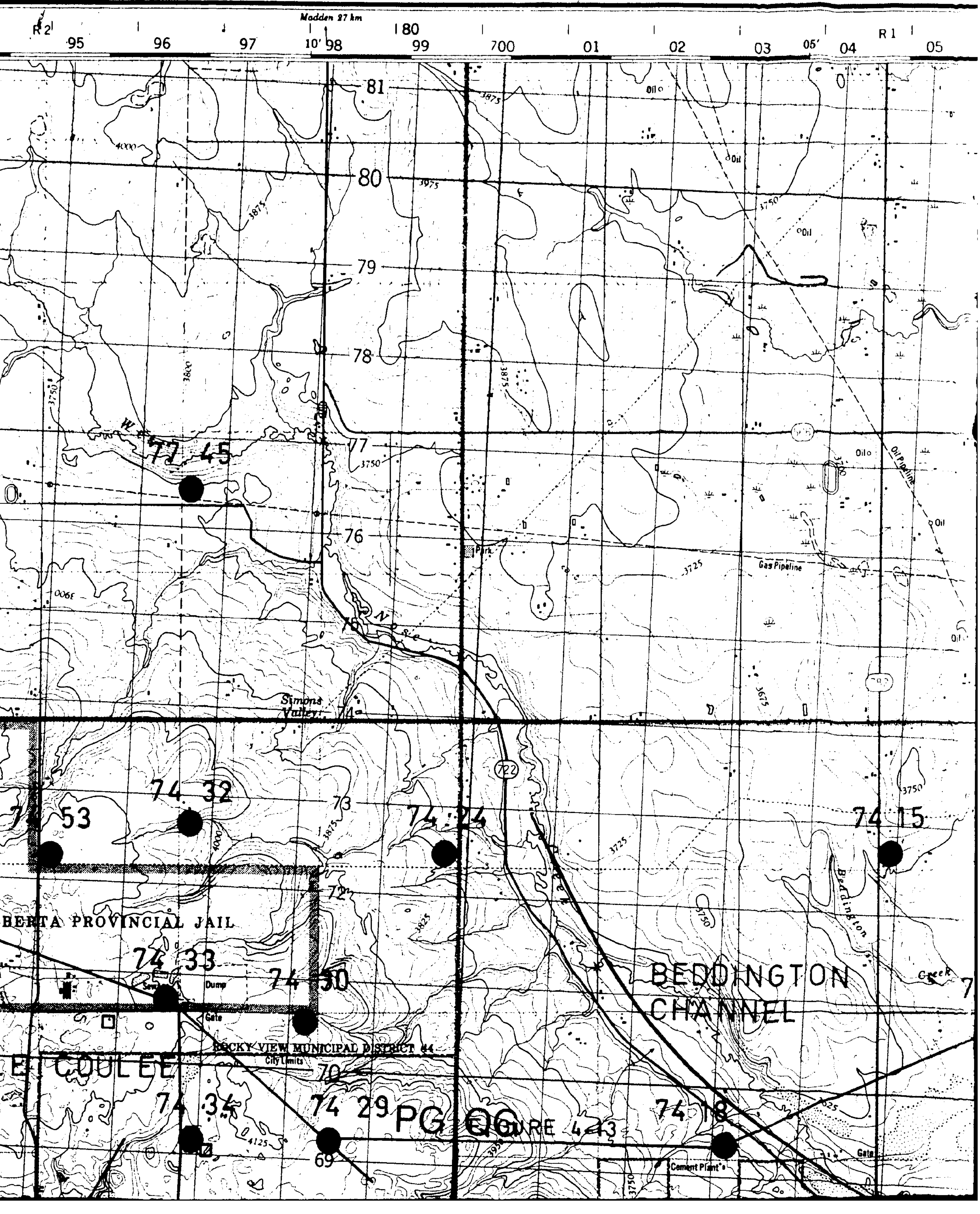
90
91
15′
93
94
78 7
80
Bigspring
Creek
78 79 8
78
77 46
77
Gas
Pipeline
2 Lines
76
766
4125
4250
4275
4000
3875
B I G
H I L L
75
Radio 180
Oil
74
78 3
Microwave 300′
4350
73
4175
Radio 200′
78 2
74 78
74 77
74
72
Radio 350′
FIGURE 4-3 ALBERTA
71
4225
4200
74 65
Water
Radio 150′
74 76
Spy Hill
70
3625
CANADIAN
TWELVE MILE
CHANNEL
69
4125
Bearspaw
PACI
68
3750

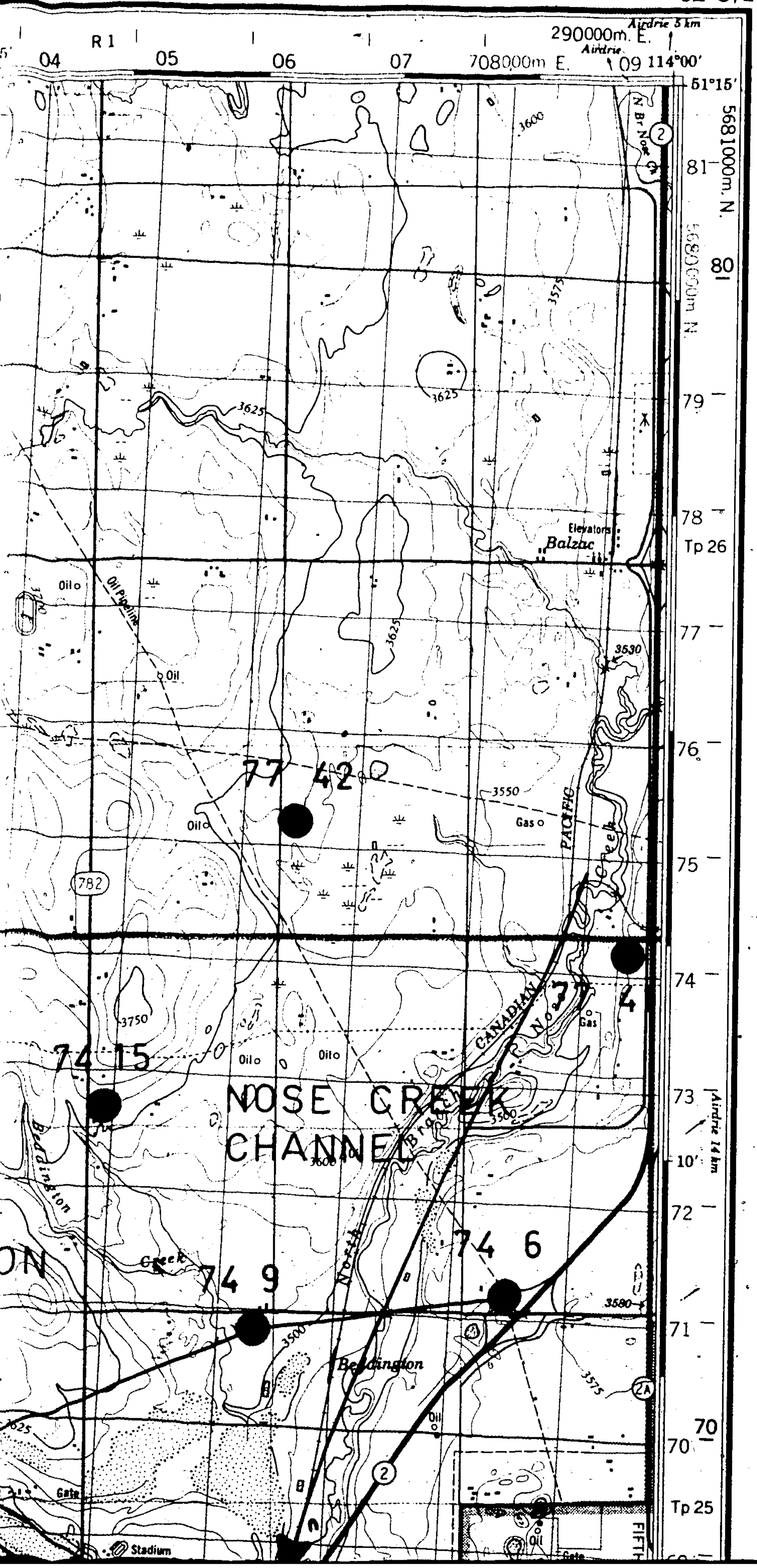
3 OF 1

EDITION 5



EDITION 5

82-O/1



Military users, refer to this map as: Référence de cette carte pour usage militaire:	SERIES A 741 SÉRIE MAP 82-0/1 CARTE EDITION 5 MCE ÉDITION

40F

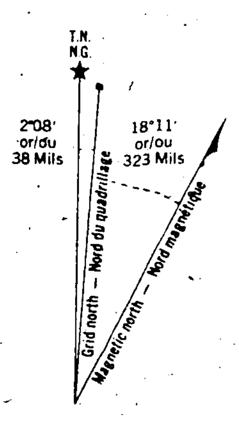
GLOSSARY GLOSSAIRE

Airfield	Terrain d'aviation
Arena	Arena
City Limits	Limites de ville
Customs	Douane
Ditch	Fossé
Dugout	Abreuvoir
Dump	Dépotoir
Filtration Plant	Usine de filtration
Gas	Gaz
Golf Course	Terrain de golf
Junk Yard	Ferraille
Kiln	Four
Lookout	Belvédère
Mine Waste	Déblai de mine
Oil Wells	Puits de pétrole
Park	Parc
Rink	Patinoire
Senior Citizens Home	Foyer de l'âge d'or
Ski Area	Station de ski
String Bog	Fondrière à filaments
Surveyed Line	Ligne arpentée
Tank	Réservoir
Water	Eau
Winter Road	Chemin d'hiver

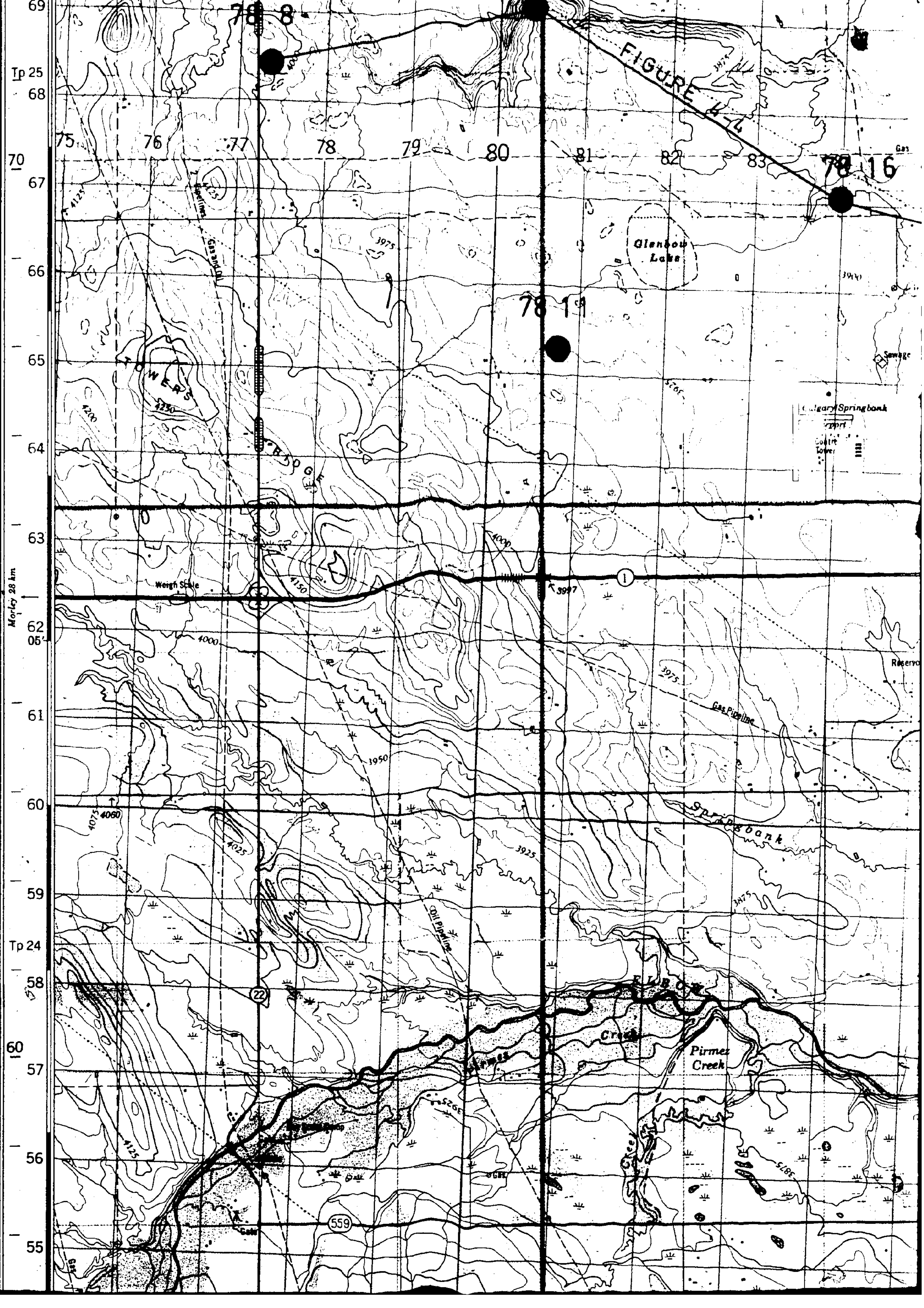
For a complete glossary see reverse side
Pour un glossaire complet, voir au verso

ABBREVIATIONS ABRÉVIATIONS

Aband	Abandoned	Abandonné, ée
C	Cemetery	Cimetière
CO	County	Comté
E	Elevator	Élévateur
Fy	Ferry	Traversier
IR	Indian Reserve	Réserve indienne
H	Hospital	Hôpital
L	Lot	Lot
Micro	Microwave	Micro-ondes
Mun	Municipality	Municipalité
P	Post Office	Bureau de poste
PH	Power House	Centrale électrique
RCMP	Royal Canadian Mounted Police	Gendarmerie Royale Canadienne
Res	Reservoir	Reservoir
Trans Sta	Transformer Station	Poste de transformateurs
TFL	Tree Farm Licence	Licence de sylviculture



Use diagram only to obtain numerical values
APPROXIMATE MEAN DECLINATION 1980


78 8
78 11
78 16
FIGURE 4-4
69
Tp 25
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05'
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60
59
Tp 24
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79
80
81
82
83
Glenbow Lake
TOWERS
RIDGE
Calgary/Springbank Airport
Control Tower
Sewage
Gas
Weigh Scale
1
3997
Morley 28 km
Reservoir
Gas Pipeline
Gas and Oil Pipelines
Oil Pipeline
Springbank
22
ELBOW
Creek
Pirmez Creek
559
Gate
4125
4200
4250
4150
4000
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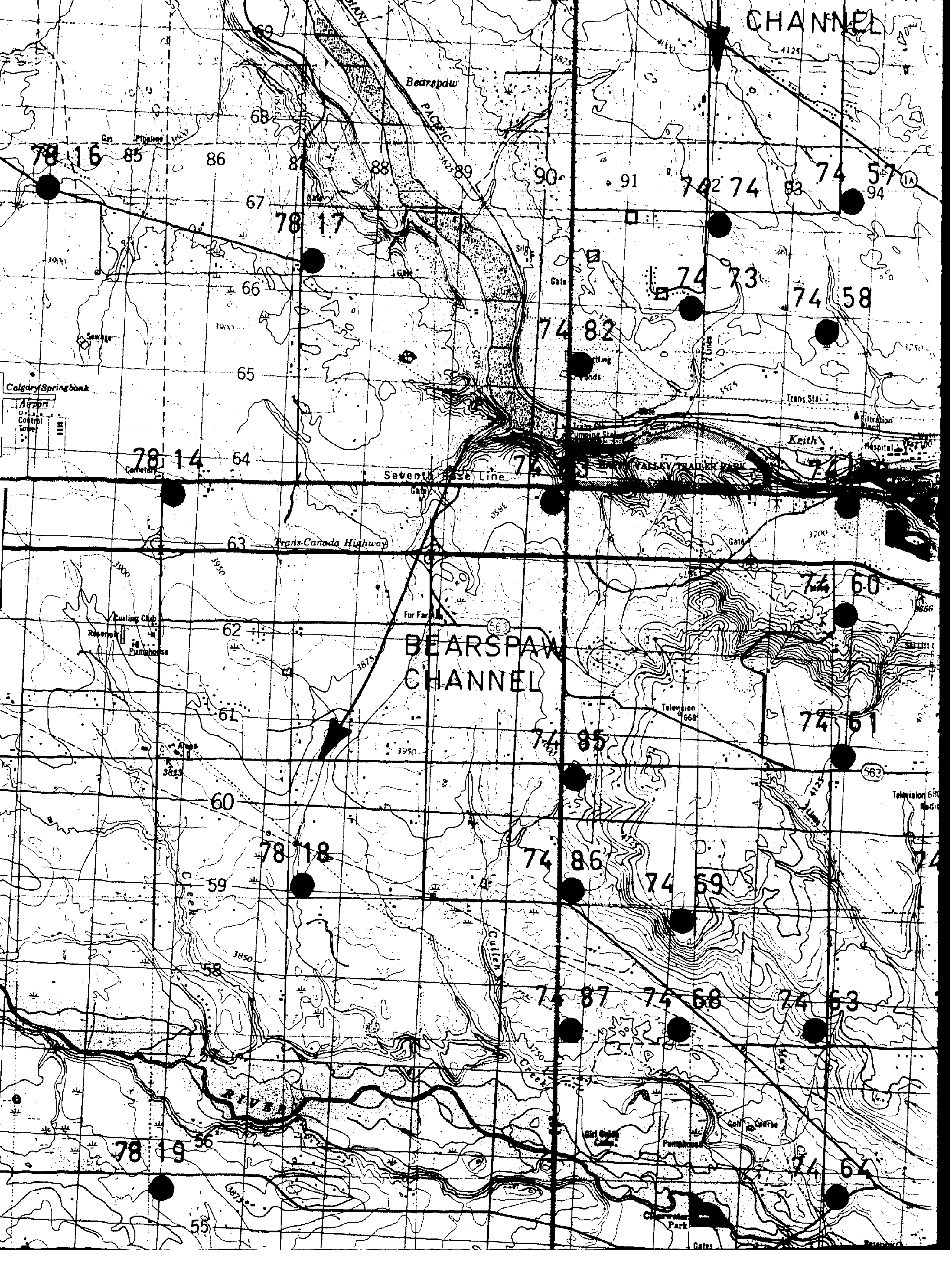
CHANNEL
Bearspaw
PACIFIC
78 16
78 17
78 14
78 18
78 19
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74 74
74 73
74 58
74 82
74 83
74 60
74 61
74 85
74 86
74 69
74 87
74 68
74 63
74 64
Calgary/Springbank Airport
Control Tower
Seventh Base Line
Trans-Canada Highway
BEARSPAW CHANNEL
Curling Club
Reservoir
Pumphouse
Fur Farm
Television 668
Keith
Filtration Plant
Hospital
Settling Ponds
Pumping Station
Gas Pipeline
Sewage
Cemetery
Cullen Creek
River
Girl Guide Camp
Pumphouse
Golf Course
Clearwater Park
Gates
563
1A
85
86
87
88
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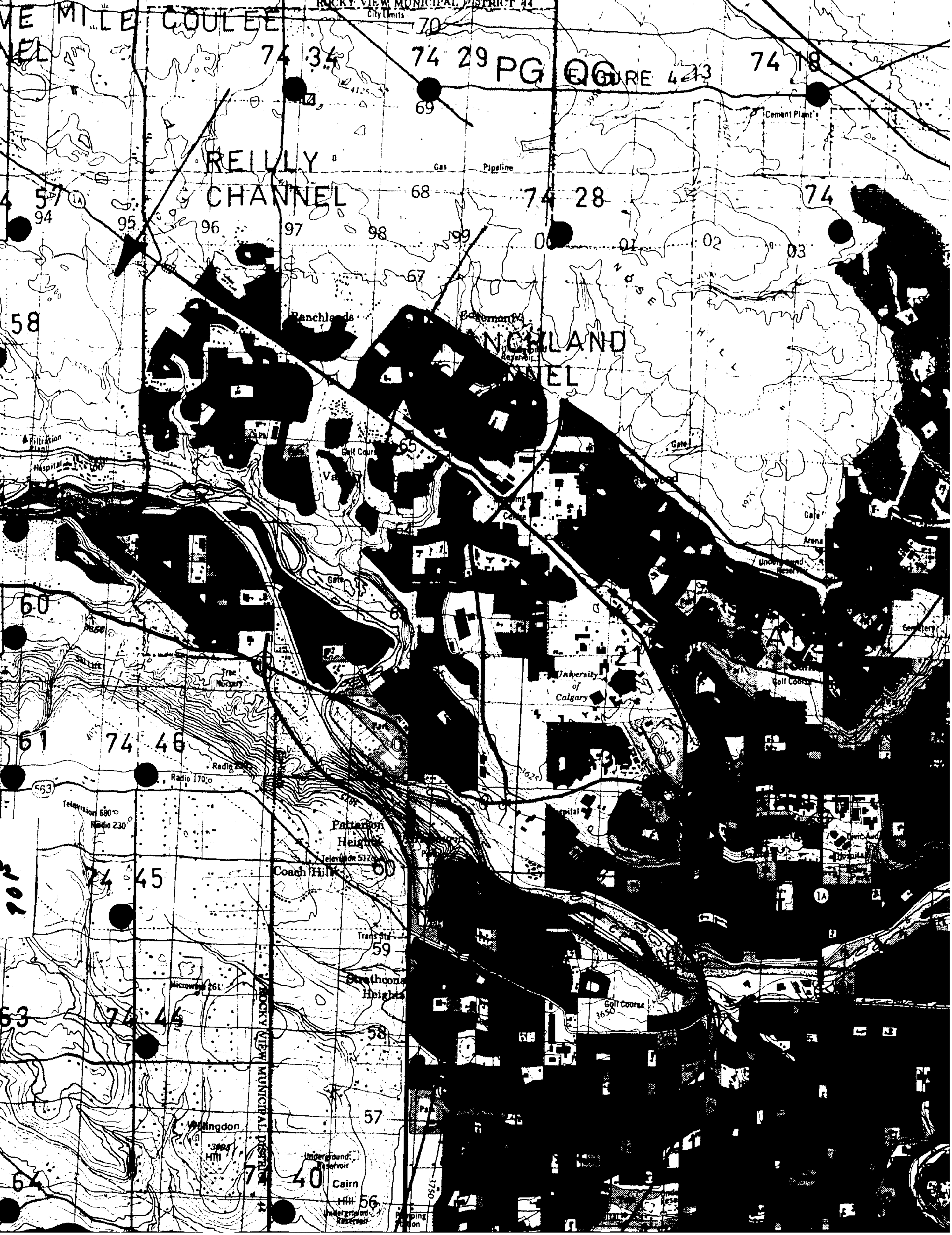
ROCKY VIEW MUNICIPAL DISTRICT 44
City Limits
VE MILE COULEE
NEL
70
74 34
74 29
PG
QG
FIGURE 4.13
74 18
69
Cement Plant
REILLY
CHANNEL
Gas Pipeline
68
74 28
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01
02
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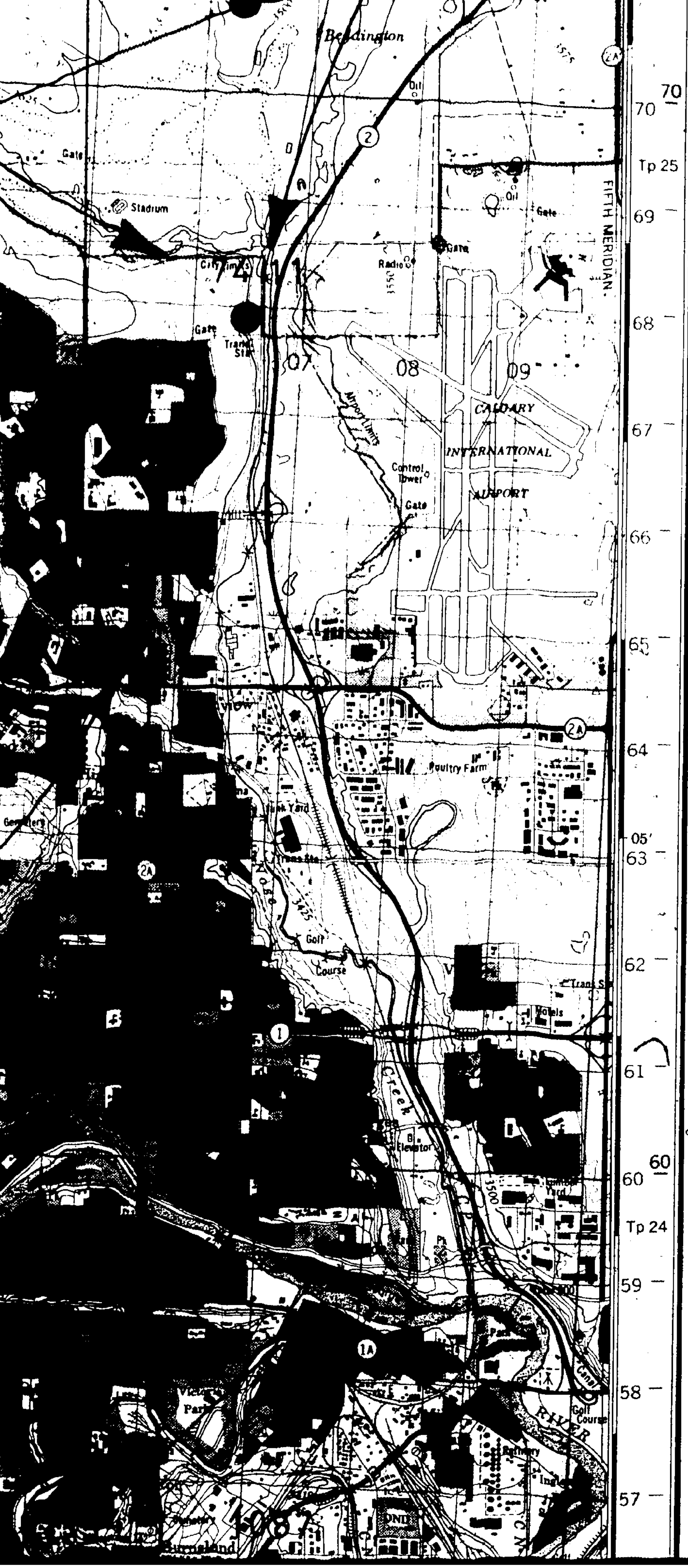
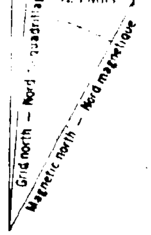
58
Ranchlands
Edgemont
RANCHLAND
CHANNEL
Underground Reservoir
NOSE HILL
Filtration Plant
Hospital
Golf Course
65
64
Gate
Arena
Underground Reservoir
60
Cemetery
21
University of Calgary
Golf Course
61
74 46
563
Radio 170
Tree Nursery
Television 680
Radio 230
Patterson Heights
Television
Coach Hill
60
74 45
Hospital
1A
Trans Stn
59
Strathcona Heights
Microwave 261
Golf Course
3650
63
74 44
58
ROCKY VIEW MUNICIPAL DISTRICT 44
57
Wellingdon Hill
Underground Reservoir
74 40
Cairn
56
Underground Reservoir
Pumping Station
64
3750

