SOILS OF THE MCMURRAY REGION, ALBERTA (TOWNSHIPS 88-89, RANGES 8-11) AND THEIR RELATION TO AGRICULTURAL AND URBAN DEVELOPMENT

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Soils of the Fort McMurray Region, Alberta

(Townships 88-89, Ranges 8-11)

and

Their Relation to Agricultural and Urban Development.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

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INTRODUCTION

This report provides information on the soils of the Fort McMurray Region (townships 88-89, ranges 8-11), with particular reference to agricultural and urban development. The field work was conducted during the months of June and July 1970. At that time all roads and as many trails as were passable were traversed using trucks and an all-terrain-vehicle. However, due to the inaccessibility of some portions of the region a helicopter was used for additional sampling in late July 1970.

The soil survey programme consisted of classifying, defining, and delineating different kinds of soil based on the nature of the parent material, thickness and sequence of soil horizons (layers), organic matter content, reaction, slope and drainage of the soil. Once defined in this way, a particular soil can be distinguished from all other kinds of soil.

In this study, alow level of detail was used for the soil mapping. This was necessitated by the limited access into the region. Therefore, the accompanying soil map was initially prepared at a scale of 1 inch = 1 mile and each map unit was usually a combination of two or more different kinds of soil. The basic soil survey information was t hen used and interpreted in the preparation maps showing Soil Materials and Landforms, Soil Drainage, and Soil Capability for Agriculture.

GENERAL DESCRIPTION OF THE FORT McMURRAY REGION

Location and Extent:

Approximately 187,780 acres were mapped in Townships 88 and 89, Ranges 8 to 11, west of the 4th meridian. This region, contained within 56° 36' and 56° 46' north latitude and 111° 07' and 111° 46' west longitude, extends 14 miles to the west, 10 miles to the south, 10 miles to the east, and 3 miles to the north of Fort McMurray (Figure 1). Fort McMurray is linked to southern communities by a line of the Northern Alberta Railway, Highway #63, and air flights from the Fort McMurray Airport.

Topography and Drainage:

For the purpose of this dicussion the region has been divided into 6 large areas (Figure 1). The most striking topographic features in the region are the steep cliffs which rise from the major rivers in the region, 200 to 400 feet to the surrounding uplands. These cliffs comprise Area I and occur along the Athabasca, Clearwater, Horse, and Hangingstone Rivers. This area has very rapid surface drainage and is deeply dissected by creeks and streams which flow from the upland areas to the major rivers. These cliffs are extremely unstable judging from the many slumps which have occurred, in particular the slumping that moved Highway 63 several feet downslope during heavy rains in late June 1970.

Area II is located east of the Athabasca River and north of the Clearwater River. The topography is undulating and a few intermittent streams flow west and south into the Athabasca and Clearwater Rivers. An elevation change of 300 feet occurs between the northeast corner of Township 89, Range 8 (1400 feet amsl) and the southwest boundary of this Area (1100 feet amsl).

Area III comprises all of the area south of the Athabasca and Clearwater Rivers. The entire region has undulating to smooth topography. The Horse and Hangingstone Rivers drain the area flowing north to the Athabasca and Clearwater Rivers and are fed by numerous small creeks and streams, many of which originate in the Cheecham Hills located 25 miles south of Fort McMurray. However, surface and internal drainage are generally poor and extensive areas of Organic soils are found in this portion of the region. The elevation change across this area approximately 200 feet going from south to north across a distance of 10 miles.

Area IV comprises the alluvial flatlands through which the Clearwater River meanders. The topography of this area is undulating to smooth and the elevation is about 800 feet asml, 200 to 300 feet lower than the surrounding uplands. The land surface in this area being only a few feet above the level of the Clearwater River, internal drainage is poor and this area is susceptible to flooding.

Area V is located north and west of the townsite of Fort McMurray, along the west bank of the Athabasca River on terraces approximately 40 feet above the present river level. The topography is undulating although there are a few long, gentle slopes where the ground surface follows the topography of the underlying limestone bedrock. Located at the base of the cliffs which comprise Area I, Area V is drained by many small creeks and streams which originate in the upland area to the west and flow into the Athabasca River. This protion of the region contains a few small areas of Organic soils and marshes.

Area VI, located west of the Athabasca River, occupies the undulating upland in the northwest portion of the map region. Gently to moderately rolling topography occurs in a sand dune area in Township 88, Range 11, Sections 17 to 21 and Sections 28 to 30. This area is drained by numerous creeks and streams which flow eastward from the Thickwood Hills to the Athabasca River and many areas of Organic soils occur in lowlying and depressional landscape positions. An elevation change of 600 feet occurs from the western edge of Township 89, Range 11 (1600 feet asml) to the southeastern boundary of the area in Township 89, Range 10 (1000 feet amsl).

Climate:

According to the ARDA publication "The Climates of Canada for Agriculture" (4) the Fort McMurray Region is classified in climate zone 7 HK. This expresses that crop failure due to drought is unlikely (H) but that the frost hazard, due to the occasional occurrence of summer frosts, places a severe restriction on agricultural production, especially the production of oats, barley, and wheat (7 K).

The Williams/Hopkins Agroclimatic Estimates of 1968 (1) published by the Canada Department of Agriculture give climatic date for 1180 points in the Great Plains of Canada. In the Fort McMurray Region an average frost-free period (32°F) of 60 to 70 days is predicted except for the lowland area along the Clearwater River in the vicinity of Draper (Township 89, Range 9, Section 31) where an average frost-free period (32°F) of 89 days is recorded. The vegetative period based on 28°F is 90 to 100 days in the Fort McMurray Region. This average annual precipitation is 16 inches with 10 inches falling during the period from May to September.

Agro-climatic areas or zones have been recognized and delineated within the province of Alberta (3). The main criteria used for establishing these zones are length of frost-free period (32°) and number of degree days above 43°F (Table 1). The Fort McMurray Region is in zone 3H, the letter H indicating that the length of frost-free period and number of degree days above 42°A are limiting factors to agricultural development.

For agricultural production the climate of the region would allow the production of pasture crops but is not generally conducive to the production of cereal grains.

Table 1. Length of Frost-Free Period and Degree Days above 42°F for Agro-climatic Zones in Alberta.

Agro-climatic Zone	Frost Free Days (32°F)	Degree Days
1	90+	2200
2	75-90	1900-2200
3	60-75	1750-2200
5	60	1750

Soil Materials and Landforms:

The advance and retreat of glacier ice and subsequent postglacial sorting have produced till, fluvial and lacustrine plains and sand dune areas in the Fort McMurray Region. These surficial deposits are the parent materials in which the soils have developed. In terms of land use potential, surface expression is an important consideration as well as the kind of material and the soil profile developed in it. Based on the soil map data, a Soil Material and Landform map has been prepared (Figure 2).

Figure 2. Soil Materials and Landform

Symbol	Soil Material	Symbol	Surface Expression
E	Well sorted, coarse textured eolian deposits	b	Slopes characterized by surface deposits which conform to but subdue the configuration of the underlying material
F	Well sorted medium to coarse textured fluvial sediments	f	Flat peat surfaces
F^G	Well sorted, coarse textured glacio-fluvial sediments	l	Generally level, even surfaces; slopes less than 2%
LG	Well sorted, fine textured glaciolacustrine sediments	r	Generally linear, parallel or intersecting smooth ridges; slopes 5 to 30%
M	Poorly sorted sediments deposited directly from glacial ice (till)	s	Long, unidirectional slopes greater than 30%
O^B	Sphagnum and forest peat deposits	t	Relatively flat surfaces in valleys bounded by steep slopes on at least one side
R	Consolidated bedrock materials	u	Generally smooth, irregular, undulating surface; slopes 2 to 5%
U	Undifferentiated sediments of complex deposition	v	Slopes characterized by thin surface deposits which confrom to and do not mask the configuration of the underlying material.

__Textural Modifiers__

cl - clay loam
scl - sandy clay loam
sil - silt loam
l - loam
cs - coarse sand
g - gravel
s - medium and fine sand

__Conventions__

1. Map csF^G_l - coarse sand textured, level Glaciofluvial plain.
2. In mixed areas dominant and subdominant units given respectively separated by period.
3. Where overlays occur, upper and lower units are given as numerator and denominator respectively.