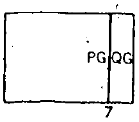




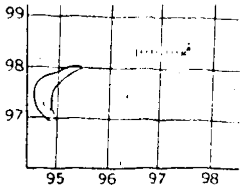
Use diagram only to obtain numerical values
APPROXIMATE MEAN DECLINATION 1980
FOR CENTRE OF MAP
Annual change decreasing 14.0

N'utiliser le diagramme que pour obtenir les valeurs numériques
DÉCLINAISON MOYENNE APPROXIMATIVE
AU CENTRE DE LA CARTE EN 1980
Variation annuelle décroissante 14.0

ONE THOUSAND METRE
UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 11
QUADRILLAGE DE MILLE MÈTRES
TRANSVERSE UNIVERSEL DE MERCATOR

GRID ZONE DESIGNATION DÉSIGNATION DE LA ZONE DU QUADRILLAGE	100 000 M. SQUARE IDENTIFICATION IDENTIFICATION DU CARRÉ DE 100 000 M
11U	

EXAMPLE OF METHOD USED
TO GIVE A REFERENCE TO NEAREST 100 METRES
EXEMPLE DE LA MÉTHODE EMPLOYÉE
POUR FIXER DES REPÈRES À 100 MÈTRES PRÈS



REFERENCE POINT
POINT DE REPÈRE
CHURCH · ÉGLISE (as above) (ci-dessus)

EASTING: Read number on grid line immediately to left of point:
ABSCISSE: Noter le chiffre de la ligne du quadrillage immédiatement à gauche du repère: 97

Estimate tenths of a square from this line eastward to point:
Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction est: 5

975

NORTHING: Read number on grid line immediately below point:
ORDONNÉE: Noter le chiffre de la ligne du quadrillage immédiatement en-dessous du repère: 98

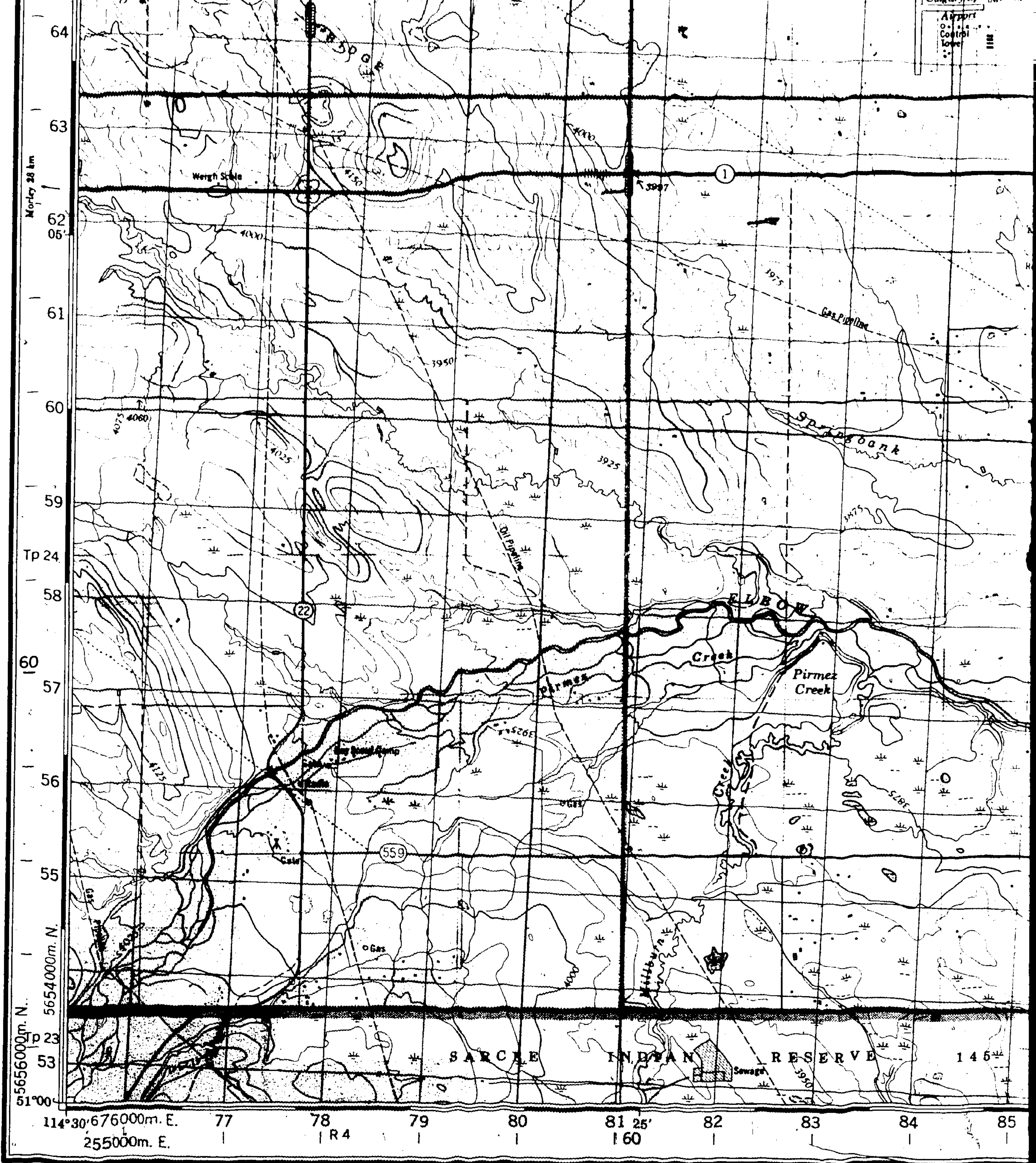
Estimate tenths of a square from this line northward to point:
Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction nord: 4

GRID REFERENCE: 984
RÉFÉRENCE AU QUADRILLAGE: 975984

Nearest similar grid reference 100 000 metres (about 63 miles)
La prochaine référence similaire est à 100 000 mètres (environ 63 milles)

BROWN NUMBERED TICKS INDICATE
THE 1000 METRE U.T.M. GRID
ZONE 12
LES AMORCES BRUNES NUMÉROTÉES REPRÉSENTENT
LE QUADRILLAGE DE 1000 MÈTRES T.U.M.

8 of



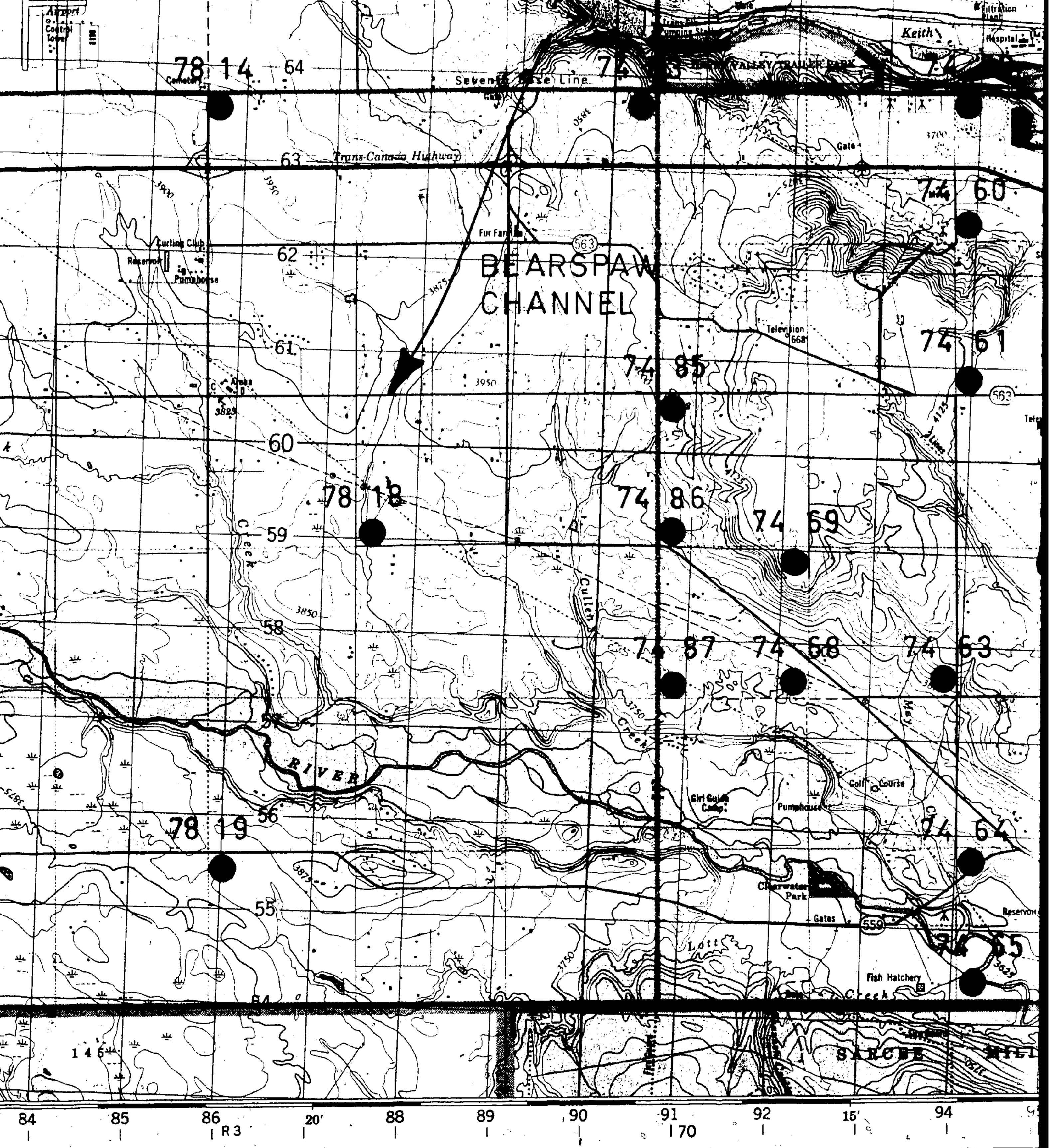
Produced by the SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES. Updated from aerial photographs taken in 1977 and 1978. Culture check 1977. Published in 1980.

Copies may be obtained from the Canada Map Office, Department of Energy, Mines and Resources, Ottawa, or your nearest map dealer.

Roads:	Rou
hard surface, all weather	pave
hard surface, all weather	pave
loose or stabilized surface, all weather .	grav
loose surface, dry weather	de
unclassified streets	rues
cart track	de t
trail, cut line or portage	sent

FOR COMPLETE REFERENCE SEE REVERSE SI

90F



	Routes:		
, all weather	pavée, toute saison	dual highway 2 chaussées séparées	more than 2 lanes plus de 2 voies
, all weather	pavée, toute saison	2 lanes 2 voies	less than 2 lanes moins de 2 voies
ilized surface, all weather .	gravier, aggloméré, toute saison .	2 lanes or more 2 voies ou plus	less than 2 lanes moins de 2 voies
, dry weather	de gravier, temps sec		
streets	rues hors classe		
....	de terre		
or portage	sentier, percée ou portage		

MPLETE REFERENCE SEE REVERSE SIDE POUR UNE LISTE COMPLÈTE DES SIGNES, VOIR AU VERSO

10

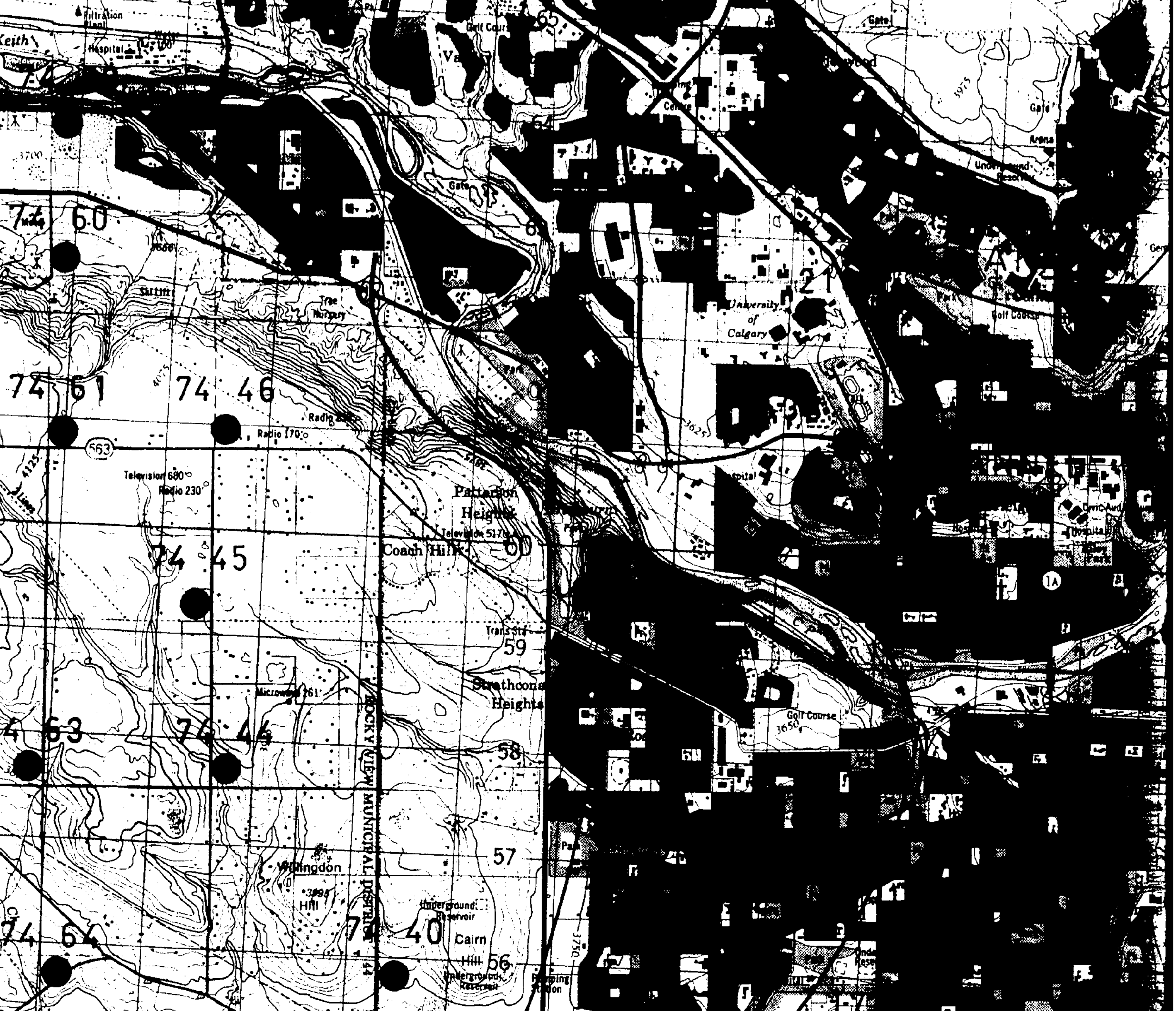
CALGARY
ALBERTA

Scale 1:50,000 Échelle

Miles 1 0 1 2

Metres 1000 0 1000 2000 3000

Yards 1000 0 1000 2000 3000 40



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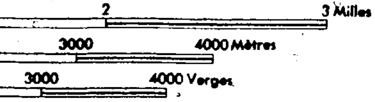

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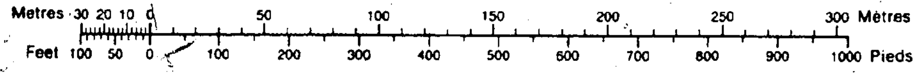
CONVERSION SCALE FOR ELEVATIONS

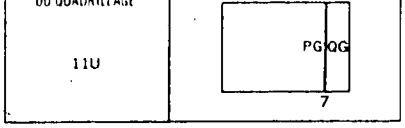
ÉCHELLE DE CONVERSION DES ALTITUDES

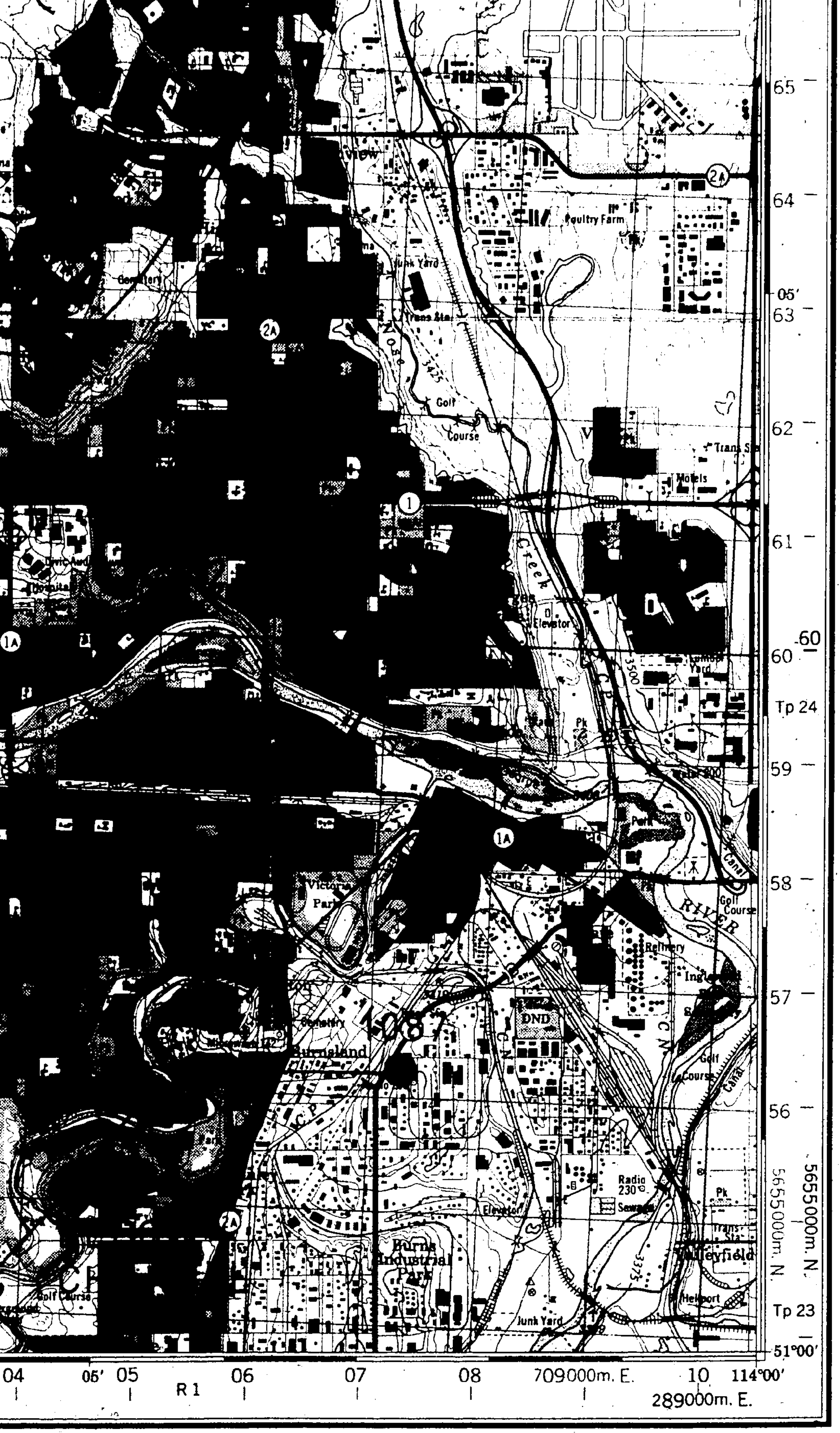


CONTOUR INTERVAL 25 FEET
Elevations in Feet above Mean Sea Level
North American Datum 1927
Transverse Mercator Projection

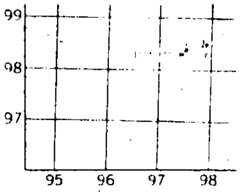
ÉQUIDISTANCE DES COURBES 25 PIEDS
Altitudes en pieds
Système de référence géodésique nord-américain, 1927
Projection transverse de Mercator

110F





EXAMPLE OF METHOD USED
TO GIVE A REFERENCE TO NEAREST 100 METRES
EXEMPLE DE LA MÉTHODE EMPLOYÉE
POUR FIXER DES REPÈRES À 100 MÈTRES PRÈS



REFERENCE POINT POINT DE REPÈRE	CHURCH · ÉGLISE	(as above) (ci-dessus)
EASTING: Read number on grid line immediately to left of point. ABSCISSE: Noter le chiffre de la ligne du quadrillage immédiatement à gauche du repère		97
Estimate tenths of a square from this line eastward to point. Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction est		5
		975
NORTHING: Read number on grid line immediately below point ORDONNÉE: Noter le chiffre de la ligne du quadrillage immédiatement en-dessous du repère		98
Estimate tenths of a square from this line northward to point. Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction nord		4
GRID REFERENCE		984
RÉFÉRENCE AU QUADRILLAGE		975984

Nearest similar grid reference 100 000 metres (about 63 miles)
La prochaine référence similaire est à 100 000 mètres (environ 63 milles)

BROWN NUMBERED TICKS INDICATE
THE 1000 METRE U.T.M. GRID
ZONE 12
LES AMORCES BRUNES NUMÉROTÉES REPRÉSENTENT
LE QUADRILLAGE DE 1000 MÈTRES T.U.M.

TABLEAU D'ASSEMBLAGE DU SYSTÈME NATIONAL

Calgary Sheet

Base Map

Figure 1-3

Établie par la DIRECTION DES LEVÉS ET DE LA CARTOGRAPHIE,
MINISTÈRE DE L'ÉNERGIE, DES MINES ET DES RESSOURCES.
Mise à jour à l'aide de photographies aériennes prises en 1977 et 1978.
Vérification des ouvrages en 1977. Publiée en 1980.

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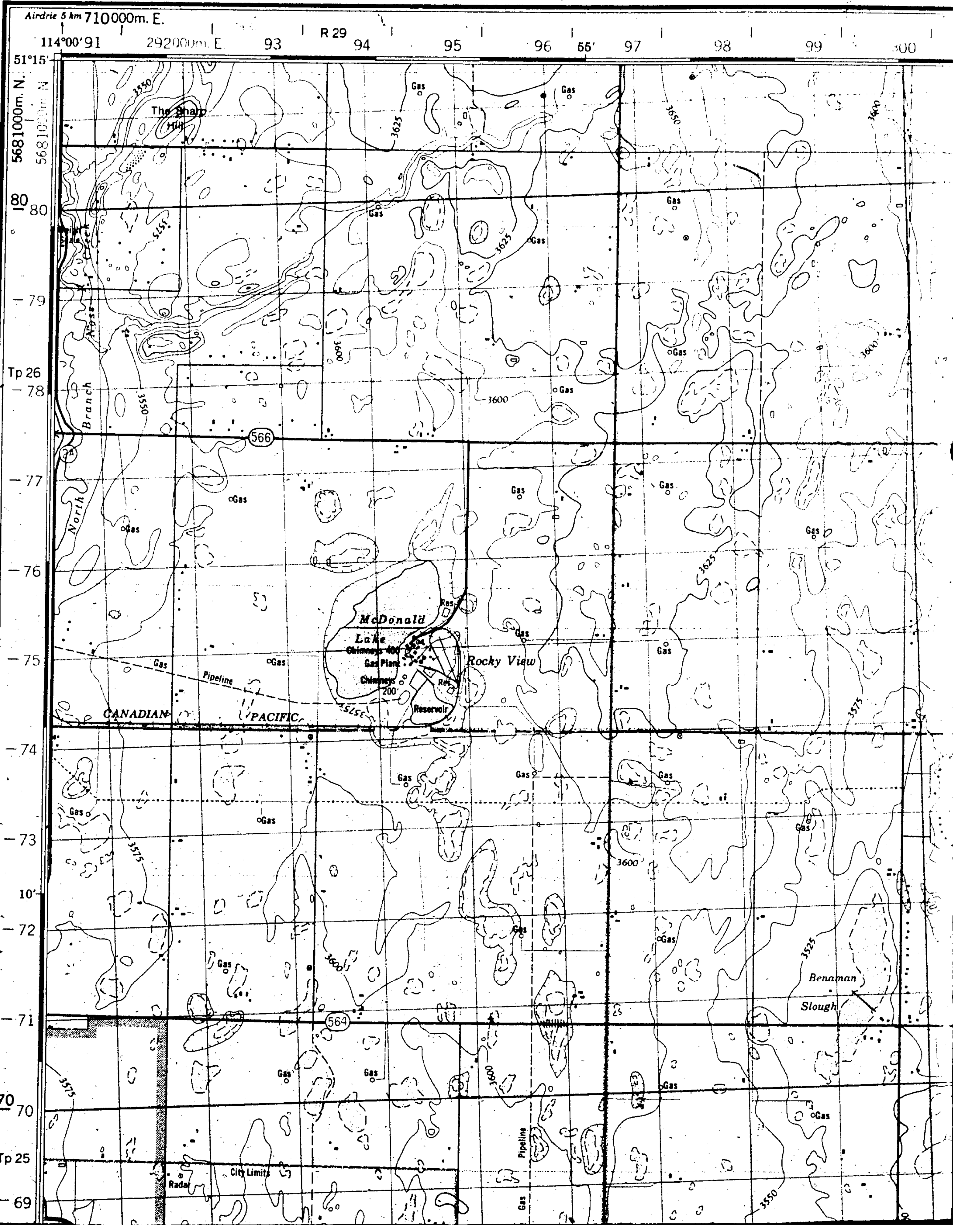
CALGARY
82-O/1
EDITION 5

1 OF

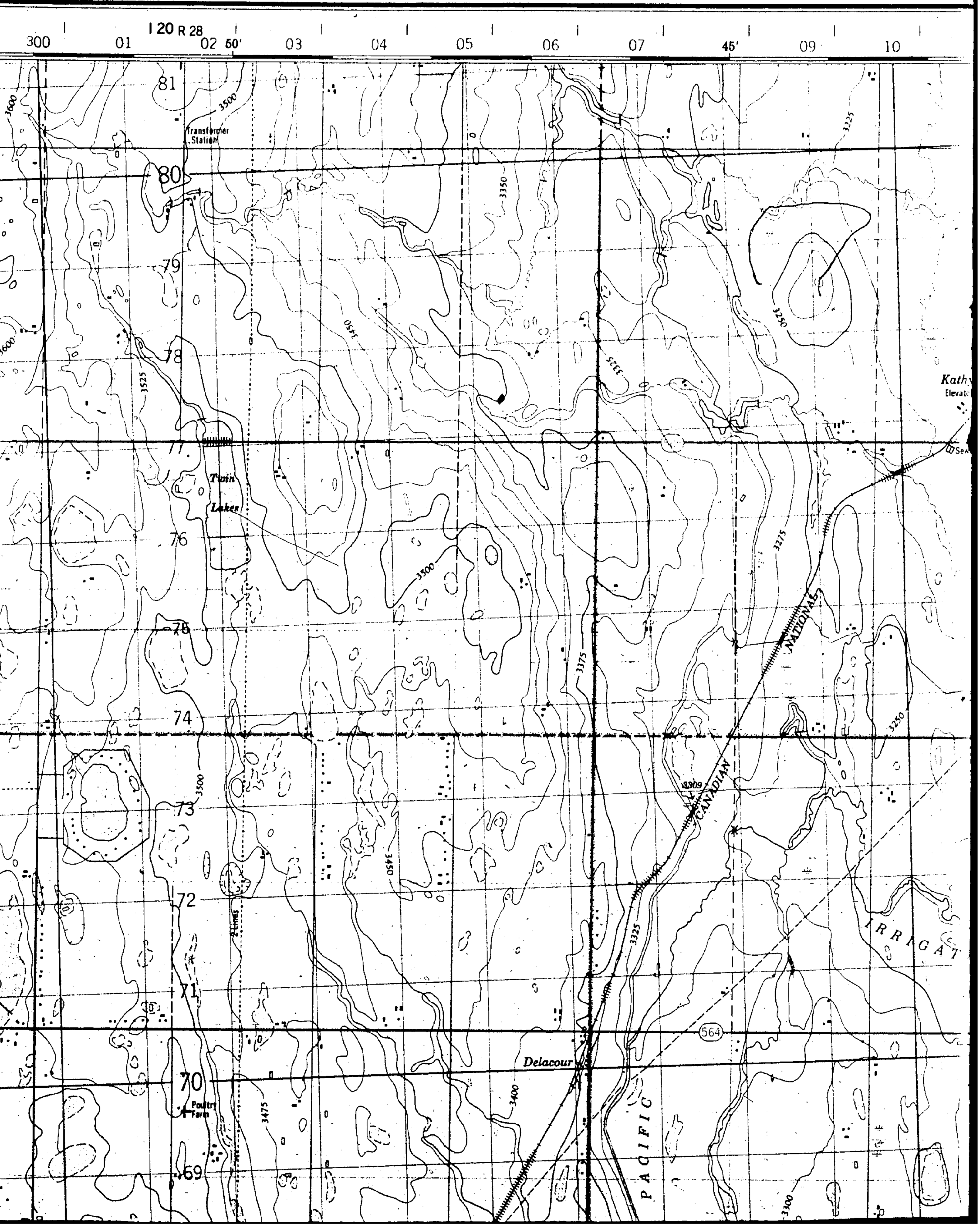
82 P/4

1:50 000



2 OF

CANADA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Transformer Station
Twin Lakes
Kathy
Elevat
Sew
Delacour
Poultry Farm
CANADIAN
NATIONAL
PACIFIC
IRRIGAT
564
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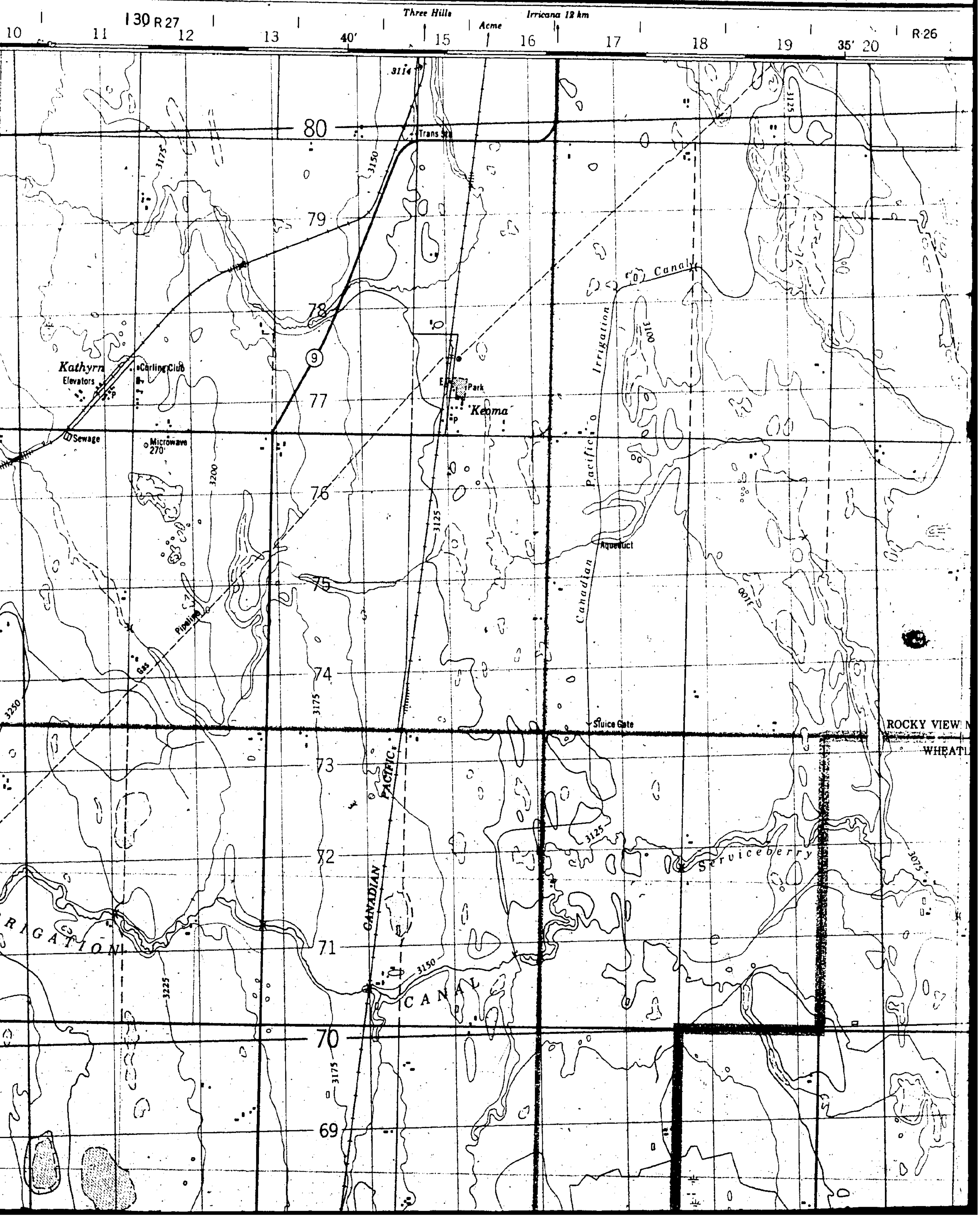
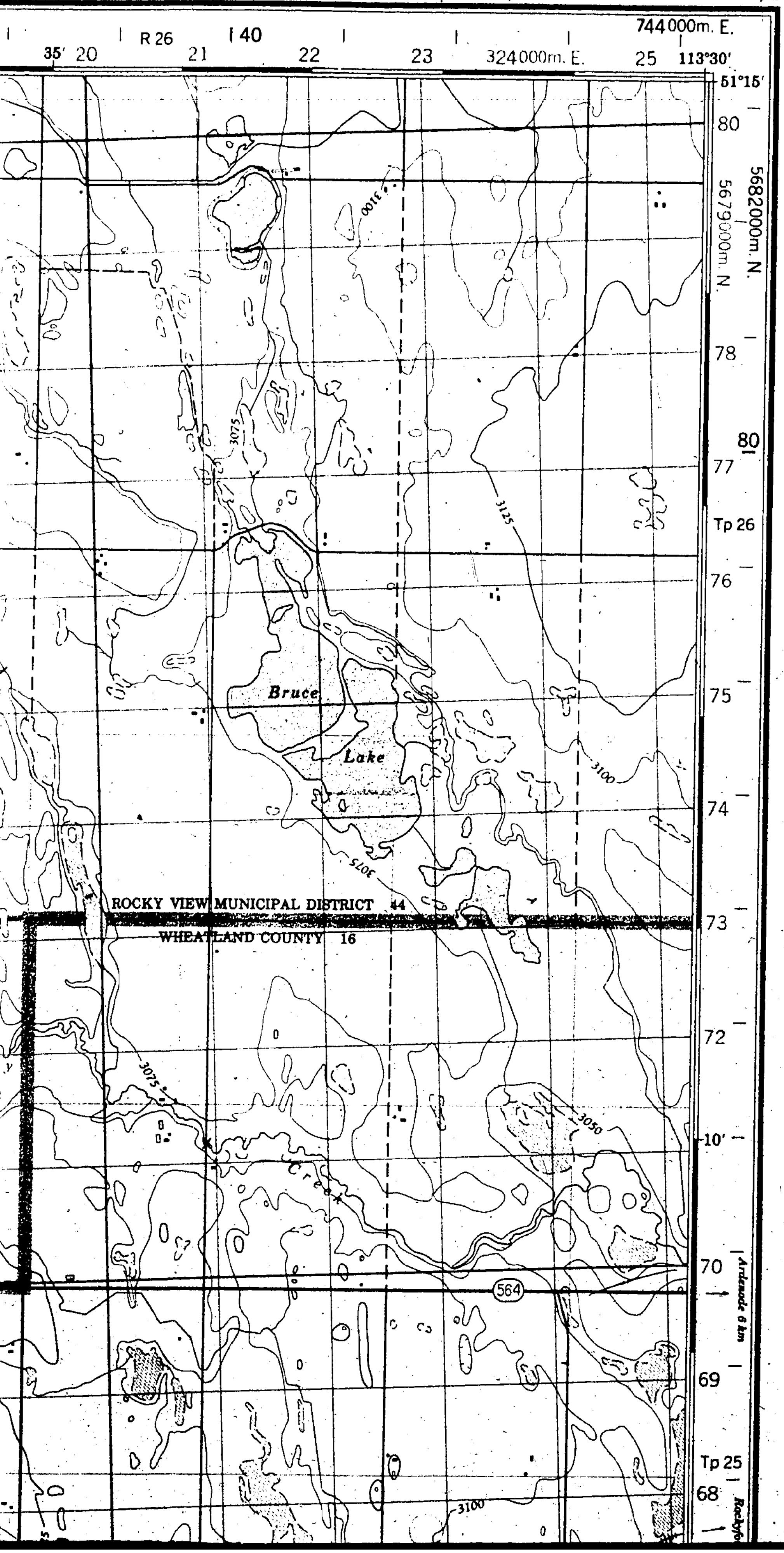
1 3 of 1

EDITION 4



EDITION 4

82 P/4



Military users, refer to this map as: Référence de cette carte pour usage militaire:	SERIES A 741 SÉRIE MAP 82 P/4 CARTE EDITION 4 MCE ÉDITION

| 40F

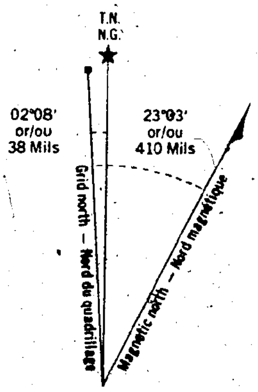
GLOSSARY GLOSSAIRE

Airfield	Terrain d'aviation
Arena	Aréna
City Limits	Limites de ville
Customs	Douane
Ditch	Fossé
Dugout	Abreuvoir
Dump	Depotoir
Filtration Plant	Usine de filtration
Gas	Gaz
Golf Course	Terrain de golf
Junk Yard	Ferraille
Kiln	Four
Lookout	Belvédère
Mine Waste	Déblai de mine
Oil Wells	Puits de pétrole
Park	Parc
Rink	Pâtinoire
Senior Citizens Home	Foyer de l'âge d'or
Ski Area	Station de ski
String Bog	Fondrière à filaments
Surveyed Line	Ligne arpentée
Tank	Réservoir
Water	Eau
Winter Road	Chemin d'hiver

For a complete glossary see reverse side
Pour un glossaire complet, voir au verso

ABBREVIATIONS ABRÉVIATIONS

Aband	Abandoned	Abandonné, ée
C	Cemetery	Cimetière
CO	County	Comté
E	Elevator	Élévateur
Fy	Ferry	Traversier
IR	Indian Reserve	Réserve indienne
H	Hospital	Hôpital
L	Lot	Lot
Micro	Microwave	Micro-ondes
Mun.	Municipality	Municipalité
P	Post Office	Bureau de poste
PH	Power House	Centrale électrique
RCMP	Royal Canadian Mounted Police	Gendarmerie Royale Canadienne
Res	Reservoir	Réservoir
Trans Sta	Transformer Station	Poste de transformateurs
TFL	Tree Farm Licence	Licence de sylviculture



Use diagram only to obtain numerical values
APPROXIMATE MEAN DECLINATION 1978

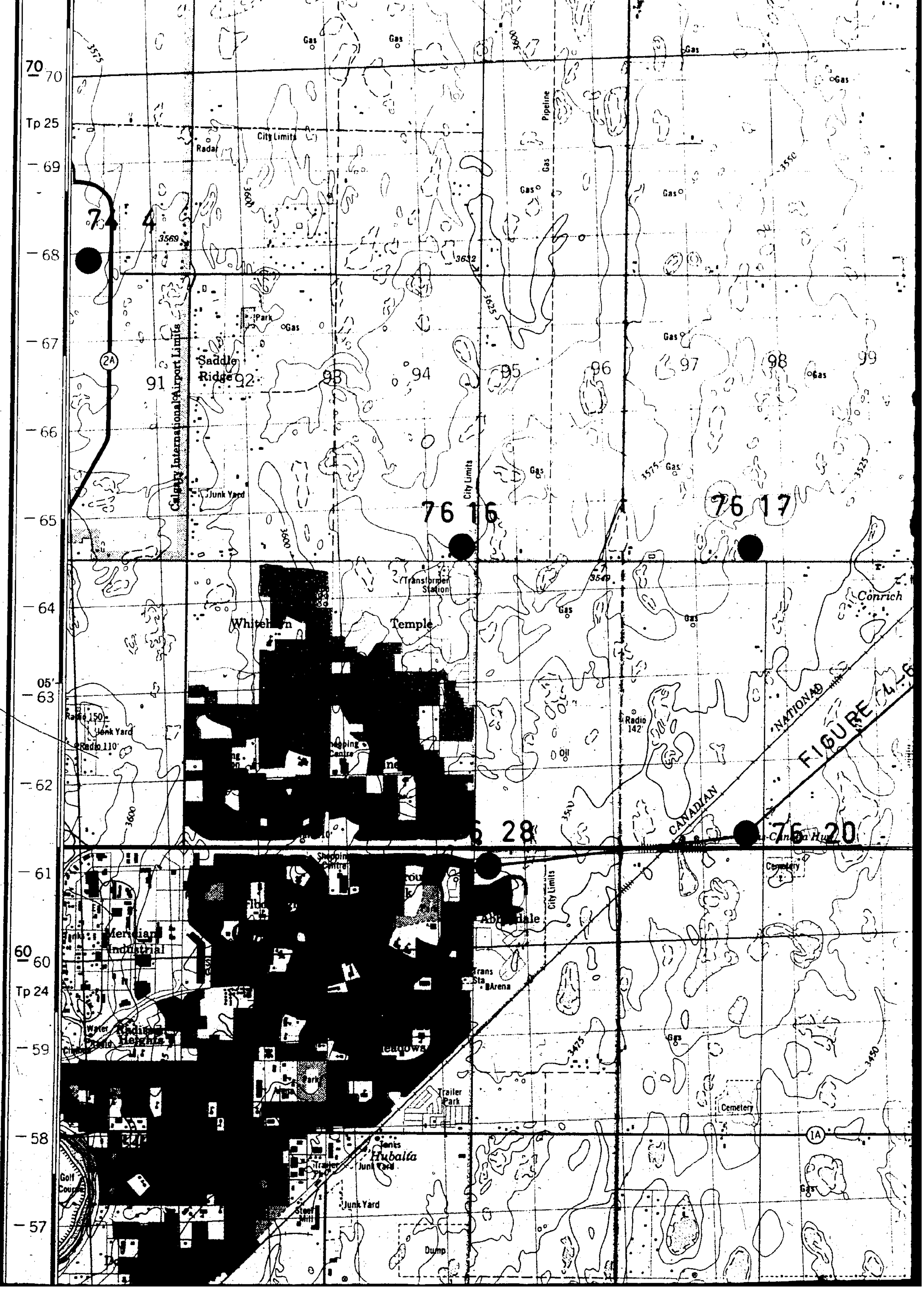


FIGURE 4-6
74 4
76 16
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Gas
Radar
City Limits
Pipeline
Saddle Ridge
Calgary International Airport Limits
Junk Yard
Park
Transformer Station
Whitehorn
Temple
Conrich
Radio 150
Radio 110
Radio 142
Oil
CANADIAN NATIONAL
Trans-Canada Hwy
Cemetery
Shopping Centre
Abbeydale
Meridian Industrial
Radisson Heights
Water Plant
Trans Sta
Arena
Meadows
Trailer Park
Hubalta
Junk Yard
Steel Mill
Golf Course
Dump
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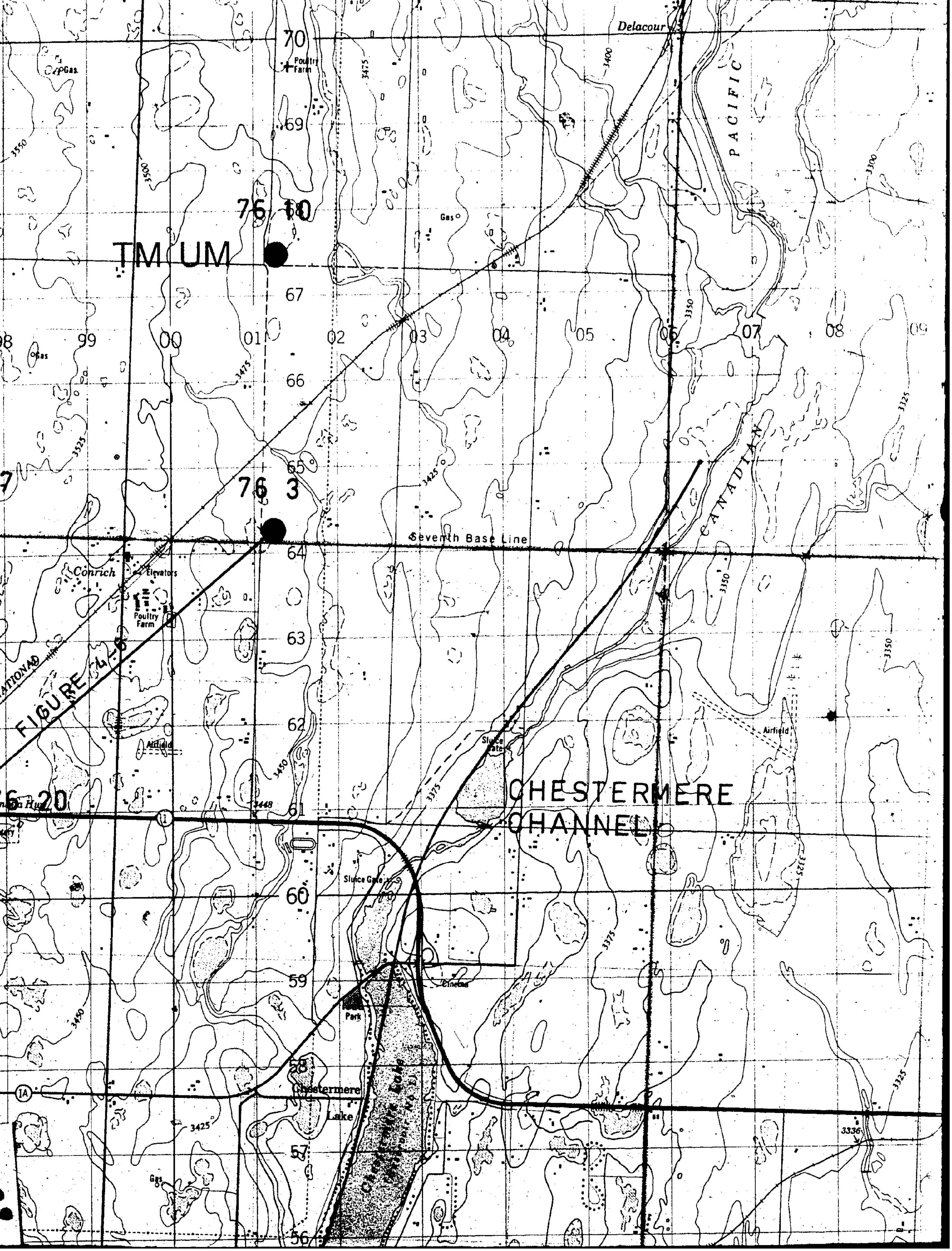
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CANADIAN
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Seventh Base Line
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Conrich
Elevators
Poultry Farm
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NATIONAL
FIGURE 4-6
3350
62
Airfield
Sluice Gate
Airfield
3450
3375
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CHESTERMERE
CHANNEL
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Sluice Gate
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Chestermere Lake
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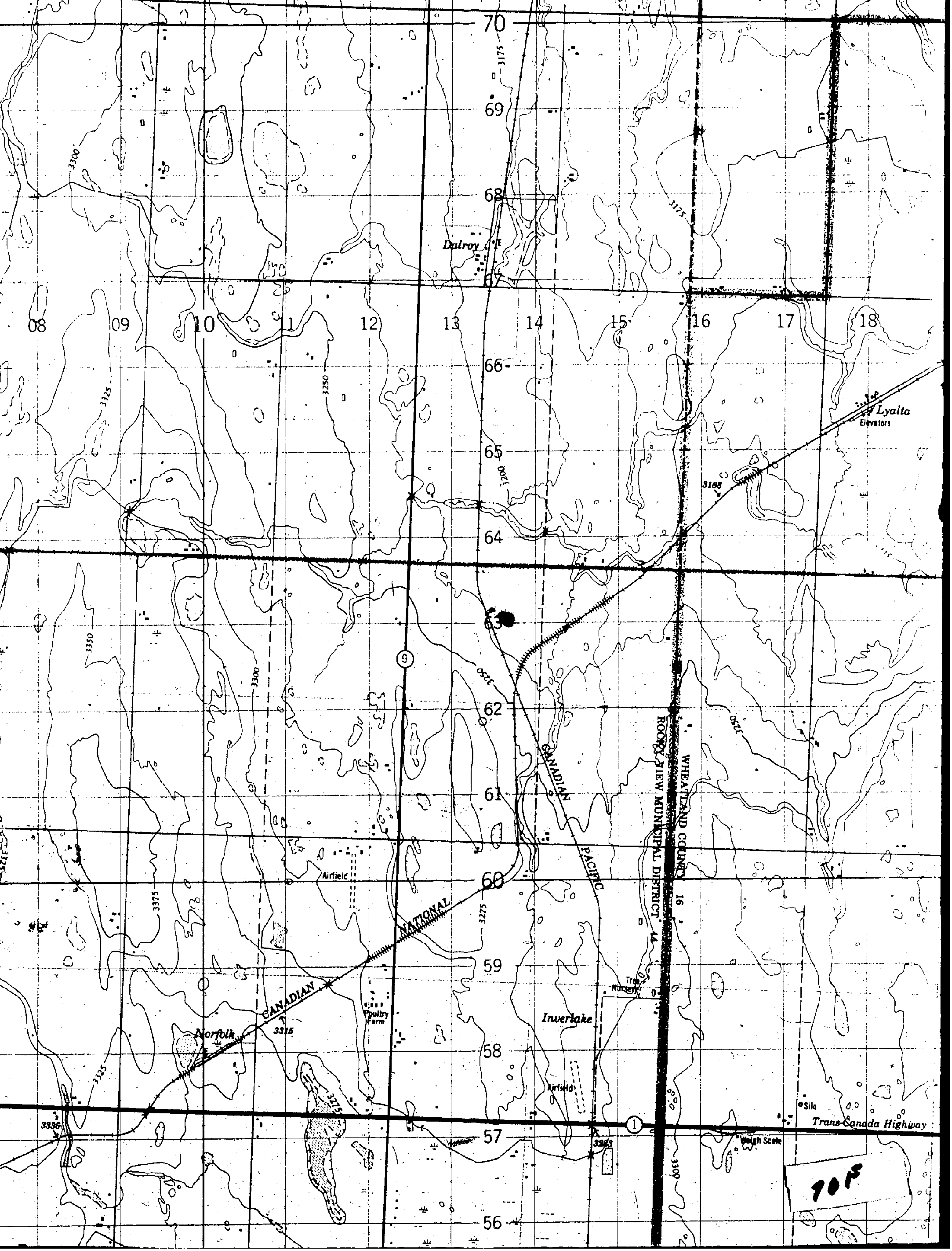
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Dalroy
Lyalta
Elevators
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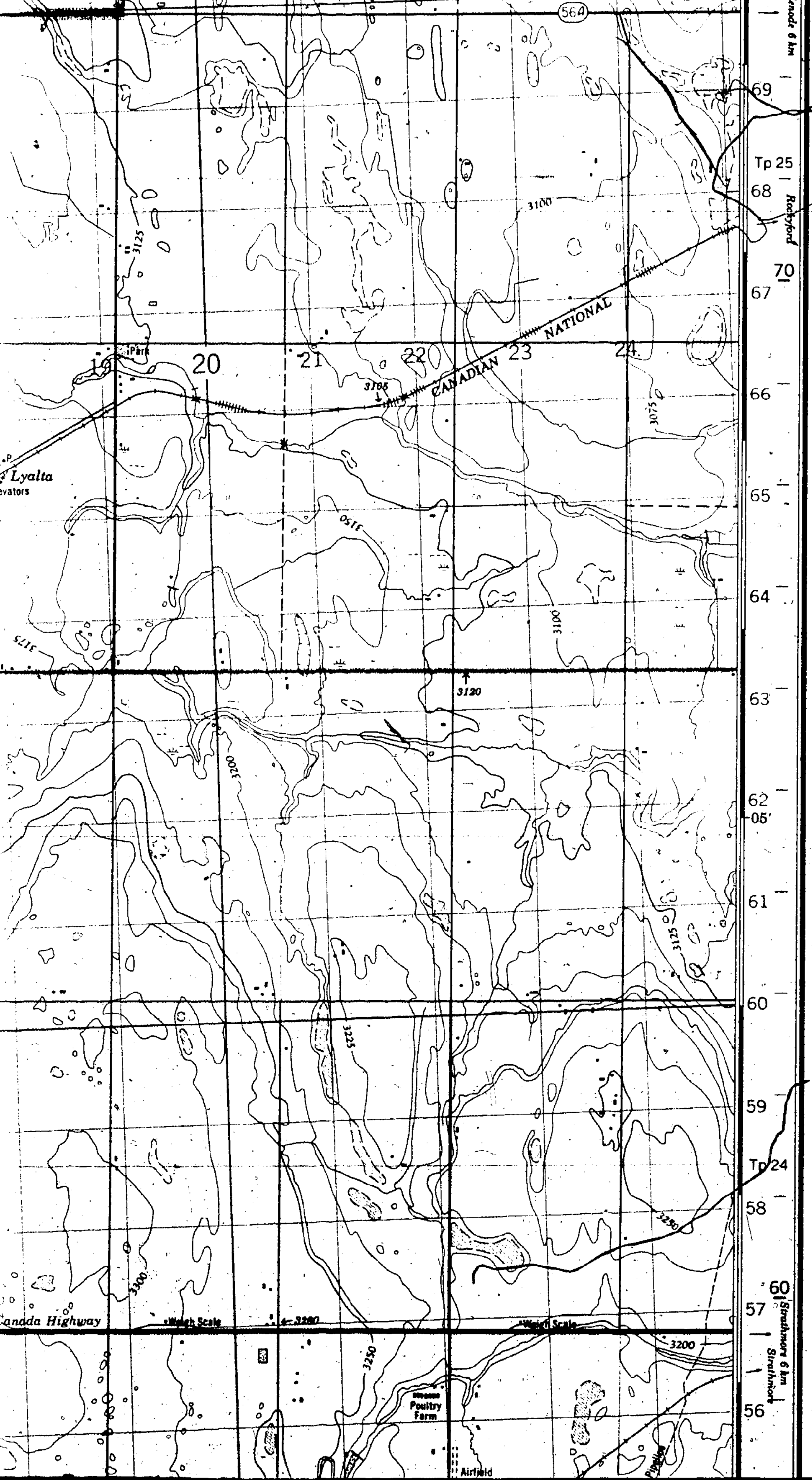
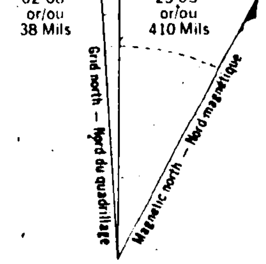
9
CANADIAN PACIFIC
CANADIAN NATIONAL
WHEATLAND COUNTY
ROCKY VIEW MUNICIPAL DISTRICT 44
16
Airfield
Poultry Farm
Norfolk
3315
Inverlake
Tree Nursery
Airfield
Silo
Trans-Canada Highway
1
Weigh Scale
3336
3283