Eolian Plain (E). The western half of Township 88, Range 11 contains an area of fine sand textured eolian sediments in the form of ridged sand dunes (fs Er). While the dunes themselves are well drained, some of the inter-dune areas are poorly drained. The acidic (pH 5.8) sand material is very loose and extensive wind erosion would probably occur should this area be cleared of its present vegetation of pine and spruce.

Fluvial Plain (F). Well sorted medium to coarse textured fluvial sediments occur as two distinct landforms in the McMurray Region.

The Clearwater River meanders through a lowlying area of neutral (pH 7.2) fluvial sediments as do the Horse and Hangingstone Rivers in the southern most portion of the region. Periodic flooding has deposited additional fluvial sediments on top of the existing land surfaces to produce alternating layers of various textures ranging from silt loam to sandy loam. These level land surfaces are only a few feet above the river levels and because they are bounded by steep slopes on at least one side are designated as terraces.

Fluvial sediments also occur as a blanket of neutral (pH 7.0) silt loam textured material overlying fossiliferous limestone bedrock of the Beaverhill Lake Formation. They are found along the Athabasca River in the vicinity of Fort McMurray where the bedrock forms a terrace between the river and the steeply sloping walls of the river valley. The land surface has an undulating to level expression following the general configuration of the underlying bedrock.

Glaciofuvial Plain (F^G). Glaciofuvial sediments with textures ranging from coarse sand and gravel to fine sand occur north of the Clearwater river. The loose, slightly acid (pH 6.0) sediments occur with level to undulating topography with organic deposits interspersed in poorly drained areas. In some cases the glaciofucial sediments form a veneer overlying either level glaciolacustrine or rolling morainal deposits.

Glaciofuvial sediments also occur south of the Clearwater River. Adjacent to the Hangingstone River, deposits of coarse, stony, poorly sorted gravel occur often overlain by a veneer of glaciolacustrine sediments. In the vicinity of the McMurray Airport, the opposite situation occurs where the coarse textured glaciofuvial material overlies glaciolacustrine or morainal sediments. In both cases the textural unconformity greatly affects the internal soil drainage by impeding water movement as discussed in the section of this report dealing with Soil Properties and their Relation to Agricultural and Urban development. The surface expression of these slightly acid (pH 6.4) coarse sediments is generally level to undulating.

Glaciofuvial sediments occur in the western portion of the region (townships 88 and 89, range 11) with level to undulating surface expression. In this area these acid sediments occur in association with glaciolacustrine or organic deposits. In relatively large areas in township 89, range 11, the coarse textured sediments occur as a relatively thin (3 feet) veneer overlaying level to undulating glaciolacustrine sediments.

Glaciolacustrine Plain (L^G). Ponding of glacial meltwaters has lead to the occurrence of extensive areas of glaciolacustrine sediments. These areas are usually poorly drained due to their low relief and the impervious nature of the sediments although better drained areas may occur adjacent to major rivers and streams. The basic glaciolacustrine sediments have a clay loam to clay texture although they generally have a thin (3-4 inches) silt capping. These sediments are usually found with level to undulating topography. Due to the restricted soil drainage significant areas of organic sediments are found in the glaciolacustrine plains.

Morainal Plain (M). Sandy clay loam till (scl M) occurs with undulating surface expression in the northeast and northwest corners of the region. The sandy clay loam texture arises from a 30 to 35% by weight clay fraction and a 50% weight coarse, sand fraction. Large boulders are absent from the neutral till itself, although some are found as erratics on the ground surface. A thin veneer (less than 15 inches) of silt loam or sandy loam texured glaciofluvial material is often found overlying the till. The high percentage of sand in this till as well as the presence of water deposited overlays suggest that the till may have been reworked and modified by the action of flowing water.

Clay loam till (cl M) containing approximately 37% (by weight) clay, but only 20 to 25% (by weight) sand, occurs with an undulating surface expression in the southwest corner of the region as well as in the vicinity of the McMurray airport. This massive till is alkaline in reaction and commonly has a thin (10 inches) overlay of glaciolacustrine sediment. Although many pebble size rock fragments are contained in the till large stones or boulders are absent.

Organic Deposits (O $\frac{B}{f}$). Organic deposits are found throughout the region and in some areas are extensive. They occur in depressional and level landscape positions where surface waters accumulate and generally consist of the plant remains of sphagnum and feather mosses, labrador tea and black spruce. A flat surface expression is common with generally little change in relief between the organic deposit and surrounding mineral sediments. Only the relatively large organic deposits have been delineated on the map (Figure 4). In other areas organic deposits and mineral sediments occur in such close association that separation of the two is not possible at the scale of mapping used. In these areas both organic and mineral sediment landforms are designated with the first mentioned being dominant (example: $O\frac{B}{f} + cl\ L\frac{G}{l}$).

The organic deposits in the region are generally slightly acid (pH 6.4) and shallow with mineral sediments often occurring within a depth of 24 to 60 inches.

Consolidated Bedrock Materials (R). Consolidated bedrock materials occur along the Athabasca River west and northwest of the Fort McMurray townsite. These materials occur as terraces (Rt) along the Athabasca River and are composed of fossiliferous limestone of the Beaverhill Lake Formation. They are generally covered by a blanket of fluvial sediments although in some locations these sediments have been stripped off during quarrying operations as along the road along the west side of the Athabasca River leading to the Great Canadian Oil Sands plant.

Undifferentiated Sediments (U). Undifferentiated sediments is a term used to describe the very steep and irregular slopes and cliffs along the major rivers in the region (Us). These areas are composed of not only the surficial sediments of the high lands above but also the underlying bedrock and are very susceptible to extensive erosion and slumping (Figure 2).

SOILS OF THE FORT McMURRAY REGION

The Canadian system of soil classification (10) is a hierarchal system by which almost all soils found in Canada can be classified on the basis of their chemical, physical, and morphological profile features. The broadest and highest category in the system is the ORDER. When a soil is classified by its ORDER alone, only a generalized statement of the major profile features is made. Soil ORDERS are subdivided into GREAT GROUPS which are in turn subdivided into various SUBGROUPS. Succeeding levels or categories of classification are soil FAMILIES, SERIES, and TYPES. As a soil is classified at lower levels in the system more specific statements as to its physical and chemical properties are being made. For this report the soils of the Fort McMurray Region are classified down to parent material phases of the SUBGROUP category only. Classification of the soils at lower (i.e. more specific) categories in the system is not possible due to the limited amount of amount of sampling carried out in the field.

The soils in the Fort McMurray Region have been mapped as groupings of soils found in a particular landscape which may include more than one parent material phase of a SUBGROUP or SUBGROUPS (see Soil Map, Figure 3). Although the Soil Map Legend gives the combination of soils in each map unit the following describes soil profile characteristics of the dominant soils in each unit.

<u>Orthic Eutric Brunisol Soils (Map Unit B1):</u>

Soils of this SUBGROUP are well drained and have developed in loam to silt loam fluvial materials. They are characterized by an