10F





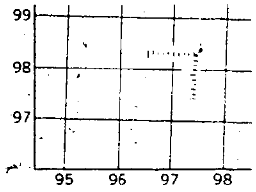
Use diagram only to obtain numerical values
APPROXIMATE MEAN DECLINATION 1978
FOR CENTRE OF MAP
Annual change decreasing 5.6'

N'utiliser le diagramme que pour obtenir les valeurs numériques
DÉCLINAISON MOYENNE APPROXIMATIVE
AU CENTRE DE LA CARTE EN 1978
Variation annuelle décroissante 5.6'

ONE THOUSAND METRE
UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 12
QUADRILLAGE DE MILLE MÈTRES
TRANSVERSE UNIVERSEL DE MERCATOR

GRID ZONE DESIGNATION DÉSIGNATION DE LA ZONE DU QUADRILLAGE	100 000 M SQUARE IDENTIFICATION IDENTIFICATION DU CARRÉ DE 100 000 M
12U	TM UM 3

EXAMPLE OF METHOD USED
TO GIVE A REFERENCE TO NEAREST 100 METRES
EXEMPLE DE LA MÉTHODE EMPLOYÉE
POUR FIXER DES REPÈRES À 100 MÈTRES PRÈS



REFERENCE POINT
POINT DE REPÈRE
CHURCH - ÉGLISE
(as above)
(ci-dessus)

EASTING: Read number on grid line immediately to left of point:
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Estimate tenths of a square from this line eastward to point:
Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction est: 5

975

NORTHING: Read number on grid line immediately below point:
ORDONNÉE: Noter le chiffre de la ligne du quadrillage immédiatement en-dessous du repère: 98

Estimate tenths of a square from this line northward to point:
Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction nord: 4

GRID REFERENCE: 984
RÉFÉRENCE AU QUADRILLAGE: 975984

Nearest similar grid reference 100 000 metres (about 63 miles)
La prochaine référence similaire est à 100 000 mètres (environ 63 milles)

BROWN NUMBERED TICKS INDICATE
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ZONE 11
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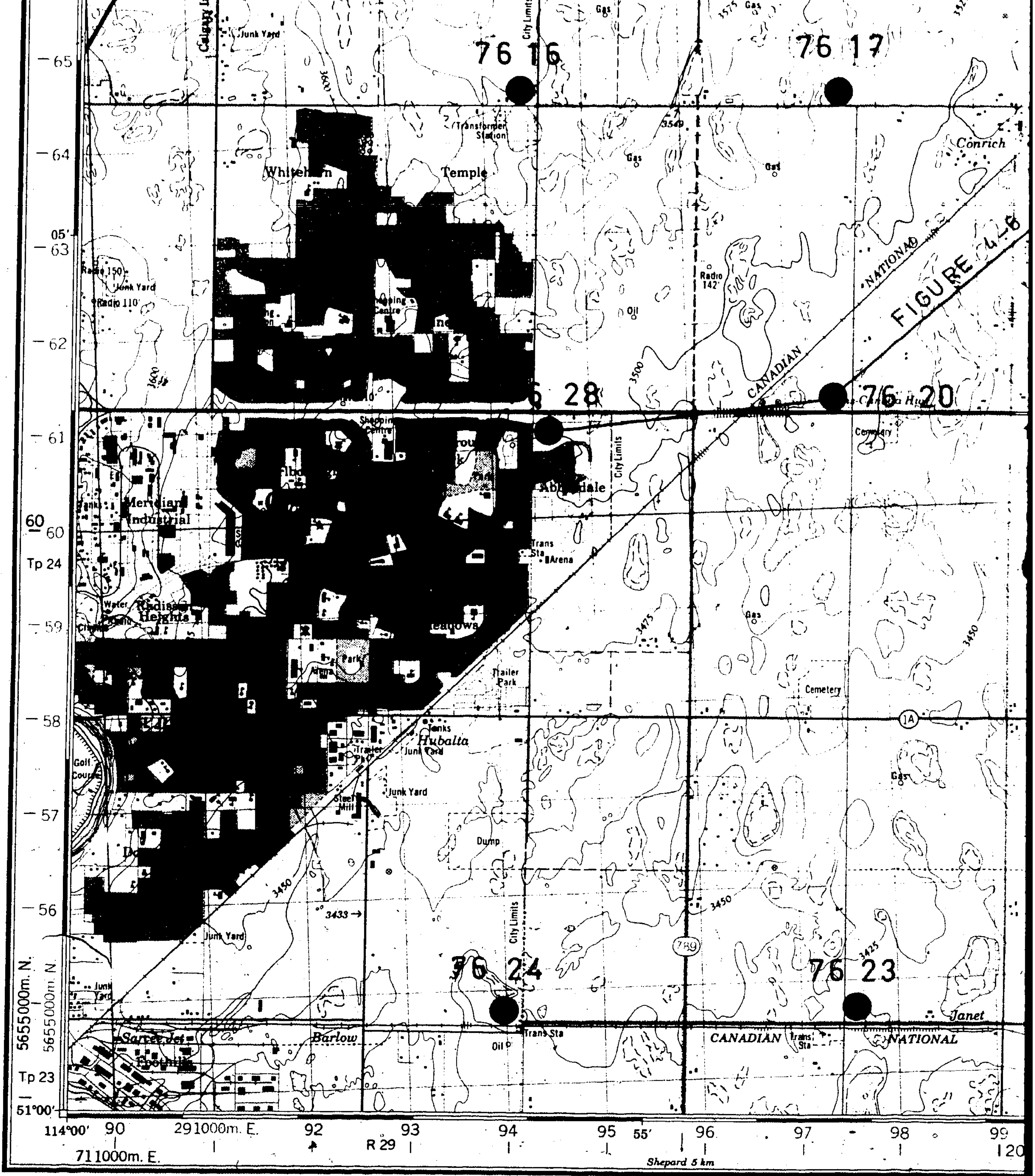
80F



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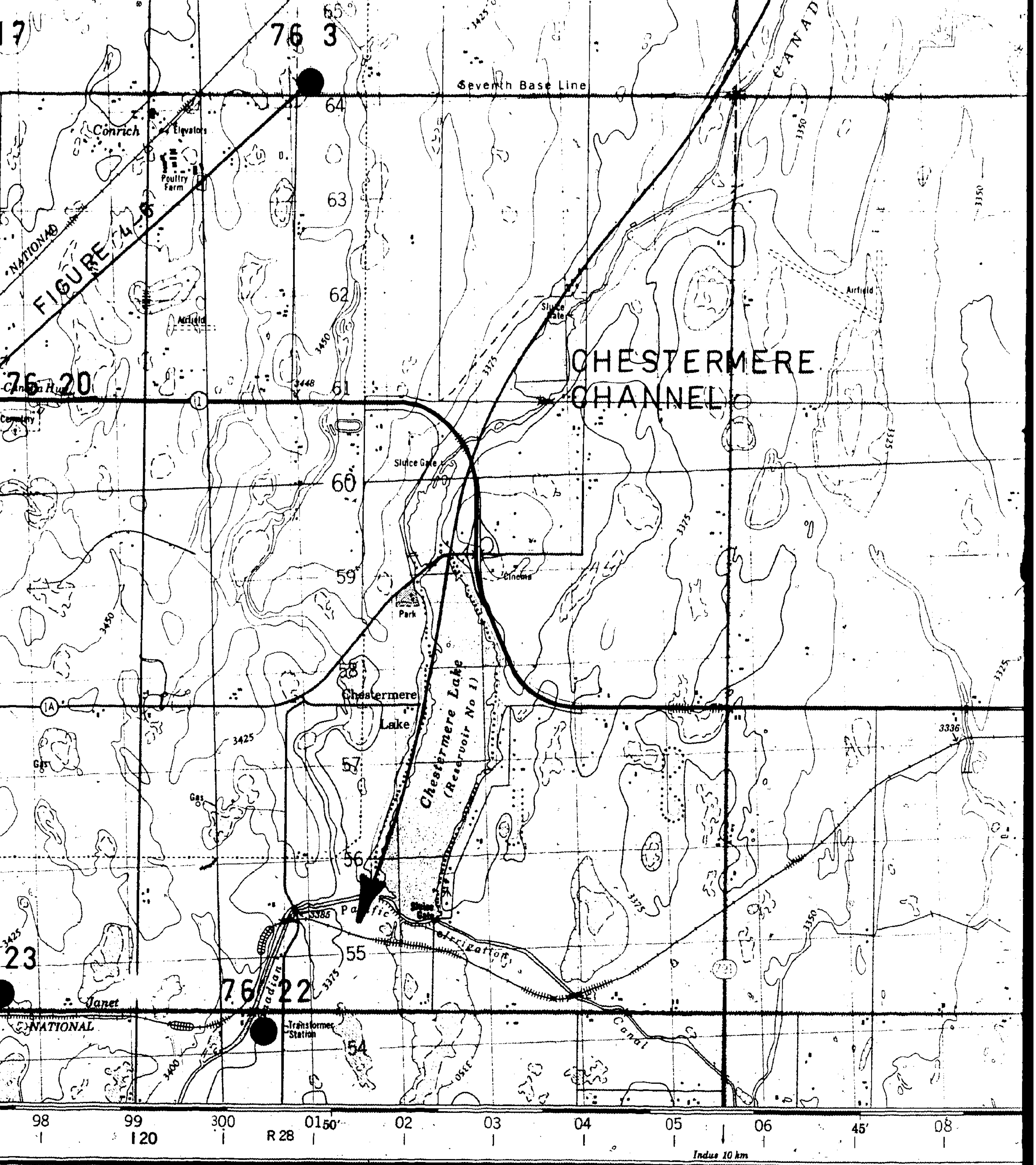
FOR COMPLETE REFERENCE SEE REVERSE

90F



	Routes:		
rface, all weather	pavée, toute saison	dual highway 2 chaussées séparées	more than 2 lanes plus de 2 voies
rface, all weather	pavée, toute saison	2 lanes 2 voies	less than 2 lanes moins de 2 voies
stabilized surface, all weather	gravier, aggloméré, toute saison	2 lanes or more 2 voies ou plus	less than 2 lanes moins de 2 voies
rface, dry weather	de gravier, temps sec	— — — — —	— — —
ified streets	rues hors classe	————	
ck	de terre	— — — — —	— — — — —
line or portage	sentier, percée ou portage	- - - - - - - -	- - - - - - - -

R COMPLETE REFERENCE SEE REVERSE SIDE POUR UNE LISTE COMPLÈTE DES SIGNES, VOIR AU VERSO

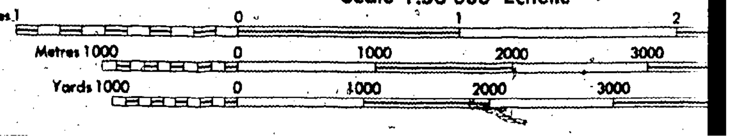
10F

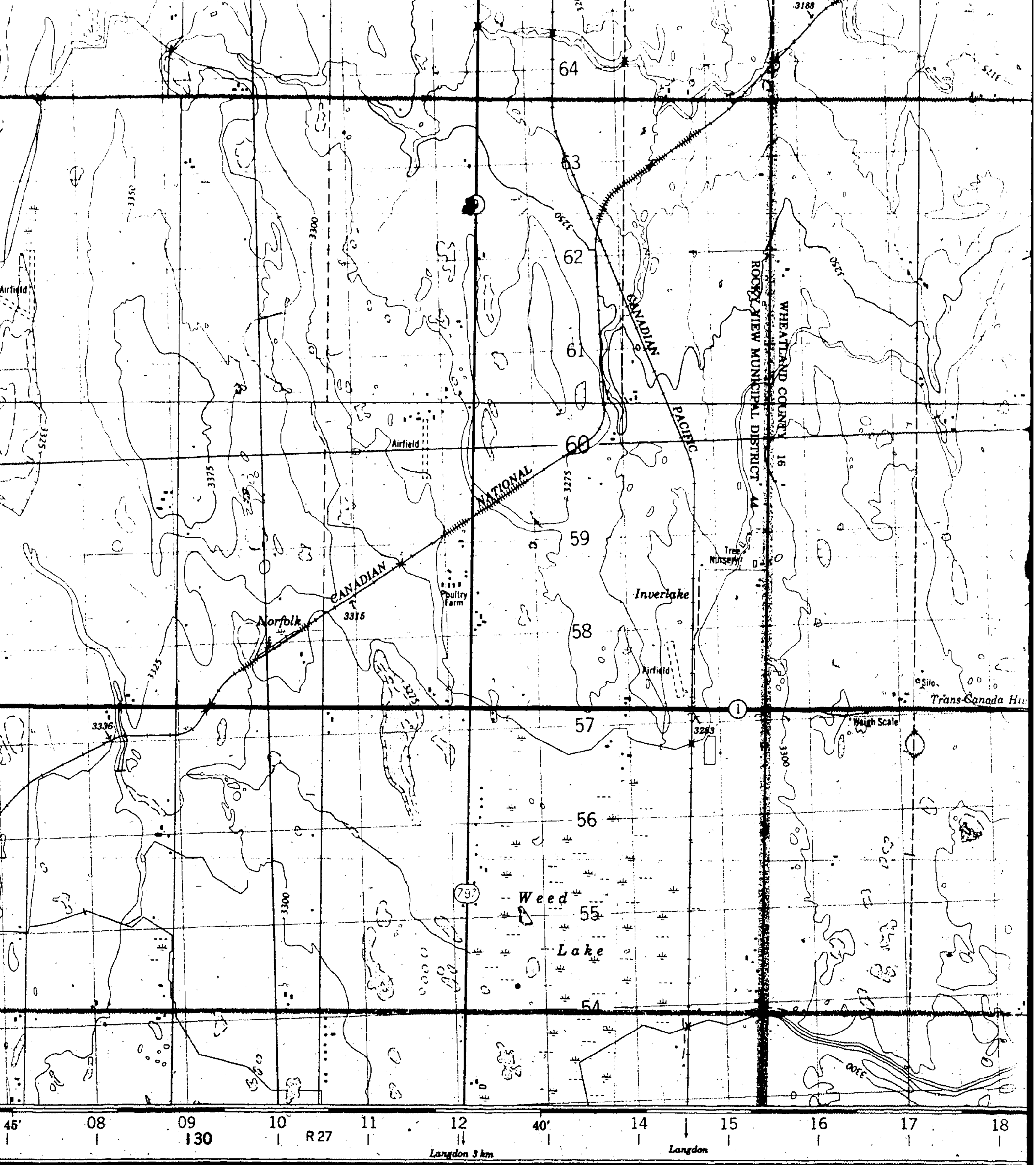
DALROY

ALBERTA

WEST OF FOURTH MERIDIAN - OUEST DU QUATRIÈME M

Scale 1:50 000 Échelle





LROY

BERTA

OUEST DU QUATRIÈME MÉRIDIEN

0 000 Échelle

1 2 3 Milles

2000 3000 4000 Mètres

2000 3000 4000 Verges

110F

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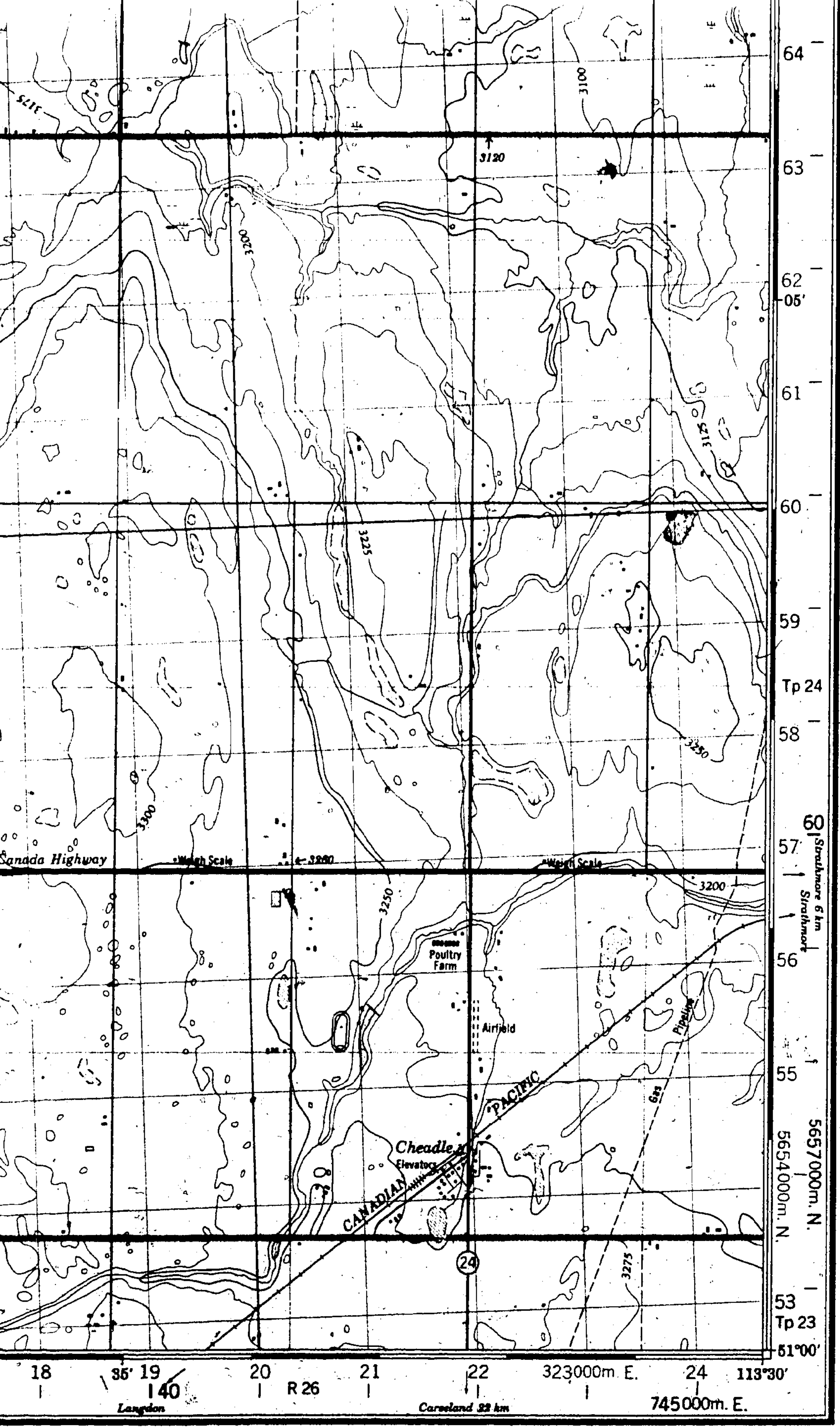
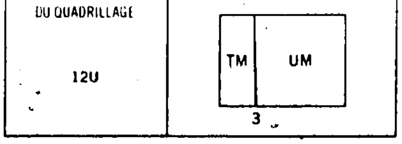
Metres 30 20 10 0 50 100 150 200 250 300 Mètres

Feet 100 50 0 100 200 300 400 500 600 700 800 900 1000 Pieds

CONTOUR INTERVAL 25 FEET
Elevations in Feet above Mean Sea Level
North American Datum 1927
Transverse Mercator Projection

ÉQUIDISTANCE DES COURBES 25 PIEDS
Altitudes en pieds
Système de référence géodésique nord-américain, 1927
Projection transverse de Mercator





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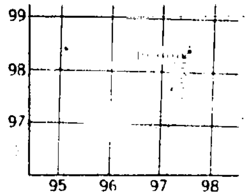
POUR FIXER DES REPÈRES À 100 MÈTRES PRÈS



REFERENCE POINT POINT DE REPÈRE	CHURCH - ÉGLISE	(as above) (ci-dessus)

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	984
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TABLEAU D'ASSEMBLAGE DU SYSTÈME NATIONAL

Dalroy Sheet-

Base Map

Figure 1-4

Établie par la DIRECTION DES LEVÉES ET DE LA CARTOGRAPHIE,
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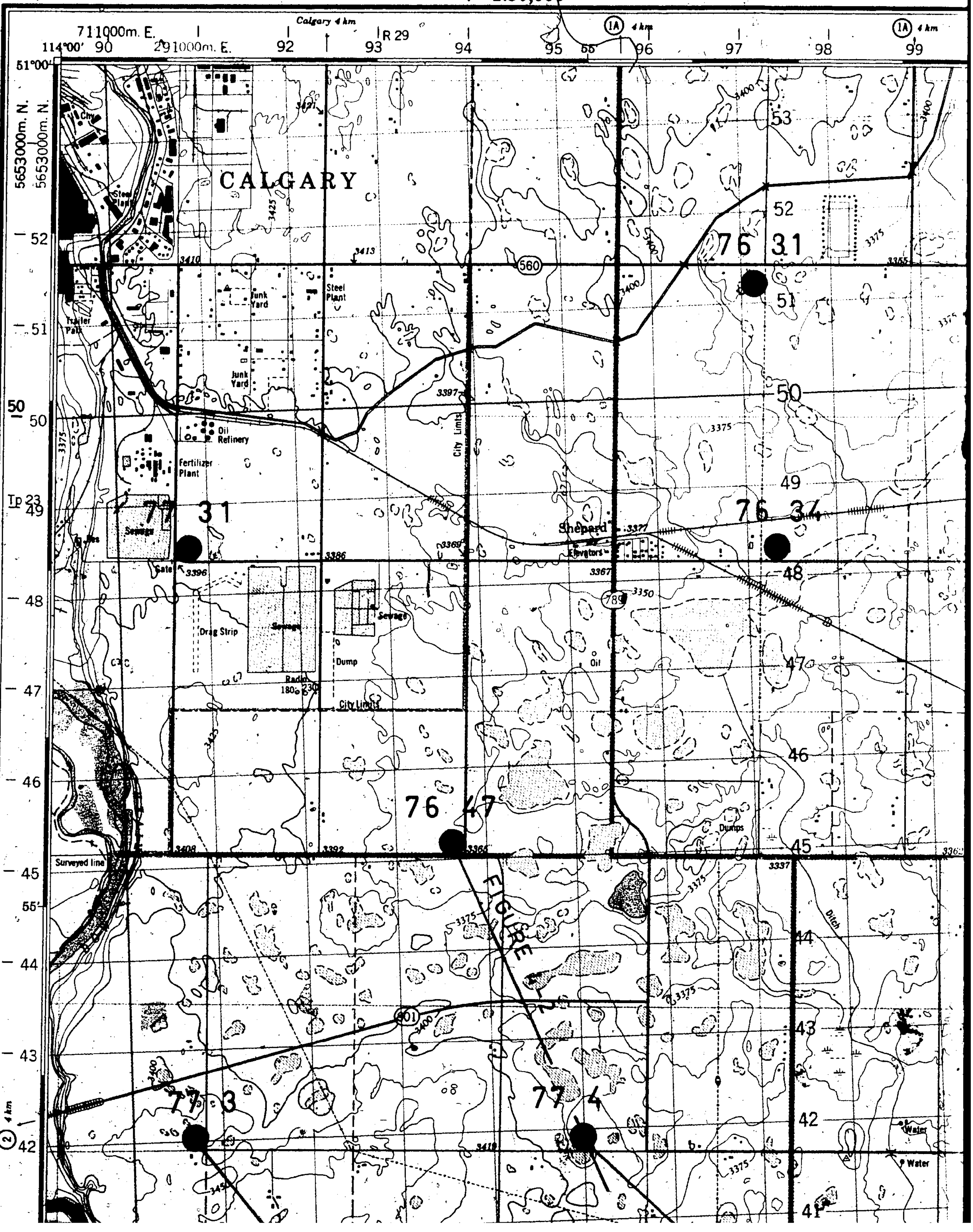
DALROY
82 P/4
EDITION 4