Figure 3. Soil Map Units

Map Symbol	Dominant Soil (s)	Subdominant Soil (s)	Landscape
B1	Orthic Eurtric Brunisol soils developed in brown, loam to silt loam fluvial veneer over limestone bedrock.	Rego Gleysol soils developed in loam to silt loam fluvial veneer over limestone bedrock.	Fluvial veneer over undulating bedrock, (2 - 5% slope).
B2	Degraded and Gleyed Degraded Systric Brunisol soils developed in loose, light yellowish brown glaciofluvial sand.		Level to undulating Glaciofluvial plain, (0 - 5% slope).
B3	Degraded and Gleyed Degraded Systric Brunisol soils developed in loose, light yellowish brown glaciofluvial sand.	Rego Gleysol and peaty Rego Gleysol soil developed in loose glaciofluvial sand.	Level to undulating Glaciofluvial plain, (0.5 - 5% slope).
B4	Degraded and Gleyed Degraded Systric Brunisol soils developed in loose, light yellowish brown glaciofluvial sand.	Terric Fibric Mesisol soils developed in the partially decomposed remains of feather and sphagnum mosses.	Level to undulating Glaciofluvial plain, (0.5 - 5% slope).
B5	Degraded and Gleyed degraded Systric Brunisol soils developed in loose, light yellowish brown glaciofluvial sand and eolian sand.	Peaty Rego Gleysol soils developed in loose fluvial sand and Terric Fibric Mesisol soils developed in the partially decomposed remains of feather and sphagnum mosses.	Undulating Glaciofluvial plain, (0.5 - 3% slope) and ridged Eolian plain (5 - 9% slope).
B6	Degraded and Gleyed Degraded Systric Brunisol soils developed in a veneer of loose, light yellowish brown fluvial sand underlain by fine textured glaciolacustrine sediments.		Glaciofluvial veneer over undulating glaciolacustrine plain (0.5 - 5% slope).
B7	Degraded and Gleyed Degraded Dystric Brunisol soils developed in a veneer of loose, light yellowish brown fluvial sand underlain by fine textured glaciolacustrine sediments.	Terric Fibric Mesisol soils developed in the partially decomposed remains of feather and sphagnum mosses and Rego Gleysol soils developed in a veneer of loose glaciofluvial sand underlain by fine textured glaciolacustrine sediments.	Glaciofluvial veneer over undulating glaciolacustrine plain (0.5 - 5% slope).
B8	Degraded and Gleyed Degraded Dystric Brunisol soils developed in loose, light yellowish brown fluvial sand.	Orthic and Gleyed Luvisol soils developed in platy, brown, sandy clay loam till and Rego Gleysol soils developed in loose glaciofluvial sand.	Undulating Glaciofluvial and morainal plain, (0.5 - 5% slope).
G1	Rego and peaty Rego Gleysol soils developed in massive sandy clay loam till.	Gleyed and Orthic Gray Luvisol soils developed in brown, sandy clay loam till.	Undulating morainal plain, (0.5 - 5% slope).
G2	Rego and peaty Rego Gleysol soils developed in massive clay loam till and Terric Fibric Mesisol soils developed in the partially decomposed remains of feather and sphagnum mosses.		Level morainal plain, (0 - 0.5% slope).
G3	Rego and peaty Rego Gleysol soils developed in massive clay loam and silty clay loam glaciolacustrine sediments and Terric Fibric Mesisol soils developed in a partially decomposed remains of feather and sphagnum mosses.		Level Glaciolacustrine plain, (0 - 0.5% slope).
G4	Rego and peaty Rego Gleysol soils developed in loose glaciofluvial sand Terric Fibric Mesisol soils developed in the partially decomposed remains of feather and sphagnum mosses.		Level Glaciofluvial plain (0 - 0.5% slope).
G5	Rego and peaty Rego Gleysol soils in massive clay loam and silty clay loam glaciolacustrine sediments.	Gleyed Gray Luvisol soils developed in massive, gray, clay loam and silty clay loam glaciolacustine sediments.	Level Glaciolacustrine plain, (0 - 0.5% slope).

Figure 3. Continued

Map Symbol	Dominant Soil(s)	Subdominant Soil(s)	Landscape
L1	Orthic and Gleyed Gray Luvisol soils developed in massive, gray clay loam and silty clay loam glaciolacustrine.		Undulating Glaciolacustrine plain, (0.5 - 5% slope).
L2	Orthic and Gleyed Gray Luvisol soils developed in massive, gray clay loam and silty clay loam glaciolacustrine sediments.	Rego Gleysol soils developed in massive, gray, clay loam and silty clay loam glaciolacustrine sediments.	Undulating Claciolacustrine plain, (0.5 - 2% slope).
L3	Orthic and Gleyed Gray Juvisol soils developed in massive, gray clay loam and silty clay loam glaciolacustrine.	Terric Fibric Misesol soils developed in the partially decomposed remains feather and sphagnum mosses and Rego Gleysol soils developed in massive, gray, clay loam and silty clay loam glaciolacustrine sediments.	Undulating Glaciolacustrine plain, (0.5 - 2% slope).
L4	Orthic and Gleyed Gray Luviscl soils developed in massive, gray clay loam and silty clay loam glaciolacustrine.	Degraded and Gleyed Degraded Dystric Brunisol soils developed in a veneer of loose, light yellowish brown glaciofluvial sand over massive, gray clay loam and silty clay loam lacustrine sediments.	Glaciofluvial veneer over undulating Glaciolacustrine plain, (0.5 - 5% slope).
L5	Orthic and Gleyed Gray Luvisol soils developed in massive light reddish brown clay loam glacio-lacustrine sediments.		Undulating Glaciolacustrine plain, (0.5 - 5% slope).
L6	Orthic and Gleyed Gray Luvisol soils developed in massive light reddish brown clay loam glacio-lacustrine sediments.	Rego and peaty Rego Gleysol soils developed in massive, light reddish brown clay loam glaciolacustrine sediments.	Undulating Glaciolacustrine plain, (0.5 - 5% slope).
L7	Orthic and Gleyed Gray Luvisol soils developed in massive light reddish brown clay loam glacio-lacustrine sediments.	Degraded and Gleyed Degraded Dystric Brunisol soils developed in a veneer of loose, light yellowish brown glaciofluvial sand over massive, light reddish brown clay loam glaciolacustrine sediments.	Glaciofluvial veneer over undulating Glaciolacustrine plain, (0.5 - 4% slope).
L8	Orthic and Gleyed Gray Luvisol soils developed in platy, brown, sandy clay loam till.		Undulating Morainal plain (2 - 5% slope).
L9	Orthic and Gleyed Gray Luvisol soils developed in platy, brown, sandy clay loam till.	Degraded and Gleyed Degraded Dystric Brunisol soils developed in a veneer of loose, light yellowish brown glacio-fluvial sand over platy, brown, sandy clay loam till.	A partial glaciofluvial veneer over undulating morainal plain, (2 - 5% slope).
L10	Orthic and Gleyed Gray Luvisol soils developed in massive, gray brown, clay loam till.		Rolling Morainal plain (2 - 5% slope).
L11	Orthic and Gleyed Gray Luvisol soils developed in massive, gray brown, clay loam till.	Terric Fibric Mesisol soils developed in the partially decomposed remains of feather and sphagnum mosses.	Undulating Morainal plain (0.5 - 5% slope).

Figure 3. Continued

Map Symbol	Dominant Soil(s)	Subdominant Soil(s)	Landscape
M1	Terric Fibric Mesisol soils developed in the partially decomposed remains of feather and sphagnum mosses.		Flat bogs. (0 - 0.5%).
M2	Terric Fibric Mesisol soils developed in the partially decomposed remains of feather and sphagnum mosses.	Rego and peaty Rego Gleysol soils developed in massive clay loam glacio-lacustrine sediments.	Flat bogs within level Glaciolacustrine plain, (0 - 0.5% slope).
M3	Terric Fibric Mesisol soils developed in the partially decomposed remains of feather and sphagnum mosses.	Rego and peaty Rego Gleysol soils developed in loose glacioflucial sand.	Flat bogs within level Glaciofluvial plain. (0 - 0.5% slope).
M4	Terric Fibric Mesisol soils developed in the partially decomposed remains of feather and sphagnum mosses.	Degraded and Gleyed Degraded Dystric Brunisol soils developed in loose, light yellowish brown glaciofluvial sand.	Flat bogs within undulating Glaciofluvial plain, (0 - 4% slopes)
R1	Gleyed Cumulic Regosol soils developed in gray, multilayered fluvial sediments of varying texture.	Rego Gleysol soils developed in gray multilayered fluvial sediments of varying texture.	Level Fluvial terraces, (0 - 2% slope).
X1	Rough broken and eroded land adjacent to major river courses.		Steeply inclined. Undifferentiated slopes.

organic surface layer consisting of the remains of leaves, shrubs, and mosses which is underlain by brownish coloured mineral soil. The brown colour becomes lighter with depth until the yellowish brown colour of the relatively unaltered parent material is reached generally at a depth of 25 inches. These soils are generally 100% base saturated and have a near neutral pH.

Degraded Dystric Brunisol Soils (Map Units B2 to B8):

Soils of this SUBGROUP are well drained and have developed in acidic, coarse textured, glaciofluvial and eolian materials in the Fort McMurray Region. These soils are characterized by and organic surface layer consisting of the remains of leaves, shrubs and mosses which is underlain by a thin, light gray coloured layer of mineral soil. The light colour is the result of leaching by percolating rainwater. A bright brown subsurface layer is below this leached layer and the brown colour grades into yellowish brown parent material with depth. These soils are not base saturated and generally have a pH lower than 5.7.