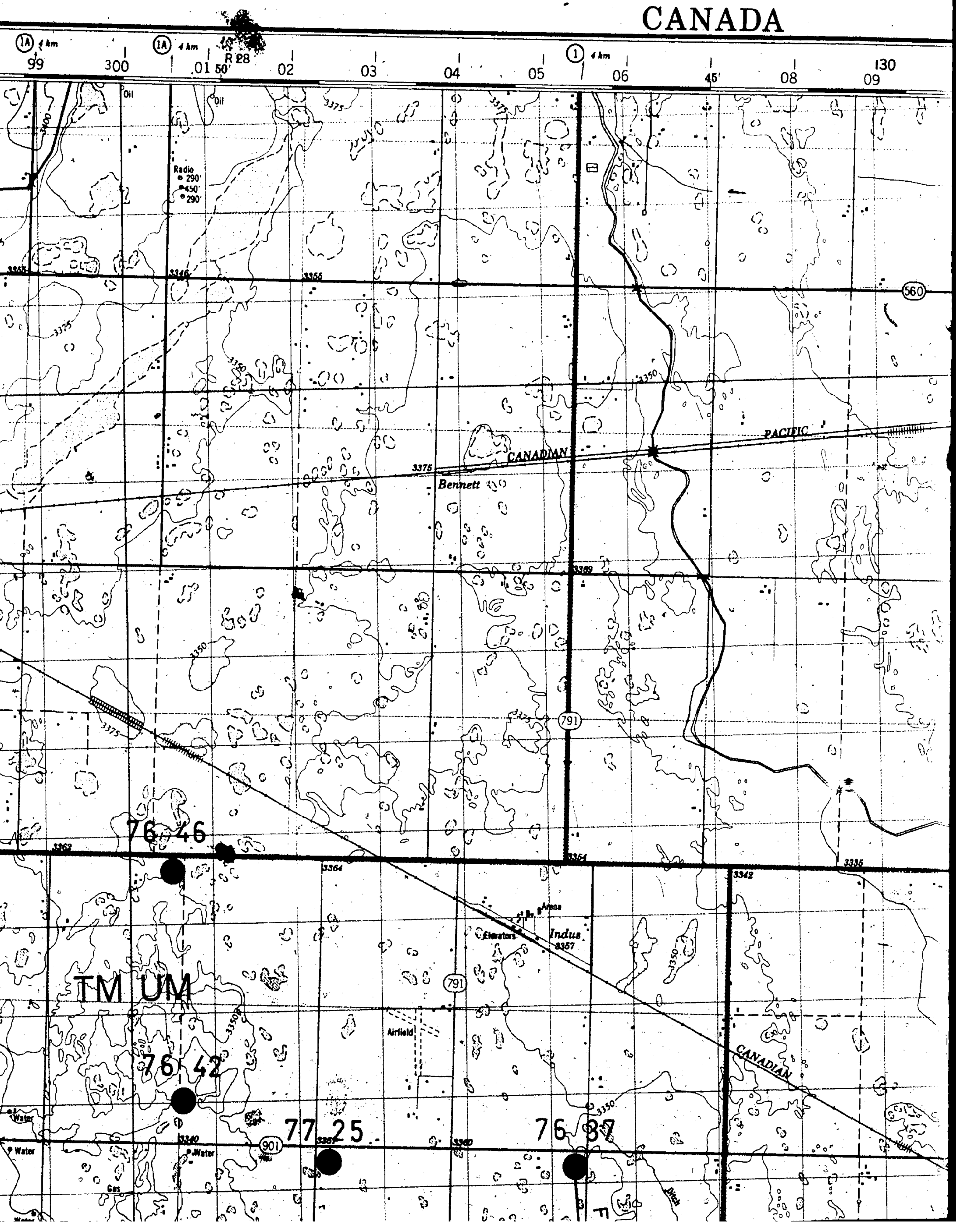
1 OF

82-I/13

1:50,000



2 OF



CANADA
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1A 4 km
1 4 km
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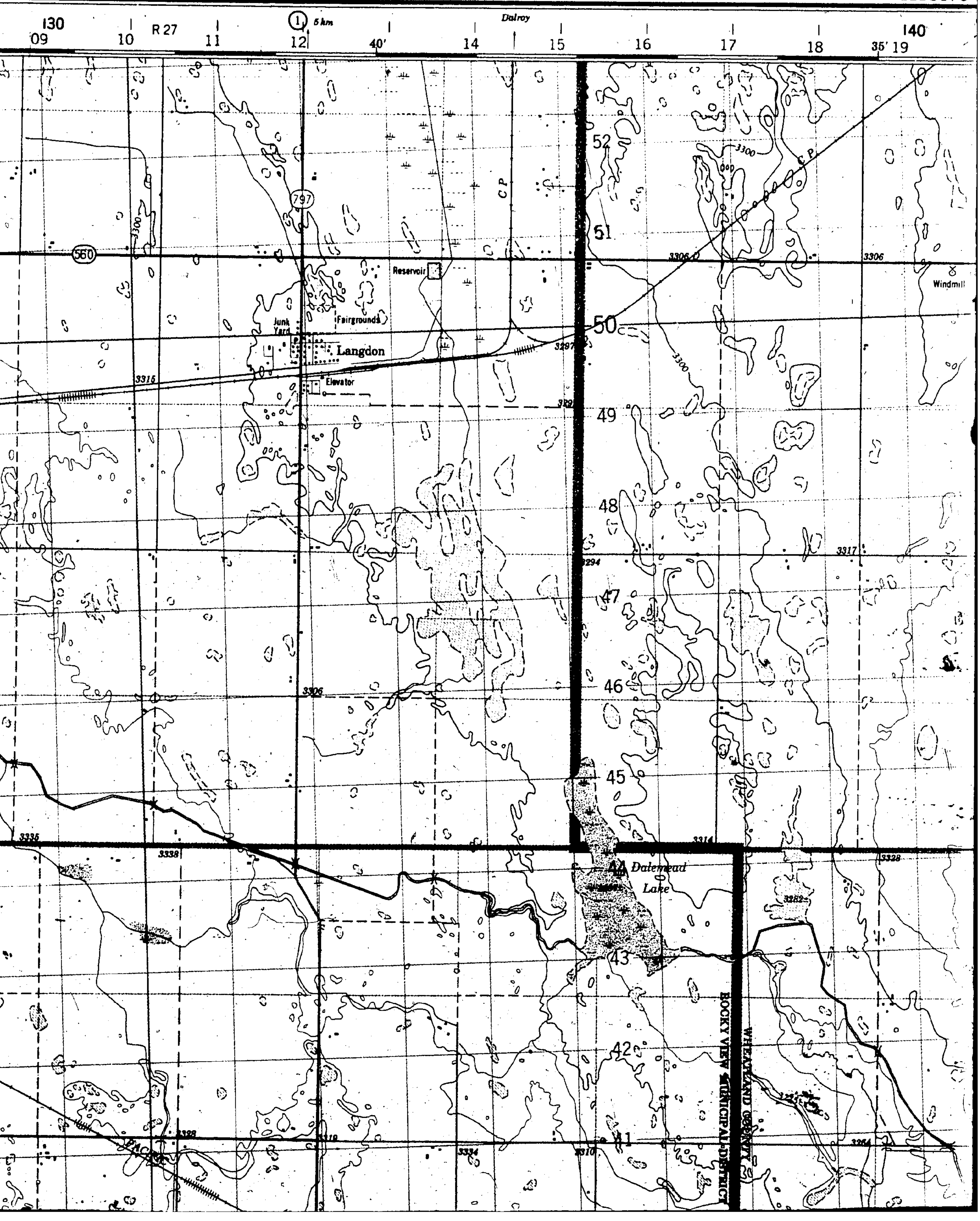
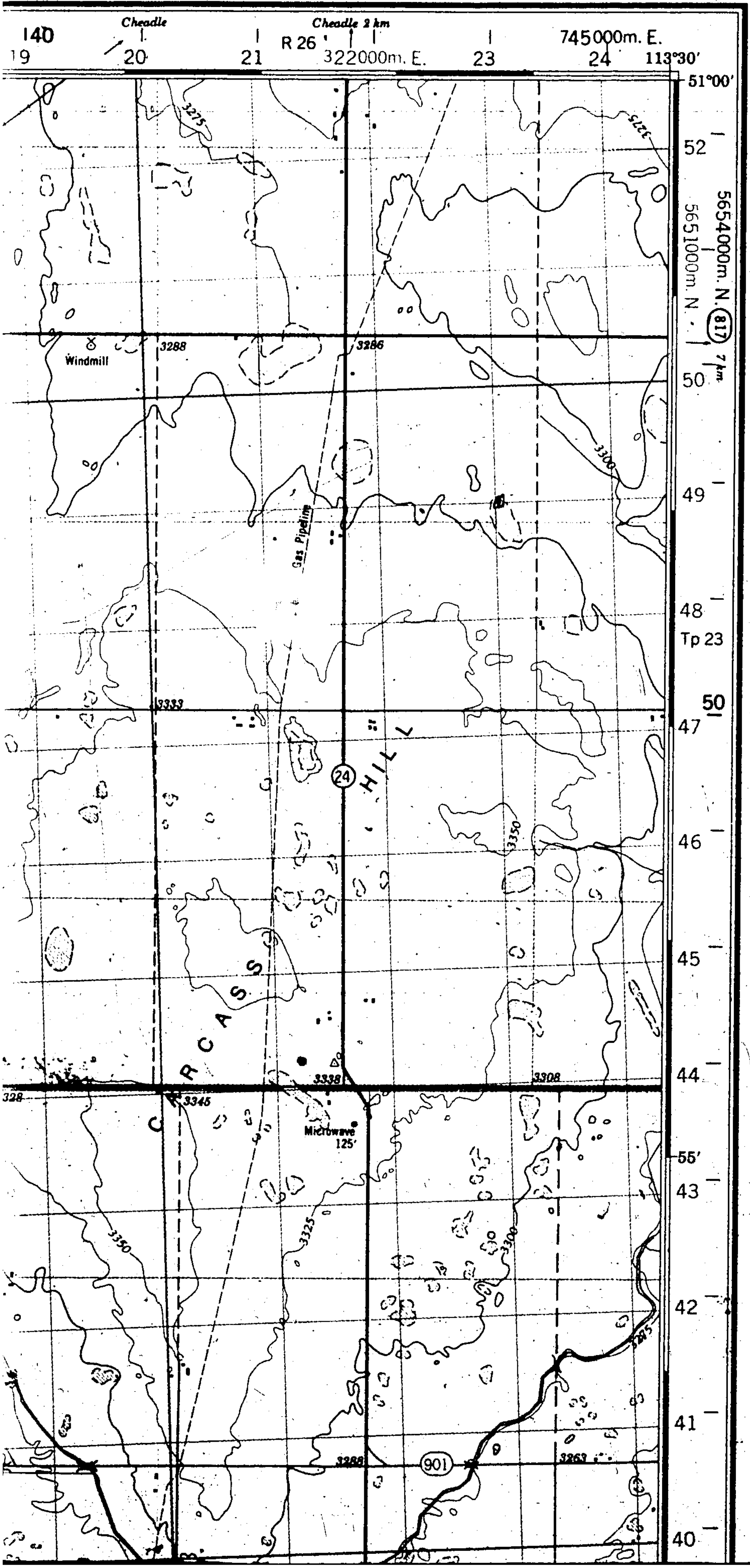
02
03
04
05
06
45'
08
09
130
Oil
Oil
Radio
290'
450'
290'
3400
3375
3350
3346
3355
560
PACIFIC
CANADIAN
3375
Bennett
3369
791
76 46
3362
3364
3354
3335
3342
Arena
Elevators
Indus
3357
TM UM
791
Airfield
76 42
CANADIAN
Water
Water
Water
3340
901
77 25
3361
3360
76 87
3350
Gas
Ditch

| 3 OF |

EDITION 5





Military users, refer to this map as:	SERIES A 741 SÉRIE
Référence de cette carte pour usage militaire:	MAP 82-I/13 CARTE
	EDITION 5 MCE ÉDITION

40F

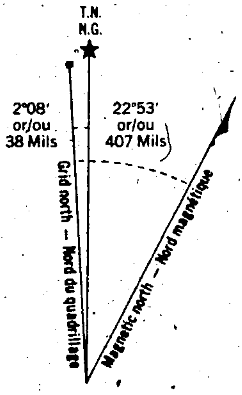
GLOSSARY GLOSSAIRE

Airfield	Terrain d'aviation
Arena	Aréna
City Limits	Limites de ville
Customs	Douane
Ditch	Fossé
Dugout	Abreuvoir
Dump	Dépotoir
Filtration Plant	Usine de filtration
Gas	Gaz
Golf Course	Terrain de golf
Junk Yard	Ferraille
Kiln	Four
Lookout	Belvédère
Mine Waste	Déblai de mine
Oil Wells	Puits de pétrole
Park	Parc
Rink	Patinoire
Senior Citizens Home	Foyer de l'âge d'or
Ski Area	Station de ski
String Bog	Fondrière à filaments
Surveyed Line	Ligne arpentée
Tank	Réservoir
Water	Eau
Winter Road	Chemin d'hiver

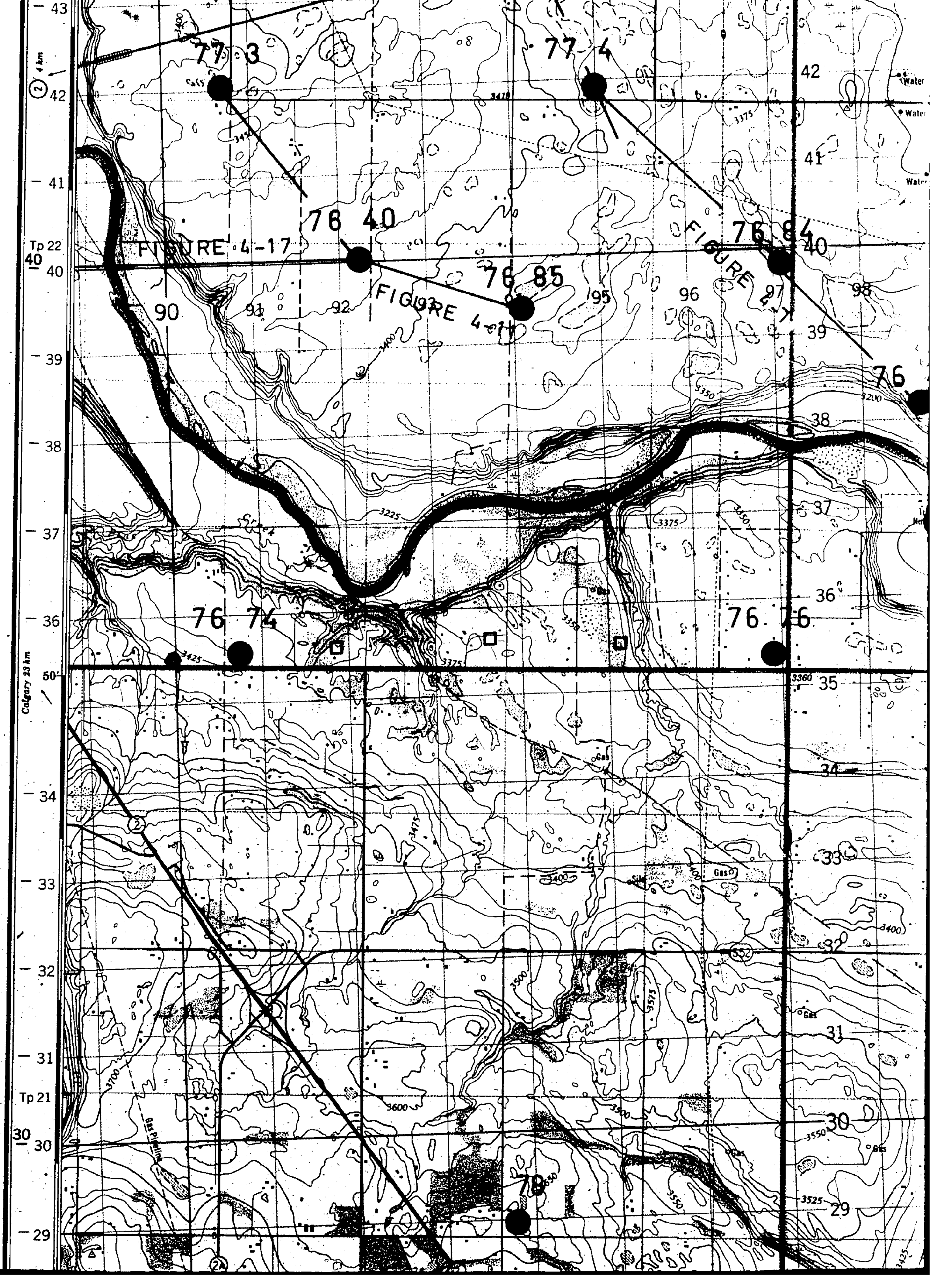
For a complete glossary see reverse side
Pour un glossaire complet, voir au verso

ABBREVIATIONS ABRÉVIATIONS

Aband	Abandoned	Abandonné, ée
C	Cemetery	Cimetière
CO	County	Comté
E	Elevator	Élévateur
Fy	Ferry	Traversier
IR	Indian Reserve	Réserve indienne
H	Hospital	Hôpital
L	Lot	Lot
Micro	Microwave	Micro-ondes
Mun	Municipality	Municipalité
P	Post Office	Bureau de poste
PH	Power House	Centrale électrique
RCMP	Royal Canadian Mounted Police	Gendarmerie Royale Canadienne
Res	Reservoir	Réservoir
Trans Sta	Transformer Station	Poste de transformateurs
TFL	Tree Farm Licence	Licence de sylviculture



Use diagram only to obtain numerical values
APPROXIMATE MEAN DECLINATION 1978


77 3
77 4
76 40
76 85
76 84
76
76 74
76 76
78
FIGURE 4-17
FIGURE 4-17
FIGURE 4-17
Tp 22
Tp 21
Calgary 23 km
4 km
Gas
Water
Gas Pipeline
3400
3450
3375
3350
3225
3200
3425
3475
3500
3550
3575
3600
3700
90
91
92
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96
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29
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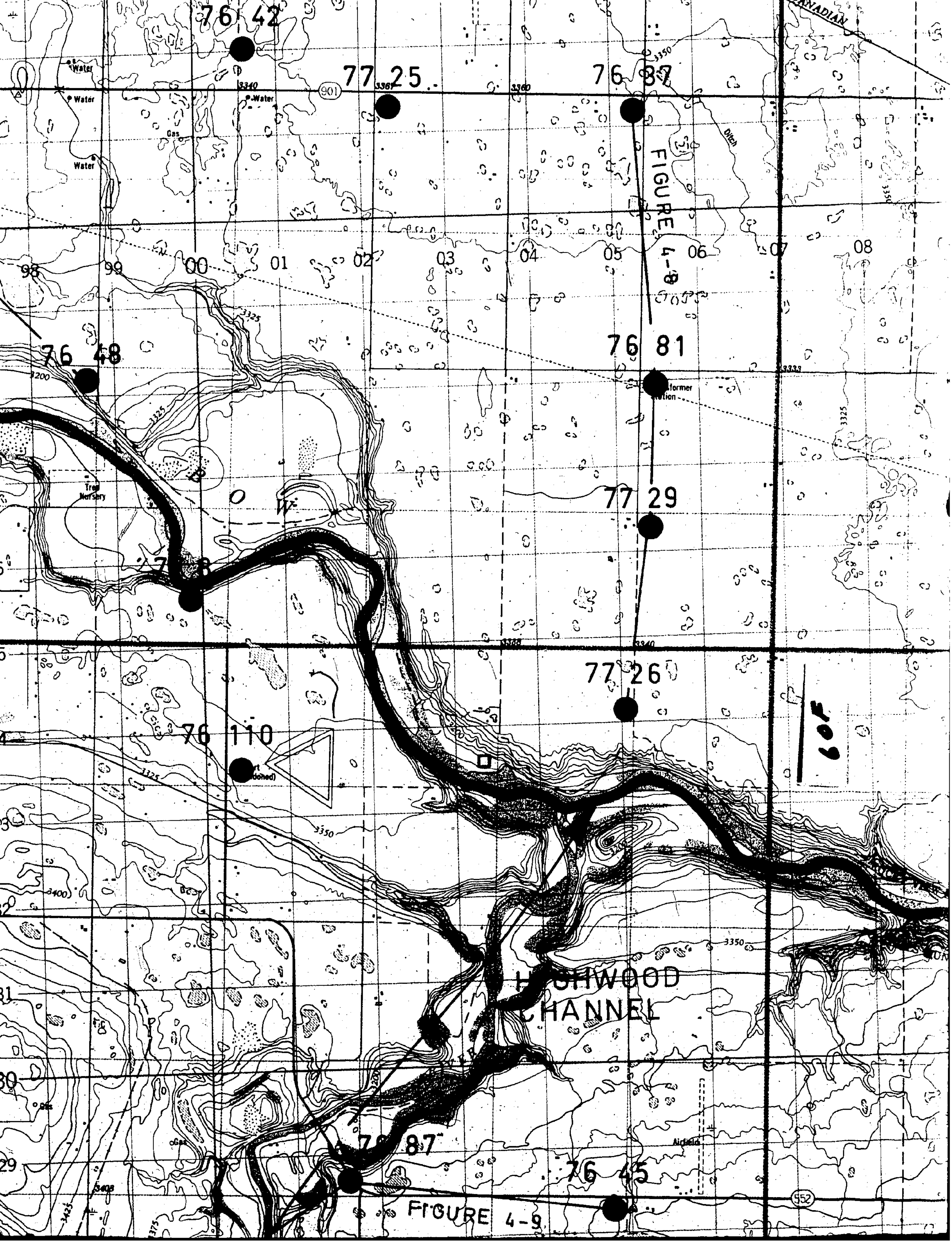
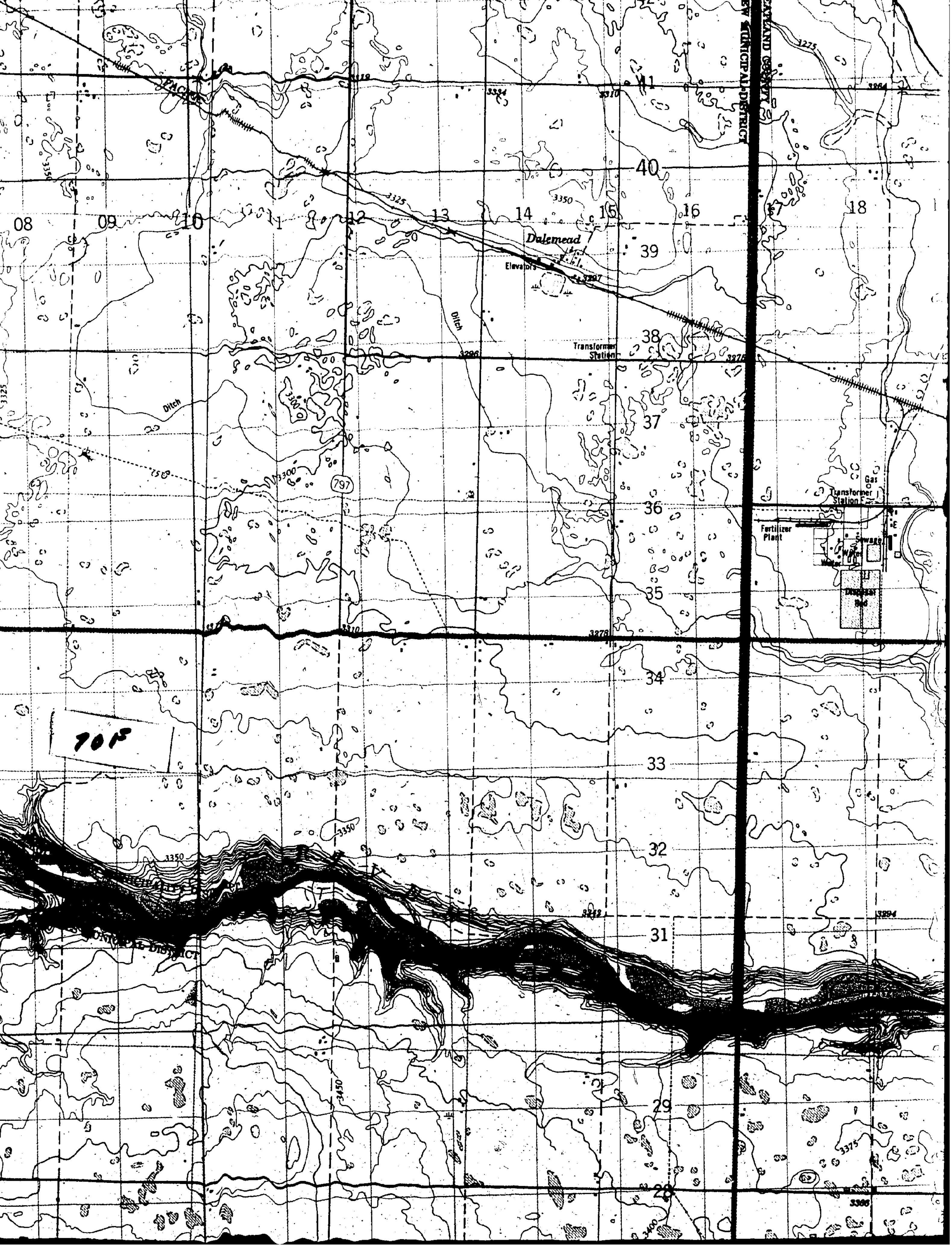

76 42
77 25
76 87
CANADIAN
Water
Water
Water
Gas
3340
3361
901
3360
3350
Ditch
FIGURE 4-8
98
99
00
01
02
03
04
05
06
07
08
3325
76 48
3200
76 81
Transformer Station
3325
Tree Nursery
B O W
77 29
3335
3340
77 26
76 110
3325
3350
3400
HIGHWOOD CHANNEL
3350
Gas
Gas
Airfield
7 87
76 45
552
FIGURE 4-9
3425
3408
60F