Imperfectly drained Gleyed Degraded Dystric Brunisol Soils occur in association with the well drained Degraded Dystric Brunisol soils. The imperfectly drained soils are generally found in lower slope positions where the soil is saturated with water due to seasonal high water table or groundwater discharge. The profiles of the imperfectly drained soils show mottling throughout the solum.

Rego Gleysol Soils (Map Units G1 to G5):

Rego Gleysol soils are poorly drained, being saturated with water and under reducing conditions continuously or during a major portion of the year. They are found throughout the region in areas of high water table or where surface water accumulates. These soils have minimal soil profile development and are characterized by dark coloured surface layers of organic rich mineral soil underlain by dull coloured and mottled parent materials. The peaty Rego Gleysol soils are similar to the above but have organic layers of sphagnum and feather mosses on their surfaces, 6 to 20 inches thick.

Orthic Gray Luvisol Soils (Map Units L1 to L11):

These soils are well to moderately well drained and have developed in till and glaciolacustrine sediments in the Fort McMurray region. This type of soil is recognized by a thin organic surface layer of the remains of leaves, shrubs and mosses which is underlain by a light coloured leached mineral soil layer. This light coloured layer from which clay and soluable materials have been removed has platy structures and soft consistency. It is underlain by a darker coloured subsurface layer in which the translocated materials have been deposited imparting to this layer a higher clay content than is found in the rest of the soil profile. This layer of accumulation is underlain by a lighter coloured, relatively deep transitional layer between the layer above and the relatively unaltered parent material below. This transitional layer resembles the parent material in colour and texture but has been somewhat leached of soluable materials imparting to it a slightly lower pH than the parent material. The total depth of solum (the upper part of the profile above the parent material) is generally 30 to 40 inches.

Imperfectly drained Gleyed Orthic Gray Luvisol soils found in association with the better drained soils. The imperfectly drained soils contain mottles throughout the profile and are found in lower slope positions in the landscape.

Terric Fibric Mesisol Soils (Map Units M1 to M4):

Portions of the landscape which are very poorly drained due to high water tables or the collection and ponding of surface runoff commonly develop thick peaty surface layers. Where the organic accumulation exceeds 20 inches the soils are classified in the Organic order rather than the Gleysolic order. In the Fort McMurray region the depth of the peaty surface layers is quite variable and in many areas soils in these two orders occur in close association (Map Units M2, M3, G2, G3, G4).

Terric Fibric Mesisol soils are characterized by surface layers of generally raw peat composed mainly of feather and sphagnum mosses. The lower materials are generally more decomposed than the surface material. In the Fort McMurray region the organic soils are shallow with mineral substrate commonly found at depths of 30 to 48 inches.

Gleyed Cumulic Regosol Soils (Map Unit R1):

The Gleyed Cumulic Regosol soils are imperfectly drained and have developed in the multilayered fluvial sediments of the Clearwater, Horse and Hangingstone Rivers' Floodplains. These soils are characterized by dark coloured surface layers of mineral soil, rich in organic matter, underlain by relatively unaltered, mottled, parent material. The organic matter content usually decreases irregularly with depth due to the frequent burying of previous surface layers by subsequent flooding.

SOIL PROPERTIES AND THEIR RELATION TO AGRICULTURAL AND URBAN DEVELOPMENT[1]

The soil members of each map unit reflect the combined effects of climate, native vegetation, drainage, texture, and nature of underlying unconforming layers and time. Within a particular climatic area texture and composition of the parent material, drainage, slope, and time are the dominant factors in soil development. Soil characteristics such as permeability, structure, consistence, and colour are dependant upon these dominant factors. The basic properties used to define soils in a natural classification system in soil surveys can also be used to evaluate soils for different uses. The degree to which a given soil characteristic or quality affects the suitability of that soil for a given use often varies with different uses. The following are some of the soil characteristics which singly or in combination affect the suitability of the soils in the Fort McMurray region and urban development.

Texture:

This basic property of soils refers to the proportion of the three main particle size categories in a soil. The categories are sand (2-.05 mm), silt (.05-.002 mm) and clay (smaller than .002 mm). Of the three main textural classifications commonly used in North America, the system used by agriculturalists and soil scientists is used to describe soil texture in this report. This system adopted by the Canada Soil Survey Committee (CSSC, formerly the National Soil Survey Committee of Canada, NSSCC), is similar to that developed by the United States Department of Agriculture (USDA).

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[1]Much of this discussion taken from "Soils of the Onanole Area and their Relation to Urban Development." 1968. Manitoba Soil Survey (8).

Figure 4 compares the CSSC system ot the Unified System used by civil engineers and the A.A.S.H.O. system of the American Association of State Highway Officials. Variations in class limits exist for the three main categories but these differences are slight. In the CSSC system the textural name applied to a soil is based on the proportions of sand, silt, and clay size particles present (Figure 5). The sands loamy sands, and sandy loams are referred to as coarse textured soils, the medium textured soils being the silts, silt loams, loams, sandy clay loams, clay loams, and silty clay loams, and the fine textured group are the silty clays, sandy clays, clays, and heavy clays. An indication of the affect of texture on other soil properties is shown in Table 2.

Table 2. Effect of Texture on Soil Characteristics*

Soil Characteristics	Soil Texture	
	Coarse	Fine
Water holding capacity	Low	High
Permeability (or drainability)	High	Low
Total pore space	Low	High
Size of pores (dominant)	Large	Small
Tendency to shrink and swell	Low	High
Bearing strength (dry)	High	High
Bearing strength (wet)	High	Low
Stability from sliding on slopes	High	Low
Erodability by water	Low	High
Soil fertility	Low	High

Agriculturalists are concerned with texture as it affect natural fertility, waterholding capacity, drainage, and ease of tillage, while engineers and builders are concerned with texture as it affects drainage, stability, ease of excavation, erodibility and trafficability.

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* Source: L.D. Hanson et al. Soils of the Twin Cities Metropolitan Area and Their Relation to Urban Development, 1966, pp. 6 (6).

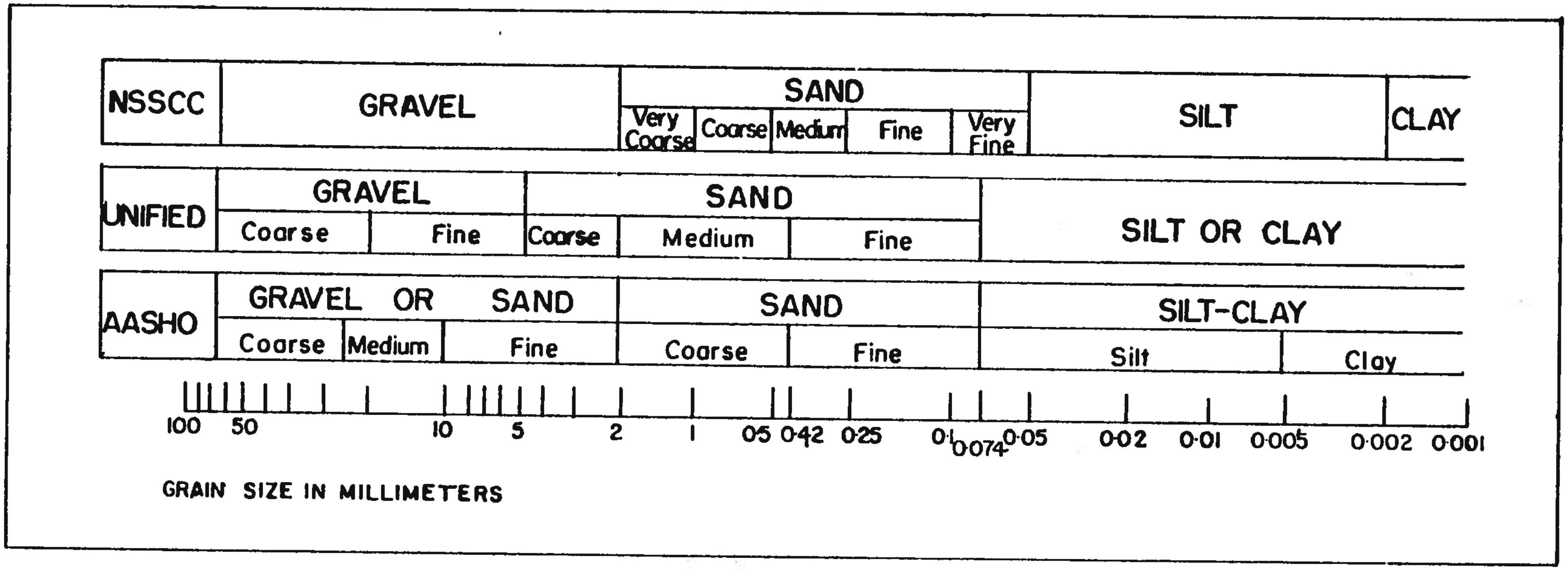

Figure 4. Comparison of particle size for the NSSCC, Unified and AASHO systems of textural classification. (Modified after Michalyna, Smith and Hopkins. 1968.)

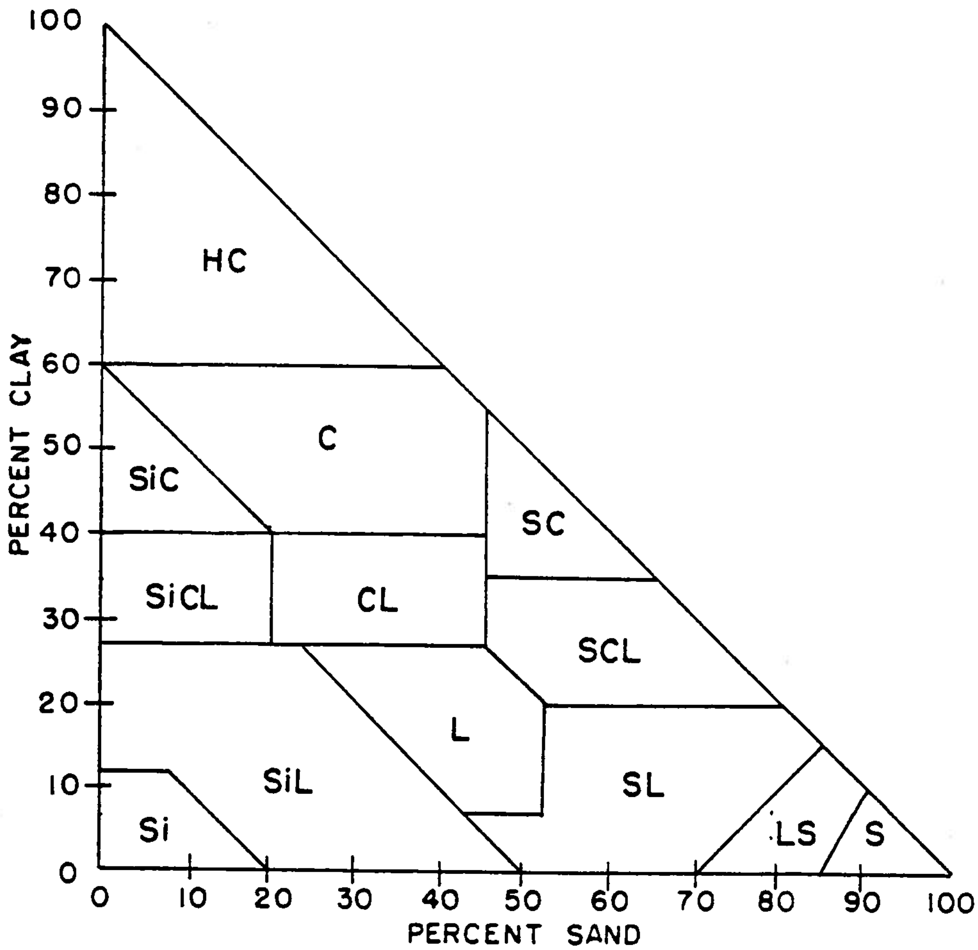

Figure 5. Soil textural triangle adopted by CSSC.

In the Fort McMurray region as generally elsewhere the silt loam and loam textured soils are best suited for agricultural development (Map Units B1, R1). In this region their suitability for agriculture arises not only from their textural characteristics but also from their landscape position within the Clearwater and Athabasca River vallies where the climate is more moderate and the frost free period reportedly longer.

Finer textured soils tend to be less permeable and become very sticky when wet and very hard when dry, thereby reducing their ease of tillage. The low permeability also reduces the suitability of fine textured soils for on-site sewage disposal systems.

On the other hand, the sandy soils have low water holding capacity and low natural fertility, which reduce their agricultural potential. The occurrence of unconforming textural layers in a soil affects water movement. When fine textured material overlies coarse textured material (clay over clay) water moves rapidly down through the soil until it reaches the fine textured material where it is impeded by the very low permeability of the finer textured material. Soils with unconfroming layers are not well suited for urban development where on-site sewage disposal systems are being considered. Also, the presence of unconforming layers impeding soil drainage limits the suitability of the soil for agricultural use in moist climates although in drier climates they may be desirable.

<u>Permeability</u>:

This term quantitatively describes the rate at which water moves vertically down through the soil. Coarse textured soils have relatively high rates while fine textured soils with massive structure have lower rates. Permeability is measured using percolation tests. Although no tests were conducted in the Fort McMurray Region there are general values for percolation rates for well drained soils of various textures (2) (Table 3).

TABLE 3. Percolation Rates of Soils in Drained Condition*

Soil Type	Percolation rates minutes/inch
Sandy and gravelly soils	less than 10
Loamy sand soils	11-30
Loam to sandy loam soils	31-60
Clay loam to silty clay loam soils	61-90
Silty clay to clay soils	more than 90

A percolation rate of from 30 to 90 minutes per inch is best for on-site sewage disposal systems (7). Although high percolation rates are desirable for some urban development they limit the soils use for agricultural development due to their low water holding capacity. On the other hand soils with very low percolation rates tend to be poorly drained which also limits agricultural development. Rates of 30 to 90 minutes per inch are considered good for agricultural soils.

Colour:

The colour and depth of the surface layer is important in soils to be used for agriculture. Deep, dark coloured surface soils indicate relatively high amounts of organic matter which contribute

* Source: L.J. Bartelli "Use of Soils Information in Urban Fringe Areas" Journal of Soil And Water Conservation 17"3, May-June, 1962, pp. 99-103 (2).

to fertility and good tilth. In the Fort McMurray Region there are few soils with deep, dark coloured surface layers. Subsurface colours are used as indicators of internal soil drainage. Poorly drained soils exhibit mottles and duller colours than well drained soils. Colours are often more reliable than the particular moisture condition at the time of examining the soil in determining natural internal soil drainage.

Structure:

Soil structure refers to the arrangement or combination of the primary soil particles of sand, silt, and clay into compound particles or clusters of primary particles. Structure affect permeability and internal drainage as well as the rooting ability of agricultural crops. Various types of structure are usually found within any one soil profile. Soils with good discernible structure usually have good permeability. Soils without structure may be rapidly permeable if coarse grained (sand, gravel) of very slowly permeable if massive and fine grained (clay).

Hydrologic Features:

This refers to the soil's position with respect to surface and subsurface water. Lowlying flood plain areas such as are found along the Clearwater River are subject to flooding and individual sewage disposal systems in such areas are undesirable. However, the chance of flooding is not as serious a limitation with respect to agricultural use in these areas although it remains a limitation. In areas of smooth undulating topography and fine textured soils, surface water collects in slight depressions and in the Fort McMurray area such depressions usually contain organic soils. In the level to slightly undulating areas in the vicinity of Fort McMurray the water table is generally close to the surface and since internal soil drainage is poor water tends to collect on the surface. These areas are unsuitable for on-site sewage disposal systems and have low suitability for agricultural development.

Chemical Properties:

Chemical properties such as pH and electrical conductivity are important for predicting the corrosive properties of soil. Underground steel conduits and pipes tend to corrode if soils have low pH values, relatively high electrical conductivity and poor internal drainage. Soils containing soluble sulphate salts in large quantities in solution can cause severe deterioration of concrete. Their presence can be detected in some cases by measuring the electrical "conductivity" or "resistivity" of the soil. Soils with a conductivity greater than 4 mmhos are considered to have significant amounts of soluble salts. The soils in the Fort McMurray Region should not present a problem with the respect to the corrosion of steel conduit, pipes and concrete since their content of soluble salts is very low. However, most of the better drained soils have a moderately low solum pH (5.4-6.4), which may be an inhibiting factor in the use of these soils for agricultural development (Appendix II).