08
09
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14
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35
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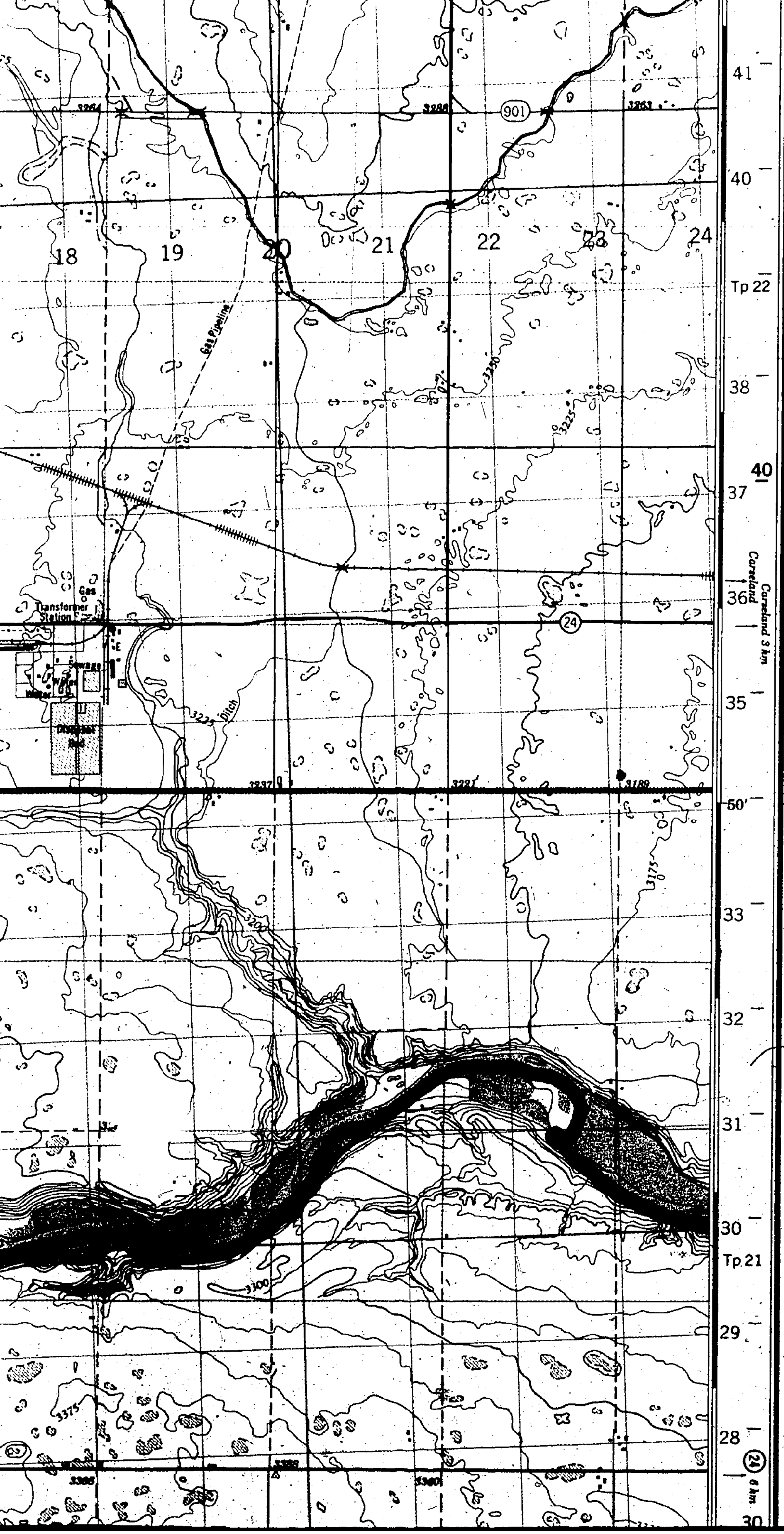
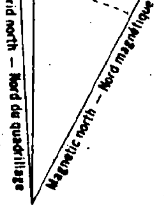
33
32
31
29
28
PACIFIC
WHEATLAND COUNTY
NEW MUNICIPAL DISTRICT
MUNICIPAL DISTRICT
Dalemead
Elevators
Ditch
Transformer Station
Gas
Fertilizer Plant
Sewage
Water
Disposal Bed
797
3319
3334
3310
3275
3364
3350
3325
3297
3296
3300
3278
3394
3312
3450
3375
3400
3386

10F





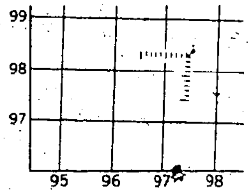
Use diagram only to obtain numerical values
APPROXIMATE MEAN DECLINATION 1978
FOR CENTRE OF MAP
Annual change decreasing 5.6'

N'utiliser le diagramme que pour obtenir les valeurs numériques
DÉCLINAISON MOYENNE APPROXIMATIVE
AU CENTRE DE LA CARTE EN 1978
Variation annuelle décroissante 5.6'

ONE THOUSAND METRE
UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 12
QUADRILLAGE DE MILLE MÈTRES
TRANSVERSE UNIVERSEL DE MERCATOR

GRID ZONE DESIGNATION: DÉSIGNATION DE LA ZONE DU QUADRILLAGE:	100,000 M. SQUARE IDENTIFICATION IDENTIFICATION DU CARRÉ DE 100,000 M.
12 U	TM UM 3

EXAMPLE OF METHOD USED
TO GIVE A REFERENCE TO NEAREST 100 METRES
EXEMPLE DE LA MÉTHODE EMPLOYÉE
POUR FIXER DES REPÈRES À 100 MÈTRES PRÈS



REFERENCE POINT POINT DE REPÈRE	CHURCH - ÉGLISE	(as above) (ci-dessus)

EASTING: Read number on grid line immediately to left of point:
LONGITUDE EST: Noter le chiffre de la ligne du quadrillage immédiatement à gauche du repère: 97

Estimate tenths of a square from this line eastward to point:
Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction est: 5

975

NORTHING: Read number on grid line immediately below point:
LATITUDE NORD: Noter le chiffre de la ligne du quadrillage immédiatement en-dessous du repère: 98

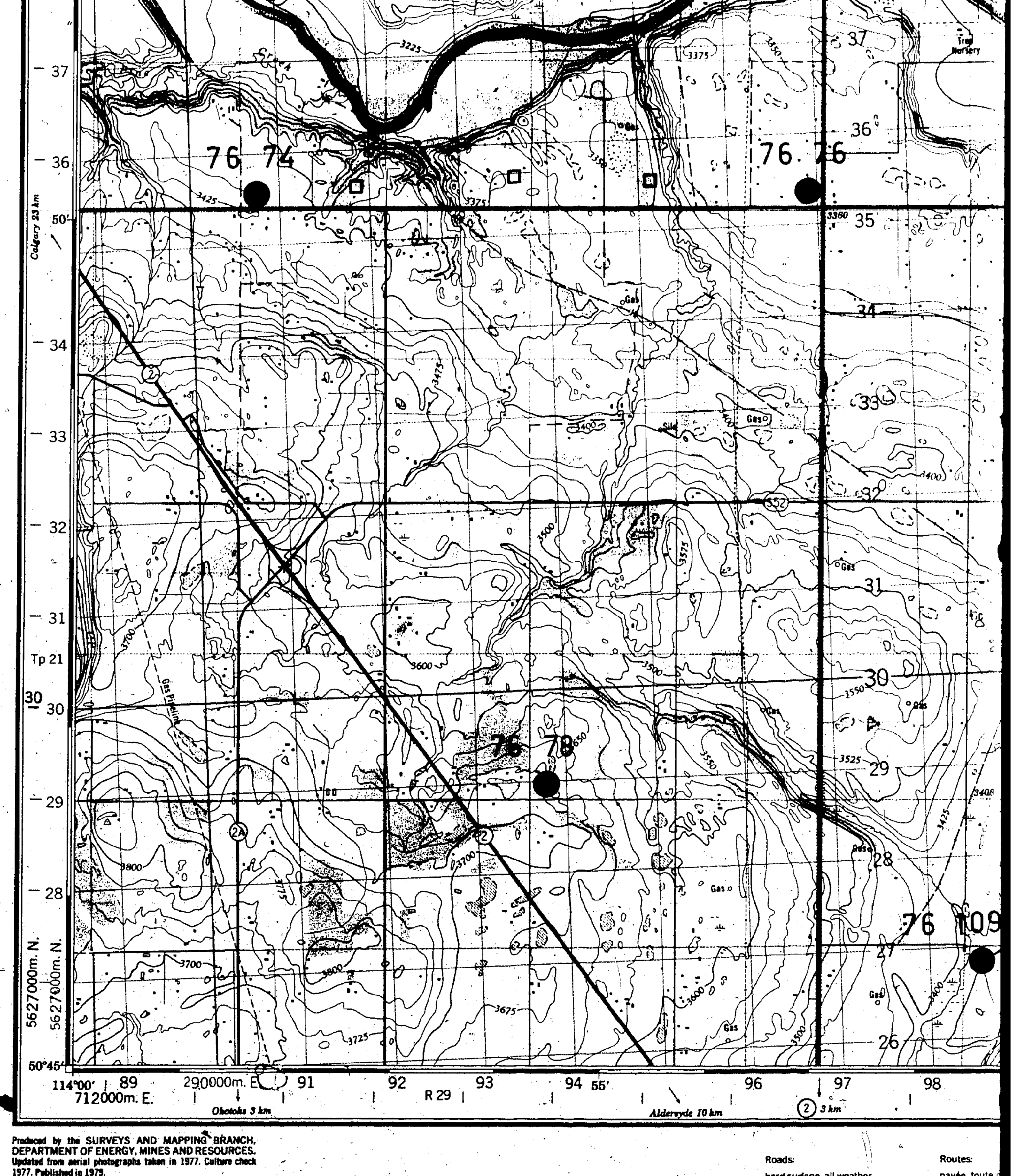
Estimate tenths of a square from this line northward to point:
Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction nord: 4

GRID REFERENCE: 984
RÉFÉRENCE AU QUADRILLAGE: 975984

Nearest similar grid reference 100,000 metres (about 63 miles)
La prochaine référence similaire est à 100,000 mètres (environ 63 milles)

BROWN NUMBERED TICKS INDICATE
THE 1000 METRE U.T.M. GRID
ZONE 11
LES TRAITS NUMÉROTÉS EN BRUN INDIQUENT
LE QUADRILLAGE DE 1000 MÈTRES U.T.M.

80F



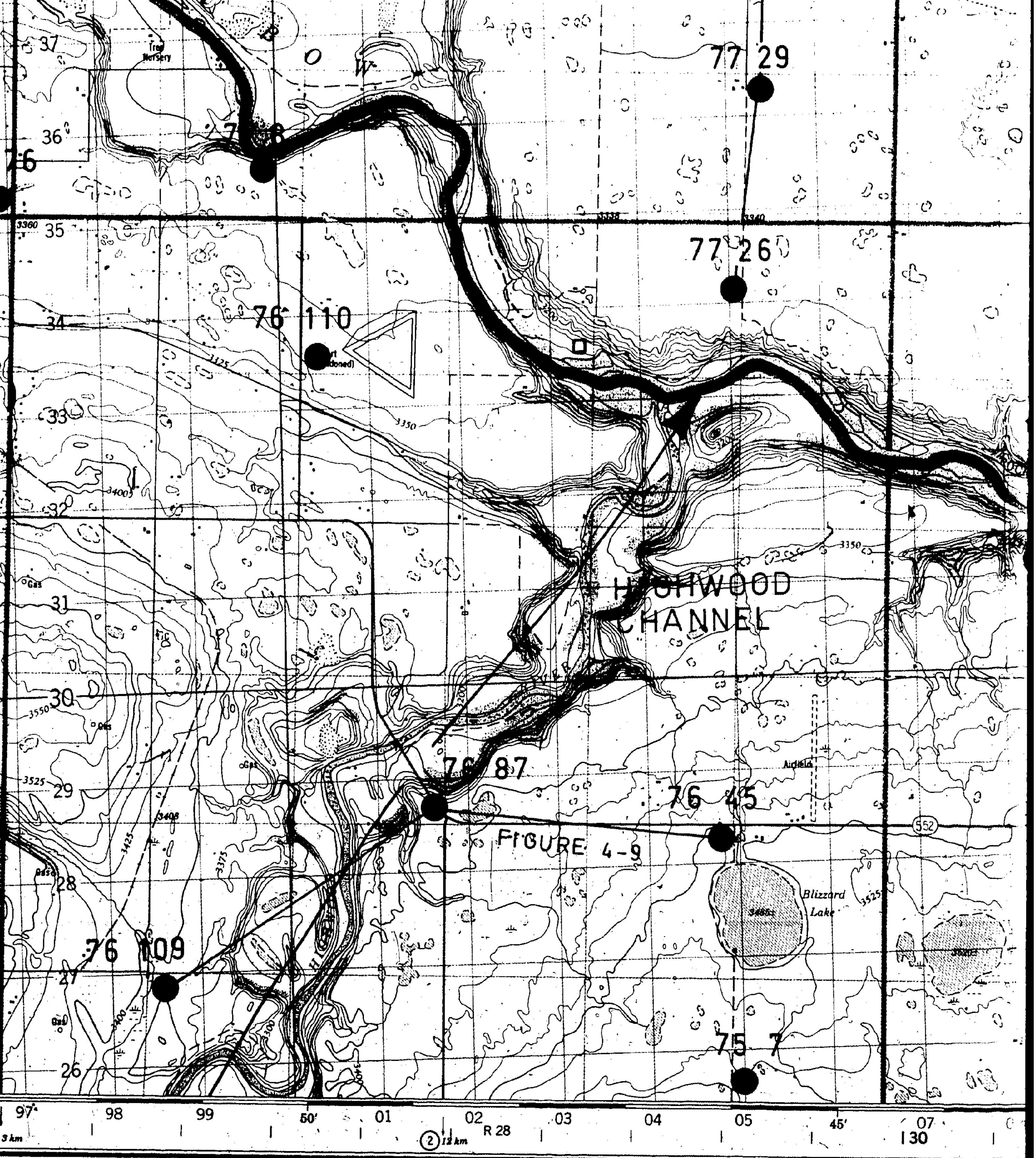
Produced by the SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES. Updated from aerial photographs taken in 1977. Culture check 1977. Published in 1979.

Copies may be obtained from the Canada Map Office, Department of Energy, Mines and Resources, Ottawa, or your nearest map dealer.

90F

Roads:	Routes:
hard surface, all weather	pavée, toute s
hard surface, all weather	pavée, toute s
loose or stabilized surface, all weather	gravier, agglo
loose surface, dry weather	de gravier, te
unclassified streets	rues hors clas
cart track	de terre
trail, cut line or portage	sentier, perce

FOR COMPLETE REFERENCE SEE REVERSE SIDE POU



Routes:

, all weather	pavée, toute saison	dual highway 2 chaussées séparées	more than 2 lanes plus de 2 voies
, all weather	pavée, toute saison	2 lanes 2 voies	less than 2 lanes moins de 2 voies
lized surface, all weather	gravier, aggloméré, toute saison	2 lanes or more 2 voies ou plus	less than 2 lanes moins de 2 voies
, dry weather	de gravier, temps sec		
streets	rues hors classe		
	de terre		
or portage	sentier, percée ou portage		

MPLETE REFERENCE SEE REVERSE SIDE POUR UNE LISTE COMPLÈTE DES SIGNES, VOIR AU VERSO

10E

DALEMEAD

ALBERTA

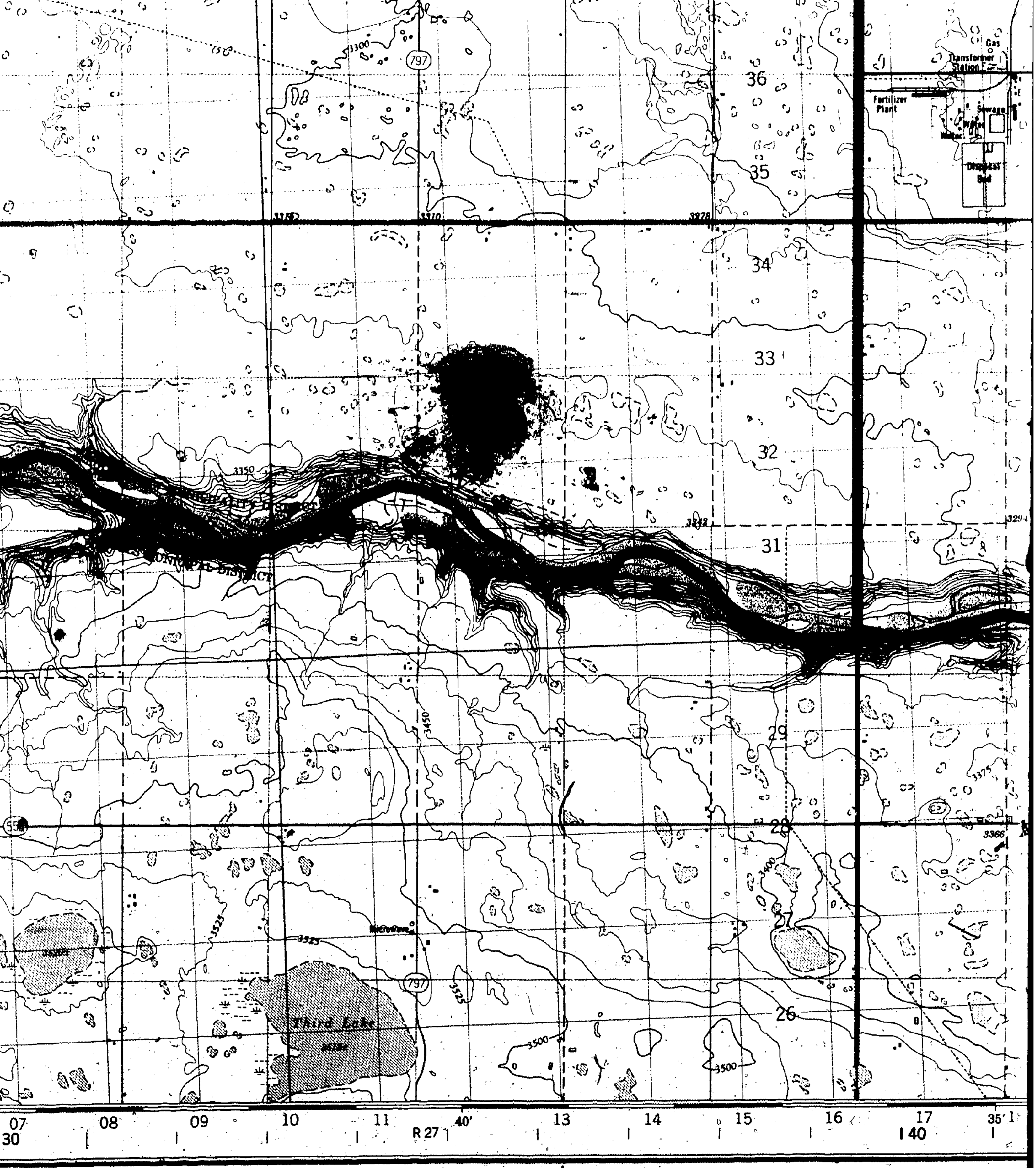
WEST OF FOURTH MERIDIAN-OUEST DU QUATRIÈME MÉRI

Scale 1:50,000 Échelle

Miles 1 0 1 2

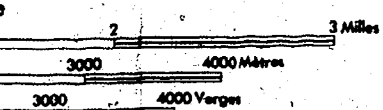
Metres 1000 0 1000 2000 3000

Yards 1000 0 1000 2000 3000 400



AD

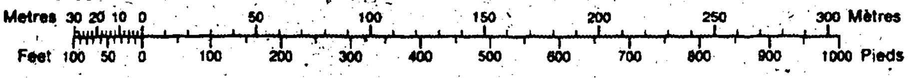
QUATRIÈME MÉRIDIEN



Information concerning location and precise elevation of bench marks can be obtained by writing to the Geodetic Survey, Surveys and Mapping Branch, Ottawa.

On peut obtenir des renseignements sur le lieu et l'altitude exacte des repères de nivellement en écrivant aux Levés géodésiques, Direction des levés et de la cartographie, Ottawa.

CONVERSION SCALE FOR ELEVATIONS ÉCHELLE DE CONVERSION DES ÉLÉVATIONS



CONTOUR INTERVAL 25 FEET
Elevations in Feet above Mean Sea Level
North American Datum 1927
Transverse Mercator Projection

ÉQUIDISTANCE DES COURBES 25 PIEDS
Élévations en pieds au-dessus du niveau moyen de la mer
Système de référence géodésique nord-américain, 1927
Projection transverse de Mercator

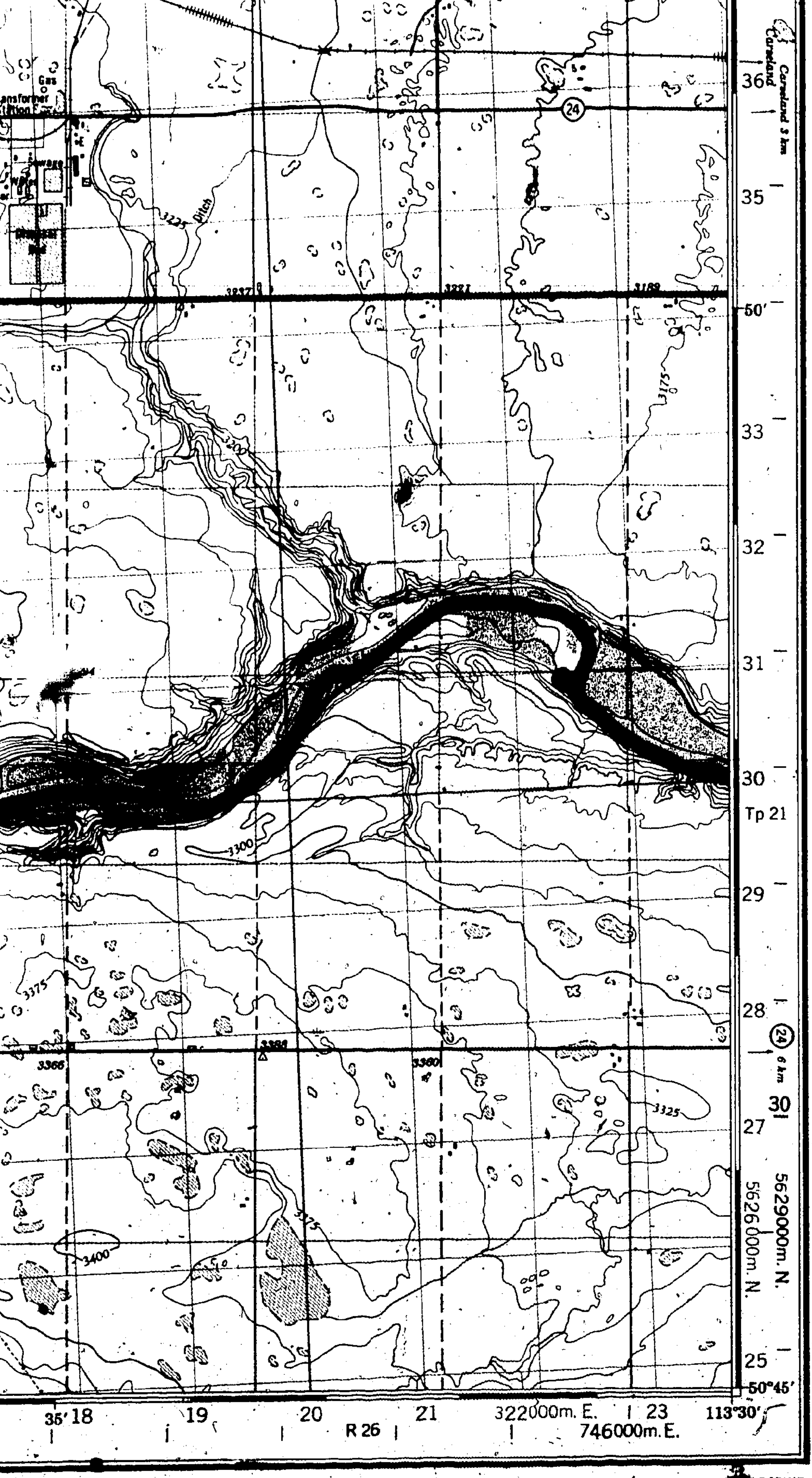
110F

DU QUADRILLAGE

12 U

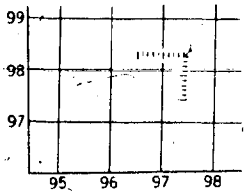
TM | UM

3



EXAMPLE OF METHOD USED TO GIVE A REFERENCE TO NEAREST 100 METRES

EXEMPLE DE LA MÉTHODE EMPLOYÉE POUR FIXER DES REPÈRES À 100 MÈTRES PRÈS



REFERENCE POINT POINT DE REPÈRE	CHURCH - ÉGLISE	(as above) (ci-dessus)

EASTING: Read number on grid line immediately to left of point:
LONGITUDE EST: Noter le chiffre de la ligne du quadrillage immédiatement à gauche du repère: 97

Estimate tenths of a square from this line eastward to point:
Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction est: 5

975

NORTHING: Read number on grid line immediately below point:
LATITUDE NORD: Noter le chiffre de la ligne du quadrillage immédiatement en-dessous du repère: 98

Estimate tenths of a square from this line northward to point:
Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction nord: 4

984

GRID REFERENCE:
RÉFÉRENCE AU QUADRILLAGE: 975984

Nearest similar grid reference 100,000 metres (about 63 miles)
La prochaine référence similaire est à 100,000 mètres (environ 63 milles)

BROWN NUMBERED TICKS INDICATE
THE 1000 METRE U.T.M. GRID
ZONE 11
LES TRAITS NUMÉROTÉS EN BRUN INDIQUENT
LE QUADRILLAGE DE 1000 MÈTRES U.T.M.

TABLEAU D'ASSEMBLAGE DU SYSTÈME NATIONAL

Dalemead Sheet

Base Map

Figure 1-5

Établie par la DIRECTION DES LEVÉS ET DE LA CARTOGRAPHIE, MINISTÈRE DE L'ÉNERGIE, DES MINES ET DES RESSOURCES. Mise à jour à l'aide de photographies aériennes prises en 1977. Vérification des ouvrages en 1977. Publiée en 1979.

Ces cartes sont en vente au Bureau des Cartes du Canada, ministère de l'Énergie, des Mines et des Ressources, Ottawa, ou chez le vendeur le plus près.