Shrink-Swell Potential:

Volume changes associated with swelling and shrinking can cause considerable stress to structures, especially to walls and foundations of houses, and to roads in areas where large moisture variations occur in soils. Swelling pressures can be large, as high as 10 tons per square foot for some clays (5). The more important factors influencing swell potential of soils are moisture variation, density, structure and mineralogic composition. The volume of coarse grained soils is usually not affect by changes in moisture content. Fine grained soils with a high percentage of montmorillonitic clays, such as those found in the claying lacustrine deposits of the Fort McMurray area, are most susceptible while silty medium textured soils may be moderately susceptible. Shrink-swell potential is relatively unimportant to the potential agricultural development in this region.

Topography or Slope:

Topography or slope of the land is important to agricultural and urban development. Slow surface drainage associated with level topography may result in high water table, a limitation to both uses. Steeply sloping areas as are found along the major rivers in the Fort McMurray Region have very high rates of surface runoff and are susceptible to extensive erosion and groundwater seepage. Such areas have no potential for agricultural development and their unstable slopes present serious engineering problems.

SOIL DRAINAGE

Soil drainage classes are defined in terms of actual moisture content in excess of field capacity and the extent of the period during which such excess water is present in the plant-root zone (10). The soil moisture status is affected by permeability, level of groundwater and seepage. However, because these are not easily observed or measured in the field they cannot be used generally as criteria of moisture status. The soil moisture status is usually reflected by soil profile morphology (i.e. soil colour; size, abundance and profile position of mottles) although topographic position and natural vegetation are useful indicators as well.

The soil map units have been grouped into four drainage classes (Figure 6) regardless of soil parent materials. Certain relationships exist however between soil drainage and soil parent materials. The coarse textured sands found north of the Clearwater River are generally well drained whereas the fine textured lacustrine materials south of Fort McMurray are generally imperfectly or poorly drained. No well drained soils are found in areas of lacustrine material as the permeability of this material is low. The best drainage class for these materials is moderately well drained. The rough broken areas, characterized by very steep unstable slopes, are rapidly drained, although there are some areas of groundwater seepage on these slopes.

Figure 6. Soil Drainage Classes

Map Symbol	Drainage Class
R	Rapidly drained soils in which soil moisture seldom exceeds field capacity in any horizon except immediately after water additions; very steep slopes.
W	Well drained soils in which soil moisture content does not normally exceed field capacity in any horizon for a significant part of the year; in this area soils found in sandy materials.
I	Moderately well and imperfectly drained soils in which soil moisture content in excess of field capacity remains from a small but significant period to moderately long periods during the year; in this area soils found in glacio-lacustrine and till deposits.
P	Poorly and very poorly drained soils in which soil moisture content in excess of field capacity remains in all horizons for most of the year (mineral soils) to areas where free water remains at or within 30 cm of the surface for most of the year (organic soils)

Convention: The small arabic number as a superscript after the drainage class indicates the approximate proportion of that class out of 10.

Example. P^6 W^4 - 60% poorly to very poorly drained.
40% well drained.

SOIL CAPABILITY CLASSIFICATION FOR AGRICULTURE

This system of classification is an interpretative classification based on the data collected during the Soil Survey of an area. There are seven different classes into which the mineral soils are grouped according to their potentialitites and limitations for agricultural use. Classes 1, 2, and 3 are considered capable of sustained production of common cultivated drops, Class 4 is marginal for this purpose, Class 5 is capable of use only for permanent pasture and hay, Class 6 is capable of use only for wild pasture, and Class 7 is for soils and land types considered incapable of use for arable culture or permanent pasture. The soils placed into each Class have the same relative degree of limitation or hazard while subclasses are used to denote the kind of limitation (10).

The major factor limiting the suitability of land in the Fort McMurray Region for agricultural development is climate. Therefore, when soil factors are considered as well, the resulting total limitations are severe. For this reason there are no Class 1, 2, or 3 areas in the Fort McMurray Region (Figure 7).

Approximately 3,350 acres have been classified as Class 4. Class 4 land occupies 60% of the alluvial areas along the Clearwater River and Athabasca River in the vicinity of Fort McMurray. Limitations in these areas, apart from climate, chance if inundation by a flooding Clearwater River (I), restricted depth of rooting caused by poor soil structure (D), or adverse soil characteristics (S) such as frequent textural changes with depth of soil. Agricultural development in these Class 4 areas will require the removal of dense forest stands.

Figure 7. Soil Capability Classification for Agriculture

Capability Class	Description
Class 4	Soils in this class have severe limitations that restrict the range of crops or require special conservation practices, or both.
Class 5	Soils in this class have very severe limitations that restrict their capability to producing perennial forage crops, and improvement practices are feasible.
Class 6	Soils in this class are capable only of producing perennial forage crops and improvement practices are not feasible.
Class 7	Soils in this class have no capability for arable culture or permanent pasture.
Class 0	Organic soils (not placed in capability classes).

Capability Subclass	Description
D	Undesirable soil structure or low permeability, or both.
F	Low natural fertility.
I	Inundation by streams or lakes limites agricultural use.
M	Moisture limitation due to low water holding capacity.
P	Stoniness limits tillage, planting and harvesting.
S	Adverse soil characteristics.
T	Adverse topography either by steepness or pattern of slopes.
W	Excess water, other than that from inundation, limit agricultural use (poor drainage, high water table, seepage, or runoff).

Conventions: Large arabic numerals denote capability classes; letters placed after the class denote subclasses. Small arabic numerals placed as a superscript after class numeral give the approximate proportion of that class out of 10.

The major proportion of the area (38% or 70,933 acres) has been classified as Class 5 due to adverse climate as well as poor soil structure which would restrict rooting (D) and inadequate soil drainage (W). Those areas classified as 5 D are generally areas of Gray Luvisol soils developed in lacustrine clays or clay loam till. When disturbed the light coloured, leached surface layer usually puddles and becomes very hard, restricting the emergence of new plants. This limitation can be overcome by the addition of high amounts of organic matter (manure). The limitation of wetness could be partially ameliorated by artificial drainage using deep ditches but at best, areas of Class 5 land are only suitable for the production of perennial forage crops.

Most of the glaciofluvial sandy areas have been classified as Class 6 (11,890 acres) due to low natural fertility (F), low water holding capacity (M) in some areas, or inadequate soil drainage (W) in others. In some cases there is a severe limitation due to an abundance of stones on the surface as well as in the soil mass (P). Soils in Class 6 have some natural grazing capacity but have such severe limitations as to make the application of improvement practices impractical. Both Class 5 and Class 6 lands contain numerous areas of organic soils which further restrict the use of these lands for agricultural development.

Class 7 soils have such severe limitations that they are not capable of use for agriculture although they may or may not have a high capability for trees, wildlife, or recreation. Class 7 areas in the Fort McMurray Region, (27,110 acres) consist of steeply sloping, unstable cliffs along the major streams and rivers in the region.

Organic soils have not been included in this classification but are simply designated by the letter O alone on the accompanying map. They occupy approximately 39,350 acres in the Region.

SOIL SUITABILITY FOR URBAN DEVELOPMENT

The soil map data has been interpreted in terms of the suitability of soils for urban development in general and selected non-agricultural uses in particular (Table 4). For these interpretations site data were extrapolated to an entire map unit using the guidelines defined in Tables 5 to 8. The interpretations are not intended to be site specific and do not substitute for on-site inspection and soil testing. They do however, provide a basis for area planning and further soil investigations.

The soil map units have been evaluated for limitations to buildings, roads, and sewage lagoons and for suitability as sources of topsoil. These evaluations should be considered as evaluations of performance not as recommendations for use of soils. The evaluations rate the map units for each use in terms of degree of limitation (slight, moderate or severe) or in terms of suitability as a source of topsoil (good, fair or poor).

A slight limitation is given if soil properties are favourable for the use. A moderate limitation is the rating given if soil properties are moderately favourable for use. This degree of limitation can be overcome or modified by planning, design or maintenance. A severe limitation is the rating given if there is one or more soil property that is seriously unfavourable for the use. This limitation generally requires major soil reclamation, special design or intensive maintenance.

Table 4. Map unit ratings for selected non-agricultural uses. (S-slight, M-moderate, V-severe, G-good, F-fair, P-poor.)