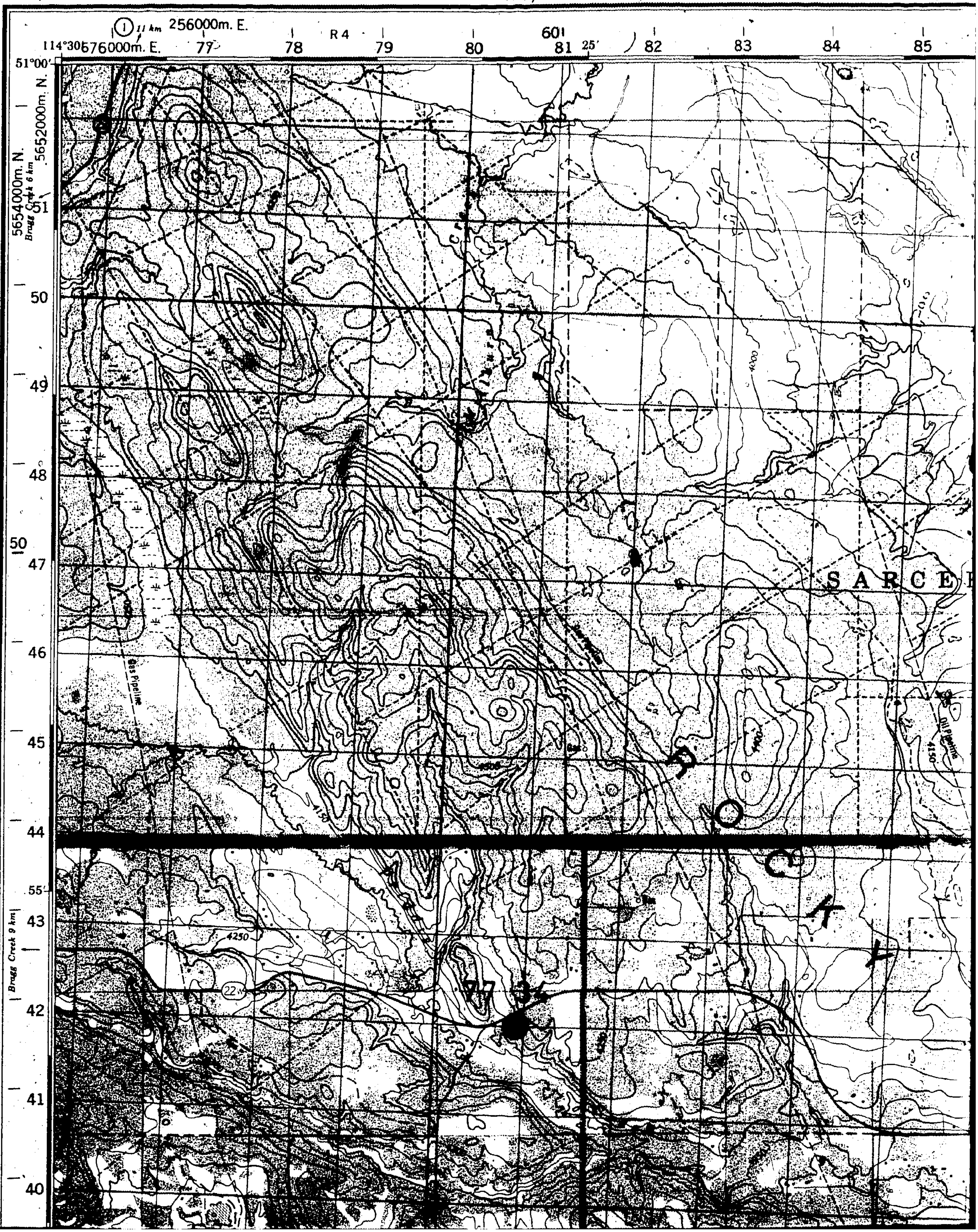
DALEMEAD
82-I/13
EDITION 5

120F12

1 OF

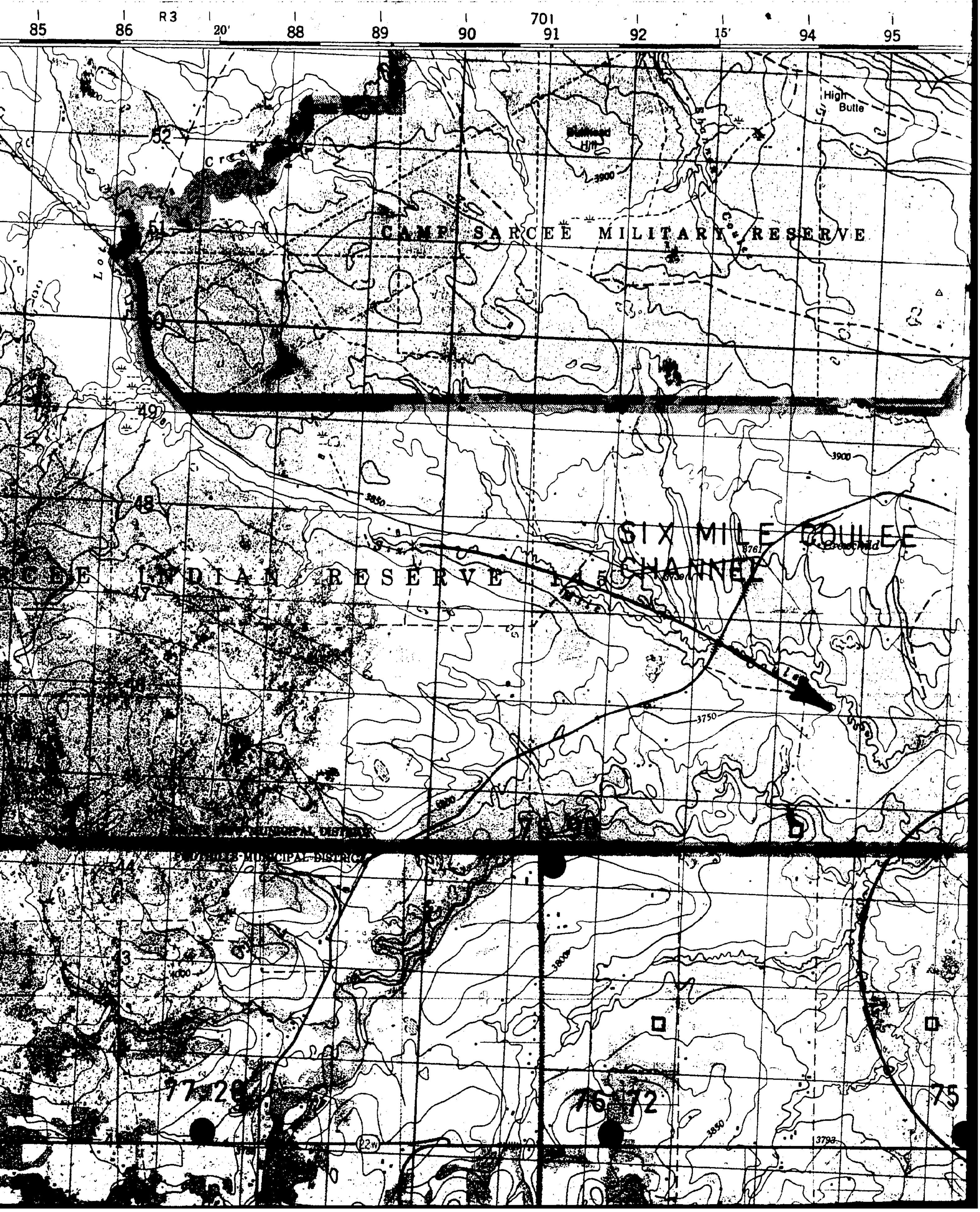
82 J/16

1:50,000



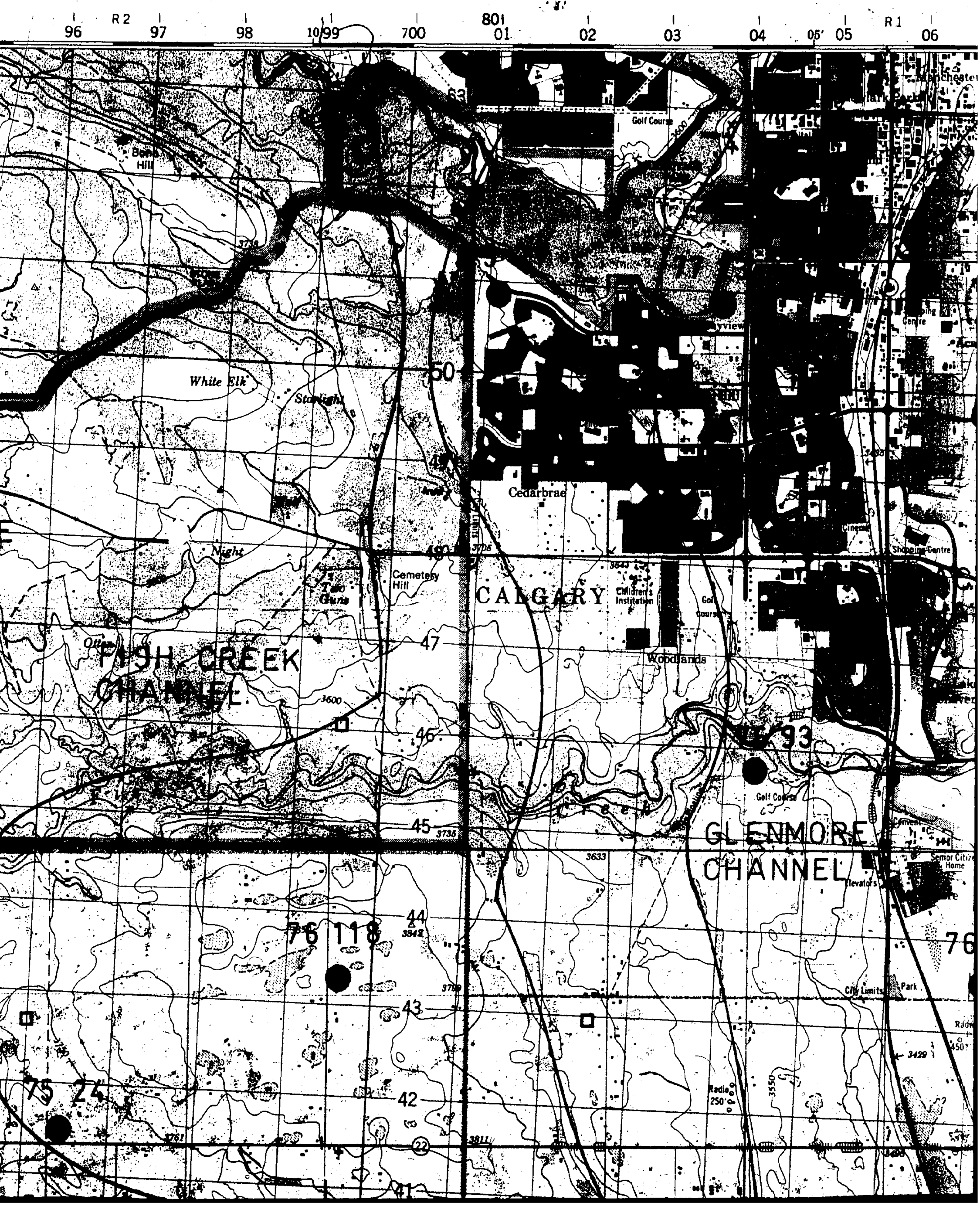
2 OF

CANADA


85
86
R3
20′
88
89
90
701
91
92
15′
94
95
High Butte
3900
CAMP SARCEE MILITARY RESERVE
SIX MILE COULEE CHANNEL
SARCEE INDIAN RESERVE 145
3850
3750
3800
FOOTHILLS MUNICIPAL DISTRICT
77 29
76 12
75
22W
3793

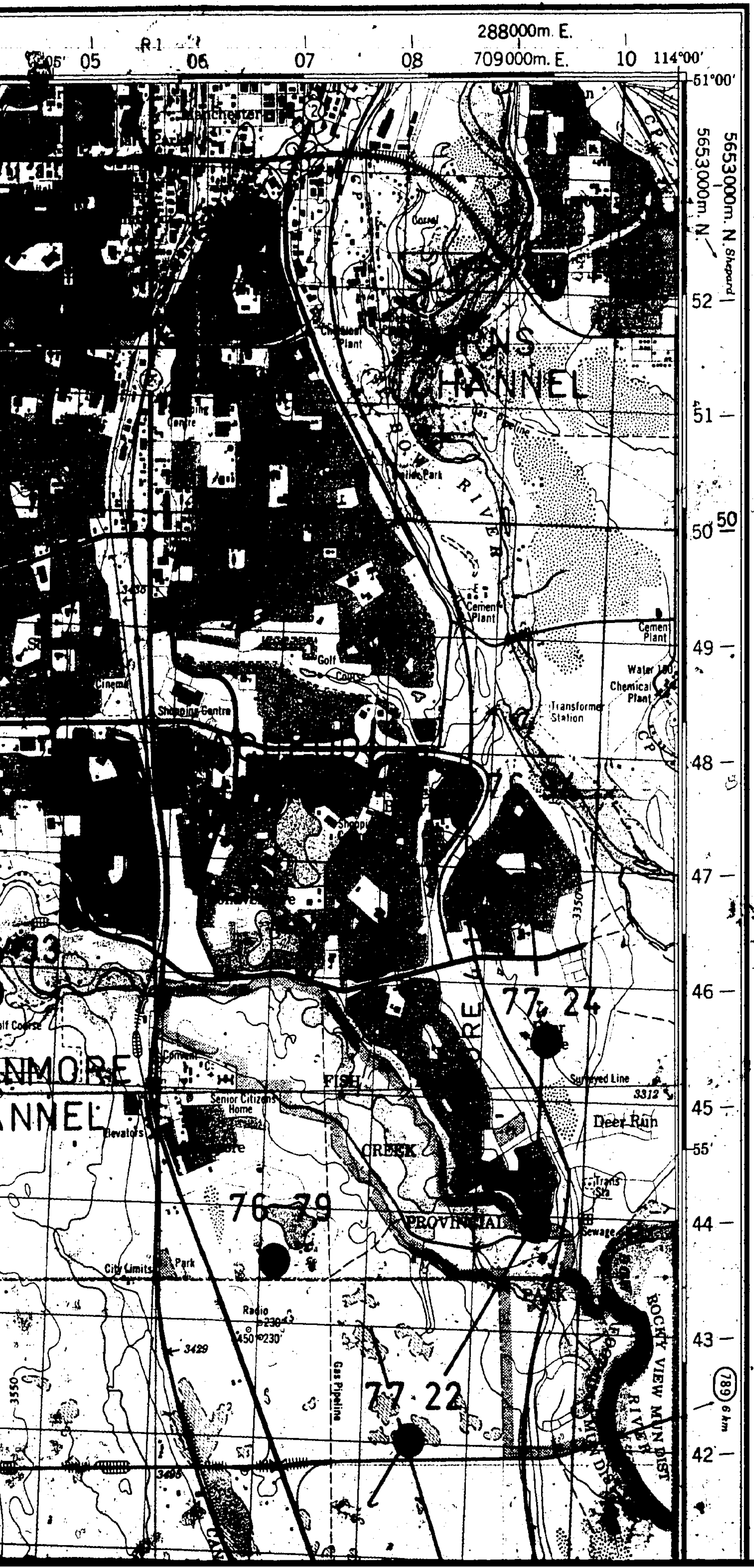
| 3 OF |

EDITION 4



EDITION 4

82 J/16



Military users, refer to this map as: Référence de cette carte pour usage militaire:	SERIES A 741 SÉRIE MAP 82 J/16 CARTE EDITION 4 MCE ÉDITION

GLOSSARY GLOSSAIRE

Airfield	Terrain d'aviation
Arena	Aréna
City Limits	Limites de ville
Customs	Douane
Ditch	Fosse
Dugout	Abreuvoir
Dump	Dépotoir
Filtration Plant	Usine de filtration
Gas	Gaz
Golf Course	Terrain de golf
Junk Yard	Ferraille
Kiln	Four
Lookout	Belvédère
Mine Waste	Déblai de mine
Oil Wells	Puits de pétrole
Park	Parc
Rink	Patinoire
Senior Citizens Home	Foyer de l'âge d'or
Ski Area	Station de ski
String Bog	Fondrière à filaments
Surveyed Line	Ligne arpentée
Tank	Réservoir
Water	Eau
Winter Road	Chemin d'hiver

For a complete glossary see reverse side

Pour un glossaire complet, voir au verso

| 40F

ABBREVIATIONS ABRÉVIATIONS

Aband	Abandoned	Abandonné, ée
C	Cemetery	Cimetière
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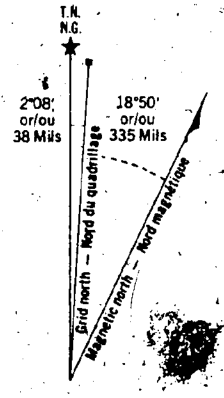
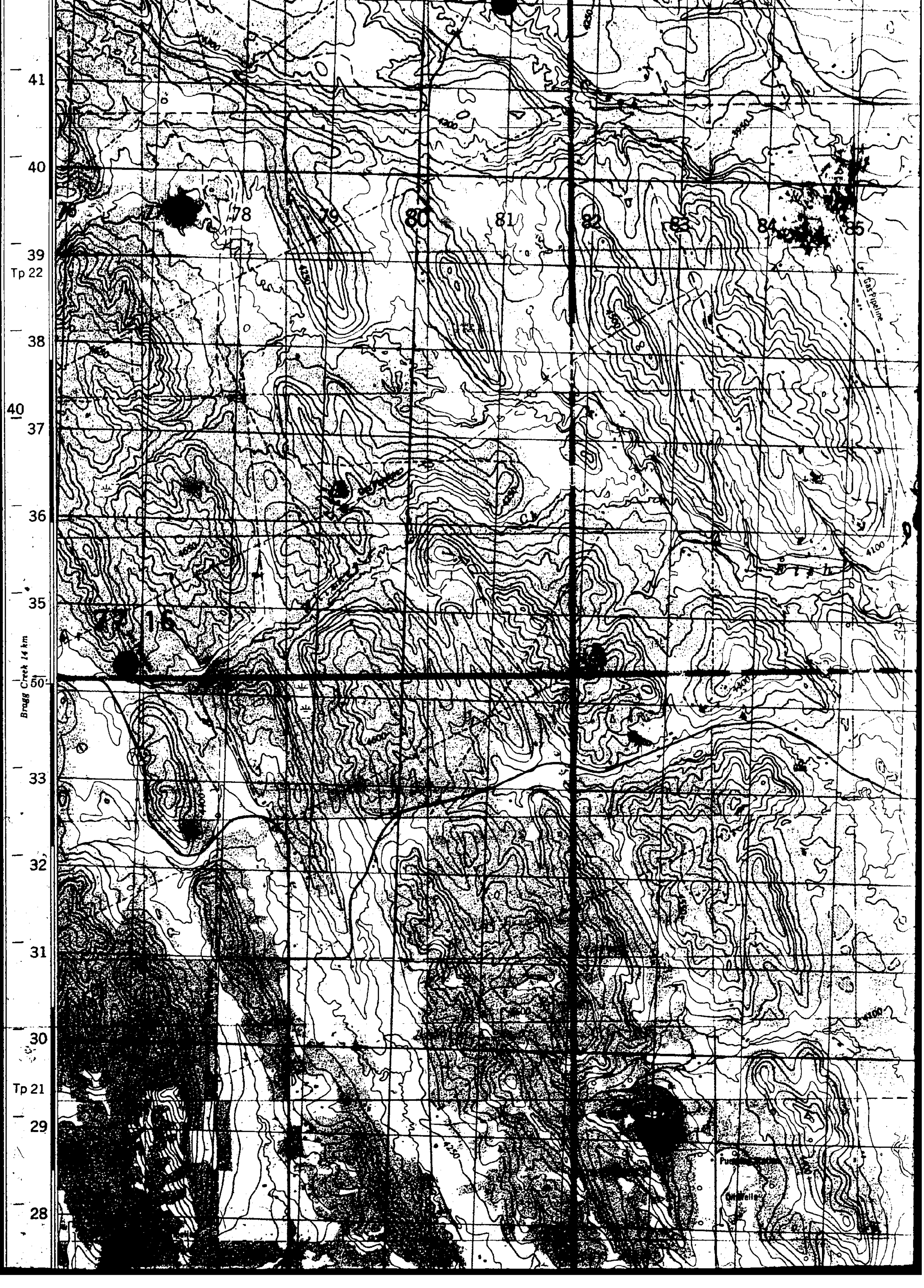
Mun	Municipality	Municipalité
P	Post Office	Bureau de poste
PH	Power House	Centrale électrique
RCMP	Royal Canadian Mounted Police	Gendarmerie Royale Canadienne
Res	Reservoir	Réservoir
Trans Sta	Transformer Station	Poste de transformateurs
TFL	Tree Farm Licence	Licence de sylviculture

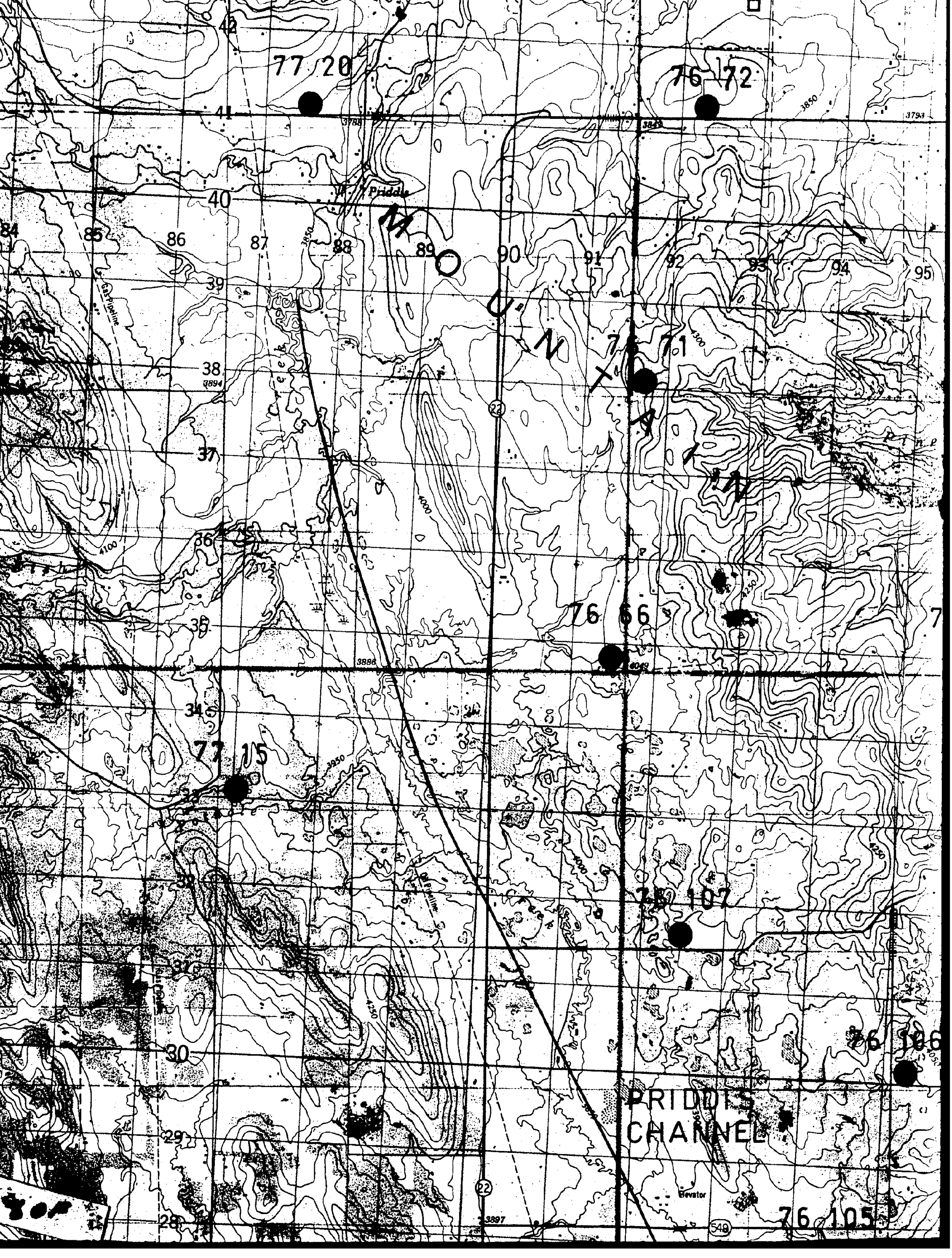


Use diagram only to obtain numerical values

APPROXIMATE MEAN DECLINATION 1978

FOR CENTRE OF MAP


41
40
39
Tp 22
38
40
37
36
35
50
Bragg Creek 14 km
33
32
31
30
Tp 21
29
28
76
77
78
79
80
81
82
83
84
85
16
4100
4200
4250
3950
Gas Pipeline
Cr
Fish
Oil Wells