Map Unit	Degree of Limitation for:			Suitability as:
	Buildings	Roads	Sewage Lagoons	Source of Topsoil
B1	M7*	M7,11	M7,5	F - P
B2	S	S	V4,5,11	P
B3,B4	S	M11	V4,5,11	P
B5	M12	M11,12	V4,5,11	P
B6	M3	M3	M4,5	P
B7	M3	M3,11	M4,5,11	P
B8	S	S	M4,5,11	P
G1,G2	V8	V8,11	V8,5	P
G3,G4	"	"	"	"
G5	"	"	"	"
L1,L5	M1,2	M1	S	P
L10	"	"	"	"
L2,L3	M1,2	M1,11	S	P
L6,L11	"	"	"	"
L4,L7	M1,3	M1,3	M3,5	P
L8	S	S	S	P
L9	S	M11	S	P
M1,M2	V8,9	V8,9,11	V8,9,5	P
M3,M4	"	"	"	"
R1	V6,8	V11,6	V5,6	F
X1	V10	V10	V10	P

* Limiting soil properties and hazards

1. high clay content
2. slow permeability
3. textural unconformity
4. rapid permeability
5. groundwater contamination hazard
6. flooding hazard
7. shallow depth to bedrock
8. seasonally high water table
9. organic soils
10. excessive slope
11. high proportion of poorly drained soi
12. wind erosion hazard.

Table 5. Guides for assessing soil limitations for permanent buildings

This guide provides ratings for undisturbed soils evaluated for single storey buildings and other structures with similar foundation requirements. By reducing slope limits by ½ this table can be used for evaluating soil limitations for buildings with larger floor areas but with foundation requirements not exceeding those of ordinary 3-storey dwellings. The emphasis for rating soils for buildings is on foundations, but soil slope, susceptibility to flooding and seasonal wetness that have effects beyond those related exclusively to foundations are considered. Also considered are soil properties such as depth to bedrock which influence excavation and construction costs, both for the building itself and for the installation of utility lines. Excluded are limitations for soil corrosivity, landscaping and septic tank absorption field. On-site investigations are required for specific placement of buildings and utility lines and for detailed design of foundations. Ratings are based on observations to a depth of 4 to 6 feet.

Soil Factors	Degree of Limitation		
	Slight	Moderate	Severe
1. Drainage	rapidly and well drained	With basements: moderately well drained	imperfectly, poorly and very poorly drained
	rapidly, well and moderately well drained	Without basements: imperfectly drained	poorly and very poorly drained
2. Depth to seasonal water table (seasonal= 1 month or more)	below 60 inches	With basements: below 30 inches	above 30 inches
		Without basements: below 30 inches	above 20 inches
3. Depth to bedrock	greater than 60 inches	with basements: 40 to 60 inches	less than 40 inches

Table 5. continued

3.	Depth to Bedrock	greater than 40 inches	Without basements: 20 to 40 inches	less than 20 inches
4.	Flooding	none	none	more than 15%
6.	Shrink-swell potential*	low (PI less than 15)**	moderate (PI 10 to 35)	high (PI greater than 20)
7.	Unified soil group+	GW,GP,SW,SP, GM,GC,SM,SC	ML,CL	CH,MH,OL,OH, Pt
8.	Stoniness	Stones more than 25 ft apart	Stones 5 to 25 ft apart	Stones less than 5 ft apart
9.	Potential frost action++	Low (F1,F2)	moderate (F3)	high (F4)
10.	Consolidated bedrock exposures	Rock exposures more than 300 ft apart, cover less than 2% of surface	Rock exposures 300 to 100 ft apart, cover 2 to 10% of surface	Rock exposures less than 100 ft apart, cover more than 10% of surface

* Limits after "Soil Mechanics in Engineering Practice", Terazghi and Peck, 1967. J. Wiley & Sons, New York.
** PI = plasticity Index
\+ Estimation of soil strength ie: its ability to withstand applied loads.
++ Only applies where frost penetrates to the assumed depth of footings and soil is moist. Class taken from "Pavement design for frost conditions", U. S. Army Corps of Engineers, 1962. E. M. 1110-1-306, pp 5-8.

Table 6. Guides for assessing soil limitations for road location.

Properties that affect design and construction of roads are:
1. those that affect the load supporting capacity and stability of subgrades.
2. those that affect the workability and amount of cut and fill.
The ASSHO and Unified Classification, and the shrink-swell potential give an indication of the traffic supporting capacity. Wetness and flooding affect stability. Slope, depth of bedrock, stoniness, rockiness and wetness affect ease of excavation and the amount of cut and fill to reach an even grade. Soil ratings do not substitute for basic soil data from on-site investigations.

Soil Factors	Degree of Limitation		
	Slight	Moderate	Severe
1. Drainage	rapidly, well and moderately well drained	imperfectly drained	poorly and very poorly drained
2. Depth to bedrock	greater than 40 inches	20 to 40 inches	less than 20 inches
3. Flooding	none	once in 5 years	more than once in 5 years
4. Slopes	0 to 9%	9 to 15%	greater than 15%
5. Shrink-swell potential*	low (PI less than 15)**	moderate (PI 10 to 15)	high (PI greater than 20)

Table 6. continued

6.	Subgrade + a) AASHO Group Index b) Unified soil class	0 to 4 GW,GP,SW,GM SM,GC,SC	5 to 8 CL (PI less than 15),ML,SP	greater than 8 CL (PI=15 or greater) CH,MH,OH,OL,Pt
7.	Stoniness	stones more than 5 ft apart	stones 2 to 5 ft apart	stones less than 2 ft apart
8.	Suscepti-bility to frost heave++	low (FI,F2)	moderate (F3)	high (F4) (silty and peaty soils)
9.	Consolidated bedrock exposures	rock exposures more than 300 ft apart, cover less than 2% of surface	rock exposures 300 to 200 ft apart, cover 2 to 10% of surface	rock exposures less than 100 ft apart, cover more than 10% of surface

* Limits after Terzaghi and Peck, 1967. Soil Mechanics in Engineering Practice. J. Wiley and Sons, New York.

** PI = Plasticity Index.

\+ Estimation of strength of soil as it applies to roadbeds.

++ Frost heave is important where frost penetrates below the hardened surface layer and moisture transportable by capillary movement is sufficient to form ice lenses at the freezing front. Classes after U. S. Army Corps of Engineers, 1962, "Pavement Design for Frost Conditions." E. M. 1110-1-306, pp 5-8.

Table 7. Guides for assessing soil limitations for sewage lagoons.

A sewage lagoon (aerobic) is defined as a shallow lake used to hold sewage for the time required for bacterial decomposition. Soils have two functions (1) as an impoinding vessel and (2) as material for the impounding embankment. When the lagoon is properly constructed it must be capable of holding water with minimum seepage.

Soil Factor	Degree of Limitation		
	Slight	Moderate	Severe
1. Depth water table*	greater than 60 inches	40 to 60 inches	less than 40 inches
2. Depth to bedrock	greater than 60 inches	40 to 60 inches	less than 40 inches
3. Flooding**	none	none	subject to flooding
4. Slope	less than 2%	2 - 9%	greater than 9%
5. Unified Soil Group +	GC,SC, CL,CH,	GM,ML, SM,MH	GP,GW,SW,SP, OL,OH,Pt
6. Organic Matter	less than 2%	2 to 15%	more than 15%

* If the lagoon floor is of relatively impermeable material at least 2 feet thick, disregard depth to watertable.

** Disregard flooding if it is unlikely to enter or damage lagoon (low velocity and depth less than 5 feet).

\+ Rated mainly for the floor of the lagoon.

Table 8 Suitability ratings of soils as sources of topsoil.

Topsoil, for these ratings, refers essentially to Ah horizon material although in some cases B and C horizon materials could be used for dressing disturbed land. These ratings are based on the quality of topsoil and ease of excavation.