77 20
76 72
MOUNTAIN
76 71
76 66
77 15
76 107
76 106
76 105
PRIDDIS CHANNEL
Priddis
Gas Pipeline
Pine
Elevator
84
85
86
87
88
89
90
91
92
93
94
95
42
41
40
39
38
37
36
35
34
32
31
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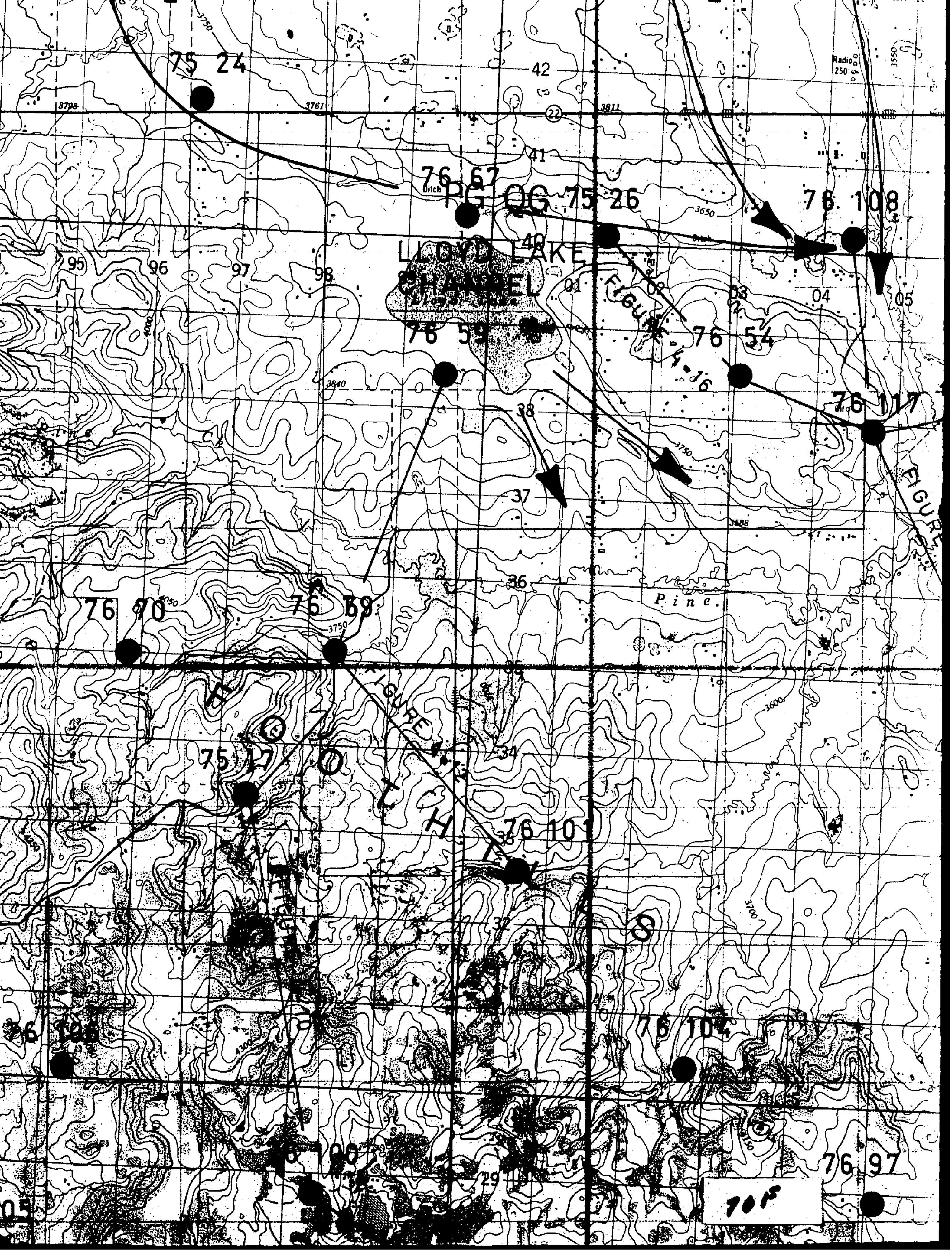
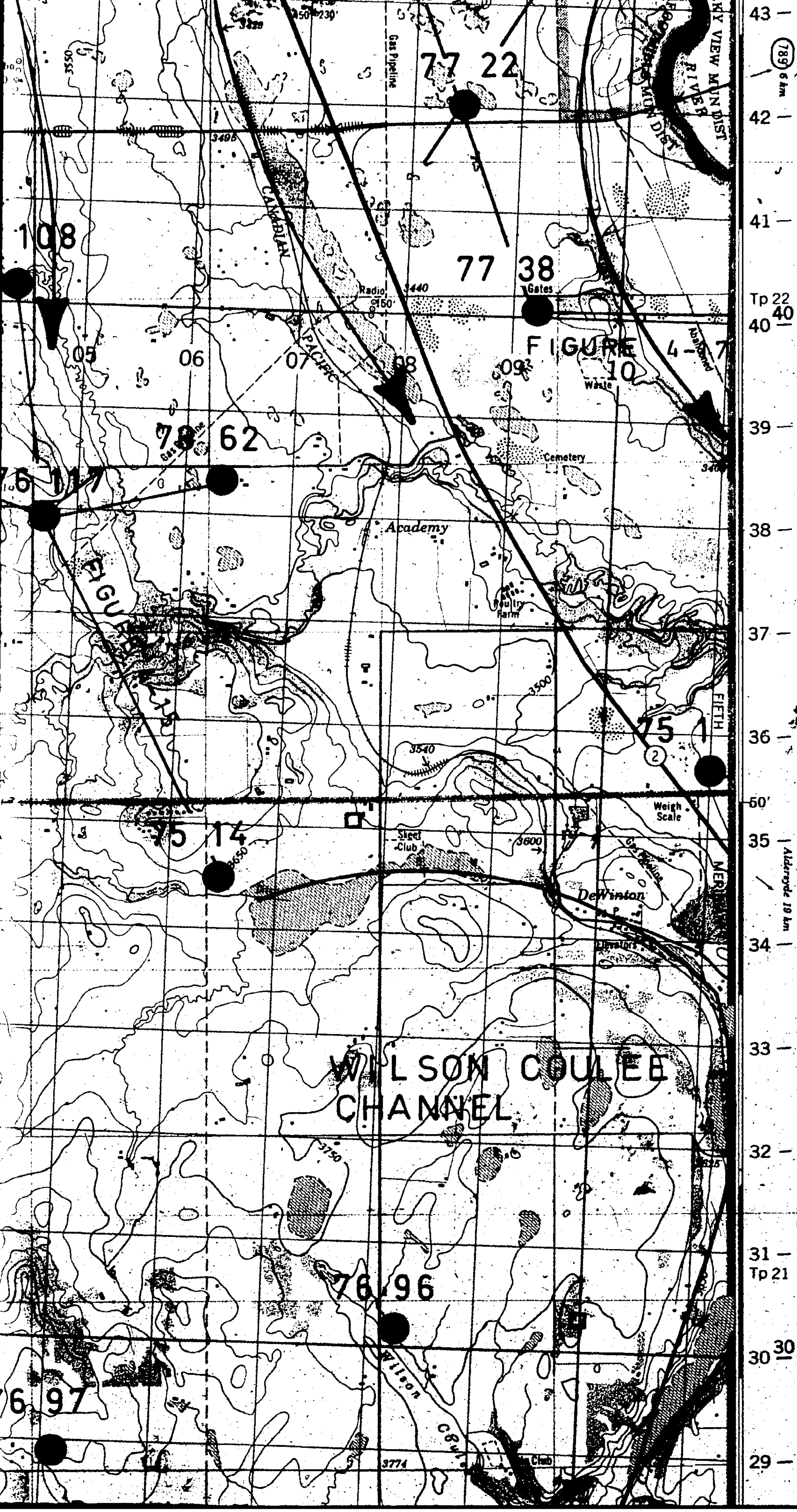
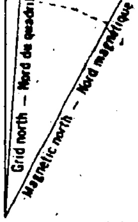
3788
3849
3850
3793
3894
4000
4100
4250
3950
3886
4049
3897
22
549


75 24
42
3798
3761
22
3811
Radio
250
3550
41
3750
76 67
Ditch
PG QG
75 26
3650
76 108
LLOYD LAKE
CHANNEL
40
95
96
97
98
01
03
04
05
4000
76 59
76 54
FIGURE 4-16
3840
76 117
38
37
3750
3688
FIGURE
36
Pine
76 70
4050
75 69
3750
FIGURE
35
FOOTHILLS
3600
34
75 17
76 101
33
3700
32
4300
76 105
76 104
76 100
29
76 97
05

10F





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Variation annuelle décroissante 5.5'

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UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 11
QUADRILLAGE DE MILLE MÈTRES
TRANSVERSE UNIVERSEL DE MERCATOR

GRID ZONE DESIGNATION: DÉSIGNATION DE LA ZONE DU QUADRILLAGE:	100,000 M. SQUARE IDENTIFICATION IDENTIFICATION DU CARRÉ DE 100,000 M.
11 U	PG QG 7

EXAMPLE OF METHOD USED
TO GIVE A REFERENCE TO NEAREST 100 METRES
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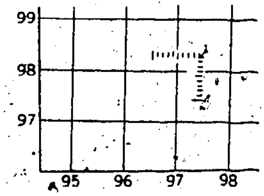
POUR FIXER DES REPÈRES À 100 MÈTRES PRÈS



REFERENCE POINT POINT DE REPÈRE	CHURCH - ÉGLISE	(as above) (ci-dessus)

EASTING: Read number on grid line immediately to left of point:
LONGITUDE EST: Noter le chiffre de la ligne du quadrillage immédiatement à gauche du repère: 97

Estimate tenths of a square from this line eastward to point:
Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction est: 5

975

NORTHING: Read number on grid line immediately below point:
LATITUDE NORD: Noter le chiffre de la ligne du quadrillage immédiatement en-dessous du repère: 98

Estimate tenths of a square from this line northward to point:
Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction nord: 4

984

GRID REFERENCE:
RÉFÉRENCE AU QUADRILLAGE: 975984

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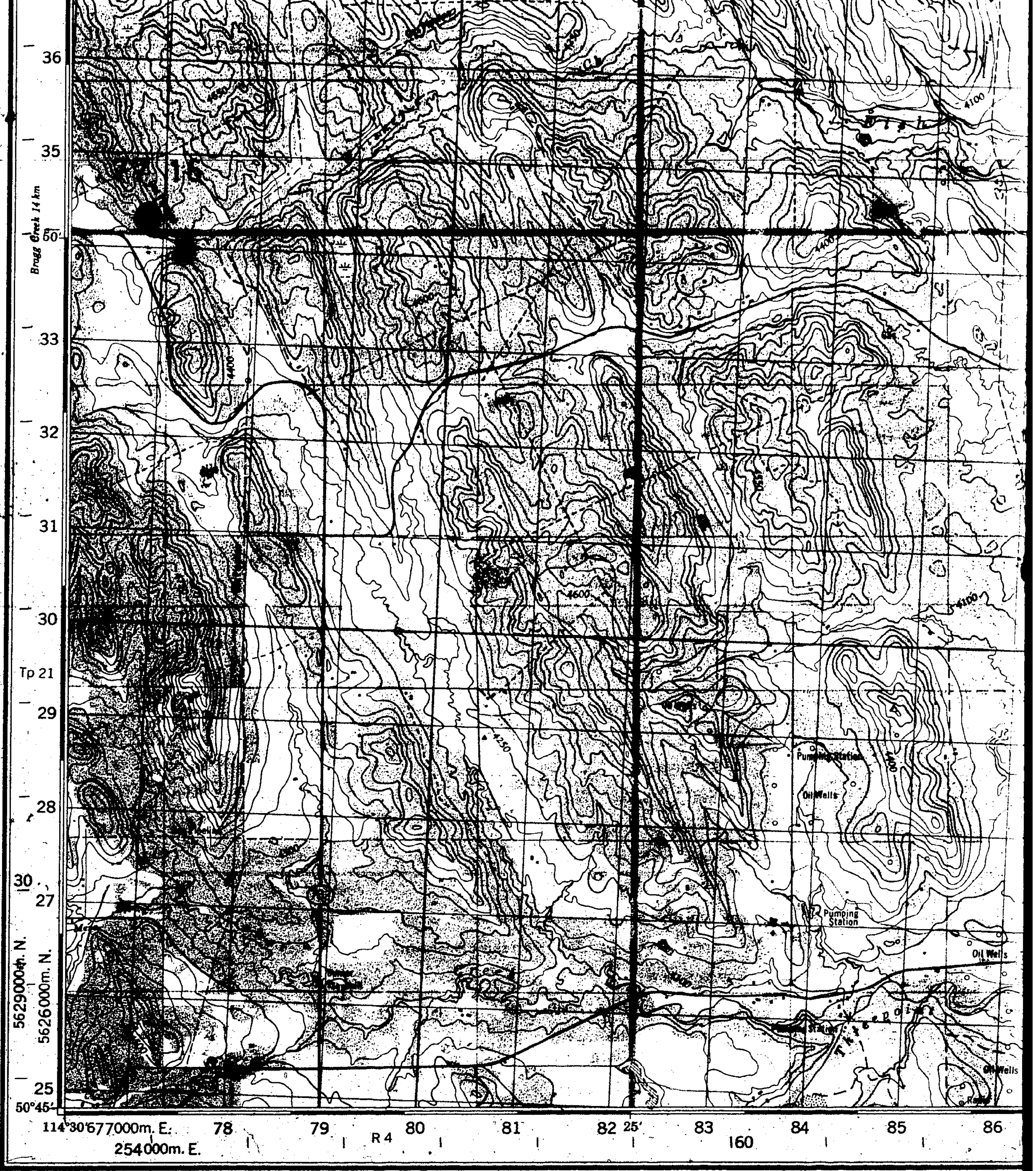
80F



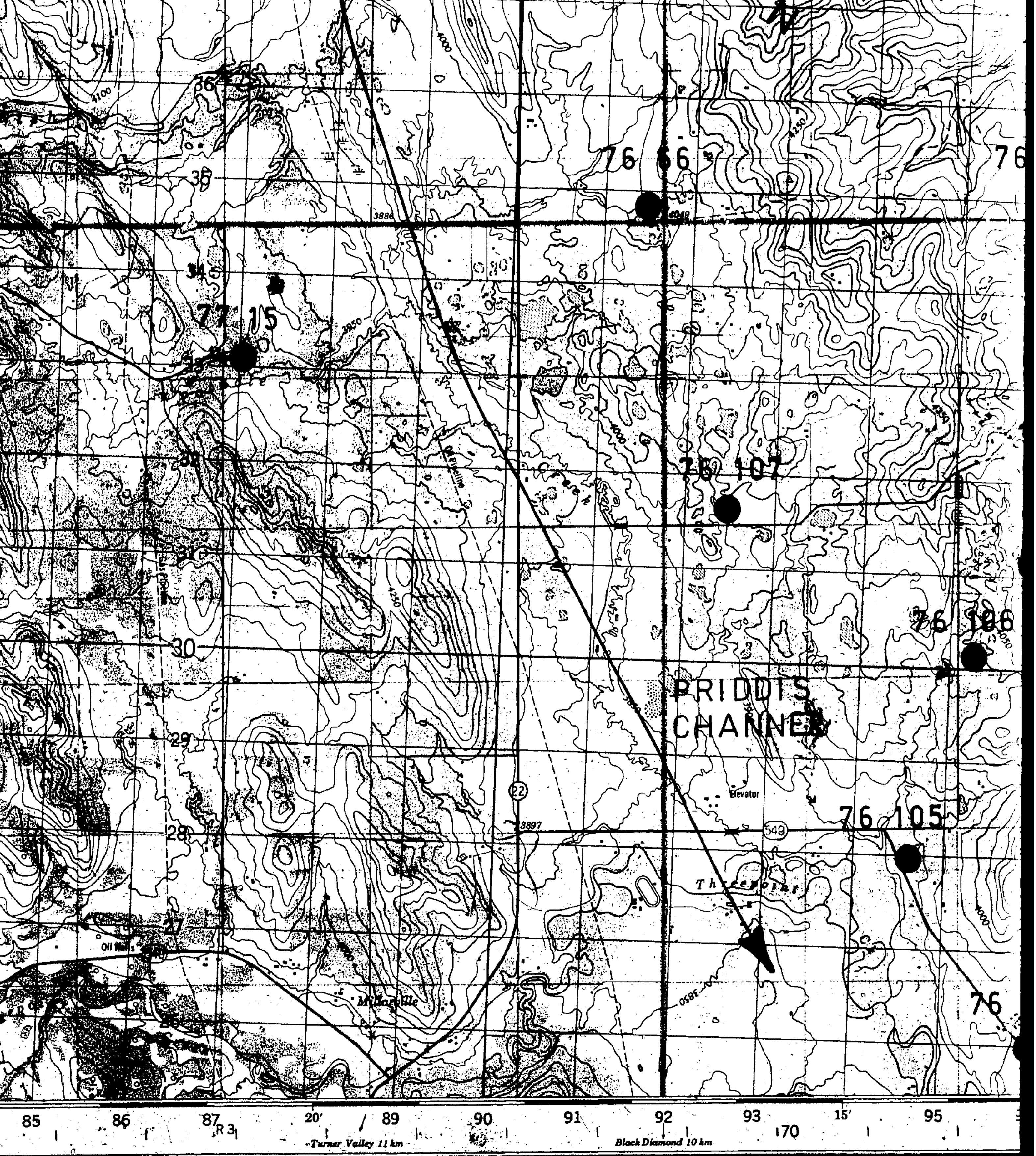
Produced by the SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES. Updated from aerial photographs taken in 1977. Culture check 1977. Information current as of 1977.

Copies may be obtained from the Canada Map Office, Department of Energy, Mines and Resources, Ottawa, or your nearest map dealer.

Roads:	Rou
hard surface, all weather	pave
hard surface, all weather	pav
loose or stabilized surface, all weather	grav
loose surface, dry weather	de r
unclassified streets	rues
cart track	de te
trail, cut line or portage	sent

FOR COMPLETE REFERENCE SEE REVERSE SI

90F



	Routes:		
ce, all weather	pavée, toute saison	dual highway 2 chaussées séparées	more than 2 lanes plus de 2 voies
ce, all weather	pavée, toute saison	2 lanes 2 voies	less than 2 lanes moins de 2 voies
bilized surface, all weather	gravier, aggloméré, toute saison	2 lanes or more 2 voies ou plus	less than 2 lanes moins de 2 voies
ce, dry weather	de gravier, temps sec		
d streets	rues hors classe		
	de terre		
e or portage	sentier, percée ou portage		

OMPLETE REFERENCE SEE REVERSE SIDE   POUR UNE LISTE COMPLÈTE DES SIGNES, VOIR AU VERSO

10[illegible]

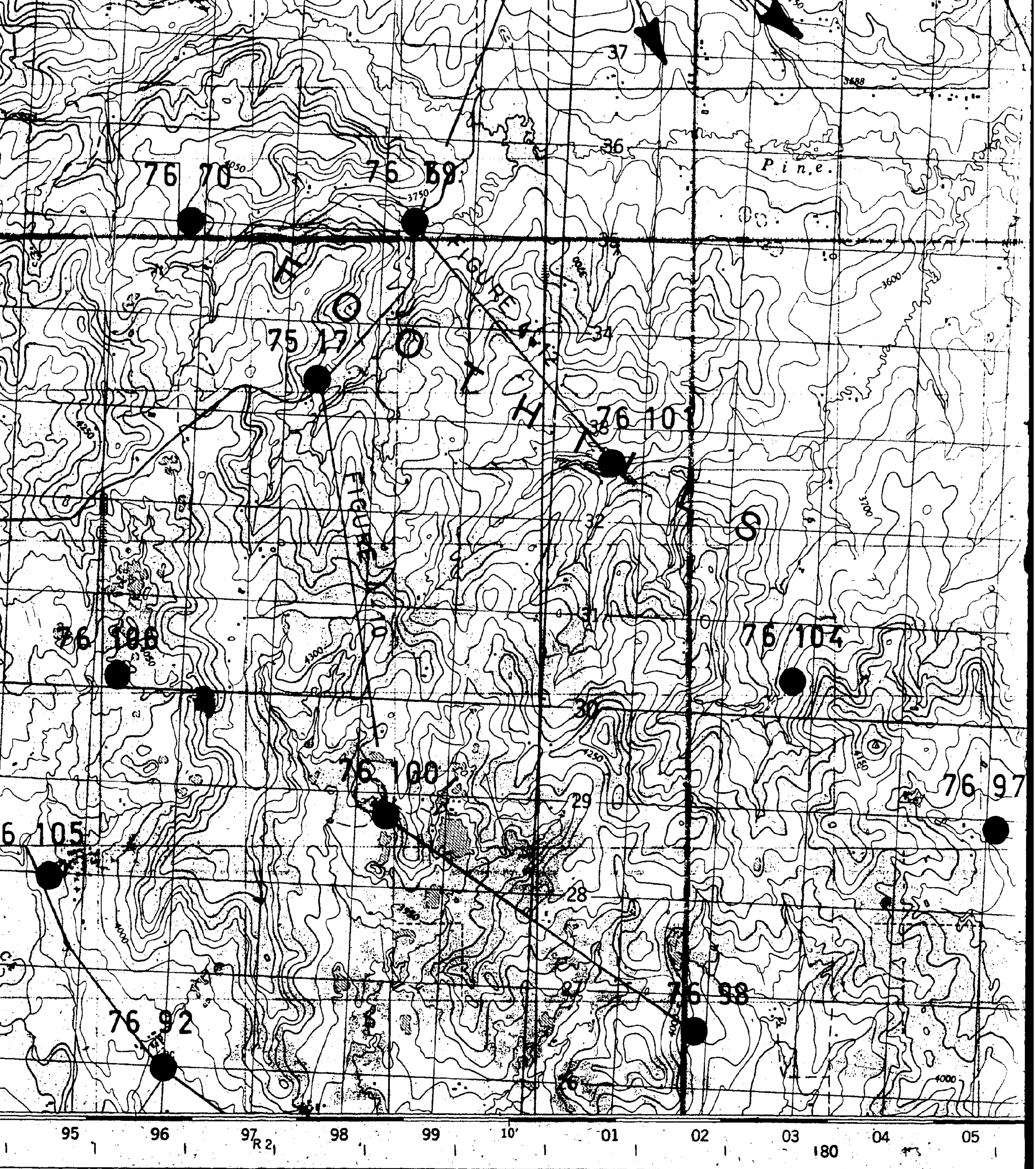
PRIDDIS
ALBERTA

Scale 1:50,000 Échelle

Miles 1 0 1 2

Metres 1000 0 1000 2000 3000

Yards 1000 0 1000 2000 3000

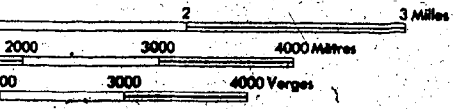


DIS

TA

110F

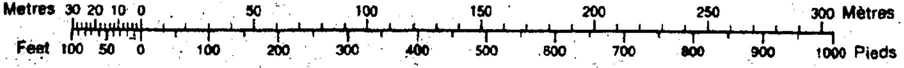
Échelle



Information concerning location and precise elevation of bench marks can be obtained by writing to the Geodetic Survey, Surveys and Mapping Branch, Ottawa.

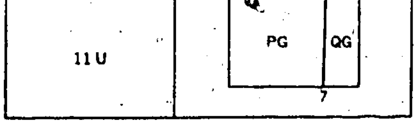
On peut obtenir des renseignements sur le lieu et l'altitude exacte des repères de nivellement en écrivant aux Levés géodésiques, Direction des levés et de la cartographie, Ottawa.

CONVERSION SCALE FOR ELEVATIONS ÉCHELLE DE CONVERSION DES ÉLÉVATIONS

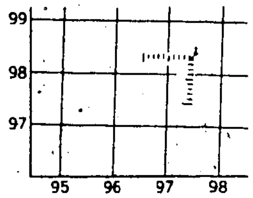


CONTOUR INTERVAL 50 FEET
Elevations in Feet above Mean Sea Level
North American Datum 1927
Transverse Mercator Projection

ÉQUIDISTANCE DES COURBES 50 PIEDS
Élévations en pieds au-dessus du niveau moyen de la mer
Système de référence géodésique nord-américain, 1927
Projection transverse de Mercator



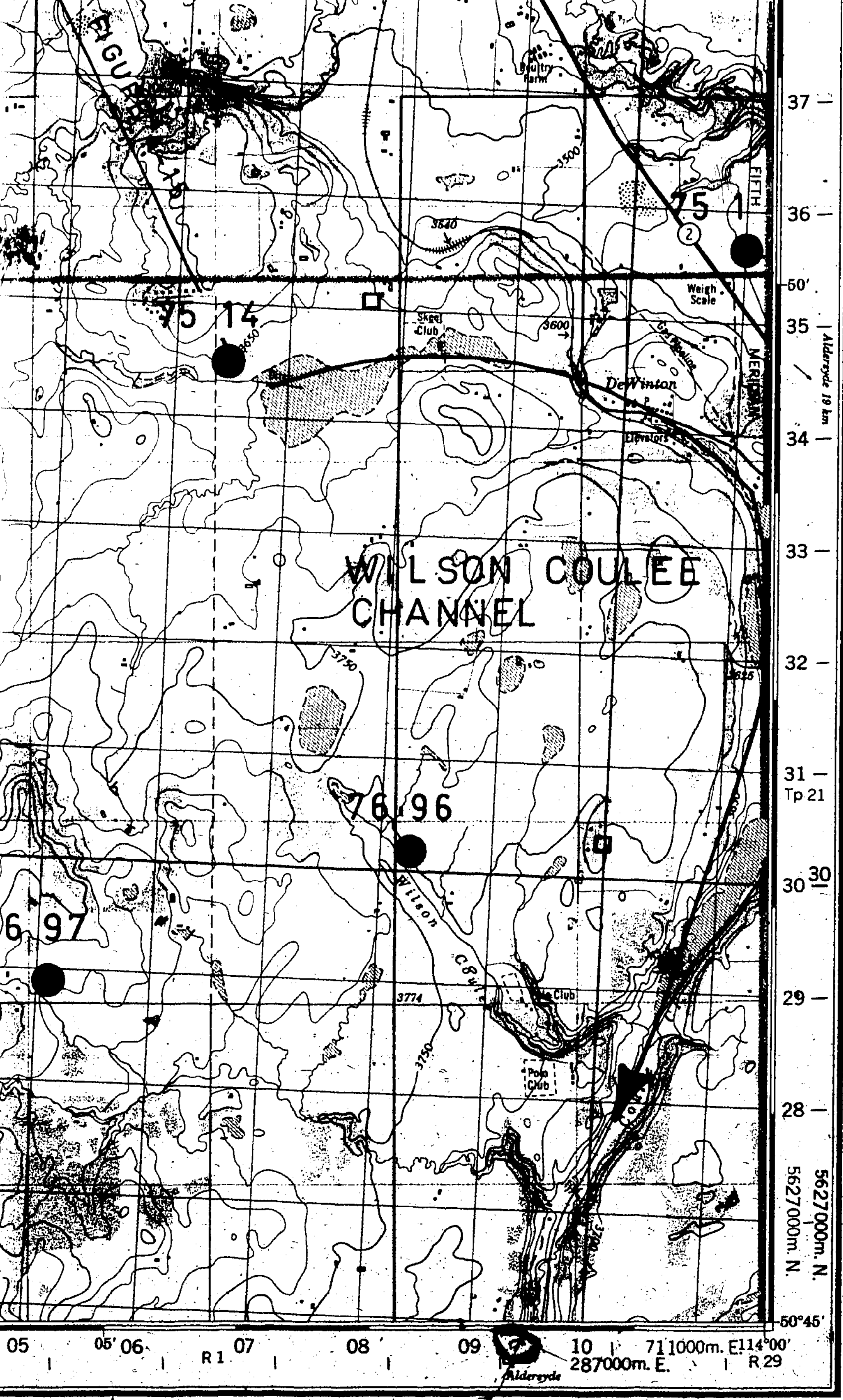
EXAMPLE OF METHOD USED
TO GIVE A REFERENCE TO NEAREST 100 METRES
EXEMPLE DE LA MÉTHODE EMPLOYÉE
POUR FIXER DES REPÈRES À 100 MÈTRES PRÈS



REFERENCE POINT POINT DE REPÈRE	CHURCH - ÉGLISE	(as above) (ci-dessus)
EASTING: Read number on grid line immediately to left of point: LONGITUDE EST: Noter le chiffre de la ligne du quadrillage immédiatement à gauche du repère:		97
Estimate tenths of a square from this line eastward to point: Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction est:		5
		975
NORTHING: Read number on grid line immediately below point: LATITUDE NORD: Noter le chiffre de la ligne du quadrillage immédiatement en-dessous du repère:		98
Estimate tenths of a square from this line northward to point: Estimer le nombre de dixièmes du carré entre cette ligne et le repère en direction nord:		4
		984
GRID REFERENCE: RÉFÉRENCE AU QUADRILLAGE:		975984

Nearest similar grid reference 100,000 metres (about 63 miles)
La prochaine référence similaire est à 100,000 mètres (environ 63 milles)

BROWN NUMBERED TICKS INDICATE
THE 1000 METRE U.T.M. GRID
ZONE 12
LES TRAITS NUMÉROTÉS EN BRUN INDIQUENT
LE QUADRILLAGE DE 1000 MÈTRES U.T.M.



Priddis Sheet

Base Map

Figure 1-6

Établie par la DIRECTION DES LEVÉS ET DE LA CARTOGRAPHIE,
MINISTÈRE DE L'ÉNERGIE, DES MINES ET DES RESSOURCES.
Mise à jour à l'aide de photographies aériennes prises en 1977. Vérification des ouvrages en 1977. Renseignements à jour en 1977.

Ces cartes sont en vente au Bureau des Cartes du Canada,
ministère de l'Énergie, des Mines et des Ressources, Ottawa,
ou chez le vendeur le plus près.

THE NATIONAL TOPOGRAPHIC SYSTEM

PRIDDIS
82 J/16
EDITION 4

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