Soil Factors	Degree of Limitation		
	Good	Fair	Poor
1. Texture	SL,FSL, VFSL,L,Sil	CL,SCL, SiCL	LS,S,SC,SiC, C, Organic
2. Depth of topsoil	greater than 6 inches	3 to 6 inches	less than 3 inches
3. Flooding	none	occasionally	frequently or constantly
4. Wetness	Better than poorly drained Drainage class not determining		poorly and very poorly drained
5. Slope	less than 9%	9 - 15%	greater than 15%
6. Stoniness	slightly stony	moderately stony	excessively stony
7. Coarse fragments (% by volume)	less than 3%	3 to 15%	greater than 15%

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APPENDIX I

Profile Descriptions of Representative Soils, Fort McMurray Region

1. Orthic Gray Luvisol Profiles Developed in:

	Horizon	Depth (in)	Description
(a) clay loam till			
	L-H	2-0	Black (10YR 2/1) organic mat composed of plant remains of deciduous leaves, shrubs and mosses.
	Ae	0-2	Pale brown (10YR 6/3) silt loam fine platy to granular; slightly hard, friable; a few stones; pH 5.4.
	ABg	2-6	Brown (10YR 5/3) clay loam; fine blocky to subangular blocky; hard; few, fine, faint, yellowish brown (10YR 5/6) mottles; many stone; pH 5.1.
	Bt	6-15	Dark Yellowish brown (10YR 4/7) silty clay; medium subangular blocky; very hard, very firm many stones; pH 5.5.
	BCg	15-35	Dark grayish brown (10YR 4/2) clay loam; massive; very hard, very firm; few, medium, faint, yellowish brown mottles; many stones; pH 6.0.
(b) sandy clay loam till	L-H	2-0	Black (10YR 2/1) organic mat of decomposed deciduous leaves, shrubs and mosses.
	Ae	0-3	Very pale brown (10YR 7/4) sandy loam; granular to weak fine platy; friable; pH 5.1.
	AB	3-7	Brown (10YR 5/3) loam; weak subangular blocky; slightly hard, firm; pH 5.3.

	Horizon	Depth	Description
	Bt	7-16	Dark brown (10YR 4/3) sandy clay loam; coarse blocky; hard, firm; pH 5.5.
	BC	16-30	Dark yellowish brown (10YR 4/4) sandy clay loam; massive; hard, firm; pH 6.1.
(c) light reddish brown lacustrine clay	L-H	2-0	Black (10YR 2/1) organic mat of decomposed deciduous leaves and mosses.
	Aeg	0-3	Light brownish gray (10YR 6/2) silt loam; fine platy; hard, friable; yellow mottles; pH 5.8.
	ABg	3-7	Pinkish gray (7.5YR 6/2) silty clay loam; medium subangular blocky; hard, firm; few, fine, faint, reddish yellow mottles; pH 5.2.
	Bt	7-16	Reddish brown (5YR 4/3) clay; medium prismatic to coarse blocky; very hard, very firm; pH 5.3.
	BCg	16-32	Light reddish brown (5YR 6/3) (moist), pinkish gray (5YR 6/2) and (7.5YR 7/2) (dry) clay; massive; very hard, very firm; a few, fine, faint, reddish yellow mottles; pH 6.1.

Horizon	Depth (in)	Description

2. Gleyed Gray Luvisol Profile Developed in gray glaciolacustrine sediments:

Horizon	Depth (in)	Description
L-H	1-0	Black (10YR 2/1) organic mat of decomposed deciduous leaves, mosses and shrubs.
Aeg	0-4	Very pale brown (10YR 7/3) silt loam; fine platy; slightly hard, friable; common, fine, faint, yellowish brown mottles; pH 5.4.
ABg	4-8	Light brown (7.5YR 6/4) silt loam; fine subangular blocky; hard, very firm; common, medium, faint, brownish yellow mottles; pH 5.1.
Btg	8-17	Brown (10YR 5/3) clay; medium blocky; very hard, very firm; common, medium, faint, brownish yellow mottles; pH 5.0.
BCg	17-31	Dark grayish brown (10YR 4/2) moist, grayish brown (10YR 5/2) dry clay; massive; very hard, very firm; common, medium, distinct, yellowish brown mottles; pH 6.2.

3. Degraded Dystric Brunisol Developed in glaciofluvial sand:

Horizon	Depth (in)	Description
L-H	2-0	Black (10YR 2/1) organic mat of coniferous leaves and decomposed mosses.
Ae	0-5	White (10YR 8/2) sand; single grain; very loose; pH 5.1; %(Fe+Al) = .08
Bm1	5-10	Strong brown (7.5YR 5/6) sand; single grain; weakly cementd; pH 5.4; %(Fe+Al) = .47

Horizon	Depth (in)	Description
Bm2	10-19	Strong brown (7.5YR) sand; single grain; weakly cemented; pH 5.6; %(Fe+Al) = .24
C	19-30	Very pale brown (10YR 7/4) and yellow (10YR 7/6) sand; single grain; loose consistency; pH 5.8; %(Fe+Al) = .12

4. Gleyed Cumulic Regosol Developed in multilayered fluvial sediments:

Horizon	Depth (in)	Description
Ah	0-5	Very dark grayish brown (10YR 3/2) sandy loam; fine granular; soft, friable; pH 6.3.
Cg	5-13	Light brownish gray (10YR 6/2) sandy loam; single grain; loose, friable; common, medium, distinct, brownish yellow mottles; pH 6.0.
IIAhbg	13-16	Dark gray (10YR 4/1) loam; weak fine granular to massive; firm, friable; common, faint, brown mottles; pH 6.1.
IICg	16-24	Grayish brown (10YR 5/2) loam; massive; firm, friable; common, distinct, brownish yellow mottles; pH 6.0.

5. Peaty Rego Gleysol Developed in gray glaciolacustrine sediments:

Horizon	Depth (in)	Description
Of	0-16	Dark brown (7.5YR 4/4) moist, reddish yellow (7.5YR 7/6) and yellow (10YR 7/6) day organic layer of undecomposed peat derived from sphagnum and feather mosses.
Cg	16-35	Grayish brown (10YR 5/2) clay; massive; very hard, very firm; common, medium distinct, yellowish brown mottles; pH 6.2.

Appendix II

Analyses of Representative Soil Profiles. Methods of analyses are standard methods used by the Alberta Soil Survey Laboratory.

			Depth		Percent			Texture	Exchangeable Cations*								
Subgroup	Material	Horizon	(in)	pH	Sand	Silt	Clay		H	Ca	Mg	Na	K	%SO_4	%OrgC	C/N	E.C.***
Orthic Gray Luvisol	clay loam till	L-H	2-0														
		Ae	0-2	5.4	23	65	12	SiL	2.5	11.4	5.9	.02	.18	.00	0.55	14	.2
		ABg	2-6	5.1	25	46	29	CL	4.1	8.9	5.0	.01	.20	.00	0.69	14	.25
		Btg	6-15	5.5	23	35	42	SiC	3.8	5.4	1.6	.01	.24	.00	0.70	18	.2
		BCg	15-35	6.0	21	41	38	CL	2.6	2.5	0.9	.01	.22	.00			.2
Gleyed Gray Luvisol	gray, glacio-lacustrine	L-H	1-0														
		Aeg	0-4	5.4	19	62	19	SiL	4.1	11.4	11.6	.26	.23	.00	0.98	14	.3
		ABg	4-8	5.1	19	60	21	SiL	4.3	5.4	11.9	.21	.27	.00	0.67	11	.3
		Btg	8-17	5.0	6	36	58	C	6.9	2.5	1.3	.04	.27	.00	0.59	12	.3
		BCg	17-31	6.2	2	26	72	C	0.6	3.0	3.7	.05	.30	.01			.7
Gleyed Gray Luvisol	reddish brown glaciolacustrine	L-H	2-0														
		Aeg	0-3	6.1	20	63	17	SiCL	1.7	12.9	8.7	.13	.08	.00	1.01	13	0.4
		ABg	3-7	5.0	12	48	40	SiCL	3.8	9.9	6.4	.10	.24	.00	0.84	11	0.3
		Btg	7-16	4.9	7	34	59	C	4.8	6.9	4.1	.01	.34	.00	0.91	15	0.25
		BCg	16-32	6.1	18	20	52	C	1.1	5.9	1.3	.01	.33	.01			0.7
Degraded Dystric Brunisol	glaciofluvial sand	L-H	2-0														
		Ae	0-5	5.1	96	4	0	S	0.8	0.0	0.1	0.0	0.1	.00	0.21	21	
		Bm1	5-10	5.4	93	7	0	S	1.4	0.0	0.1	0.0	0.1	.00	0.24	24	
		Bm2	10-19	5.6	94	6	0	S	0.8	0.0	0.7	0.0	0.1	.00	0.16	16	
		C	19-30	5.8	96	3	0	S	0.5	0.0	0.1	0.0	0.0	.00			

* - Meq/100 grams soil
** - Carbon: nitrogen ratio
*** - Electrical conductivity - mmhos

Figure 1.

FORT McMURRAY REGION

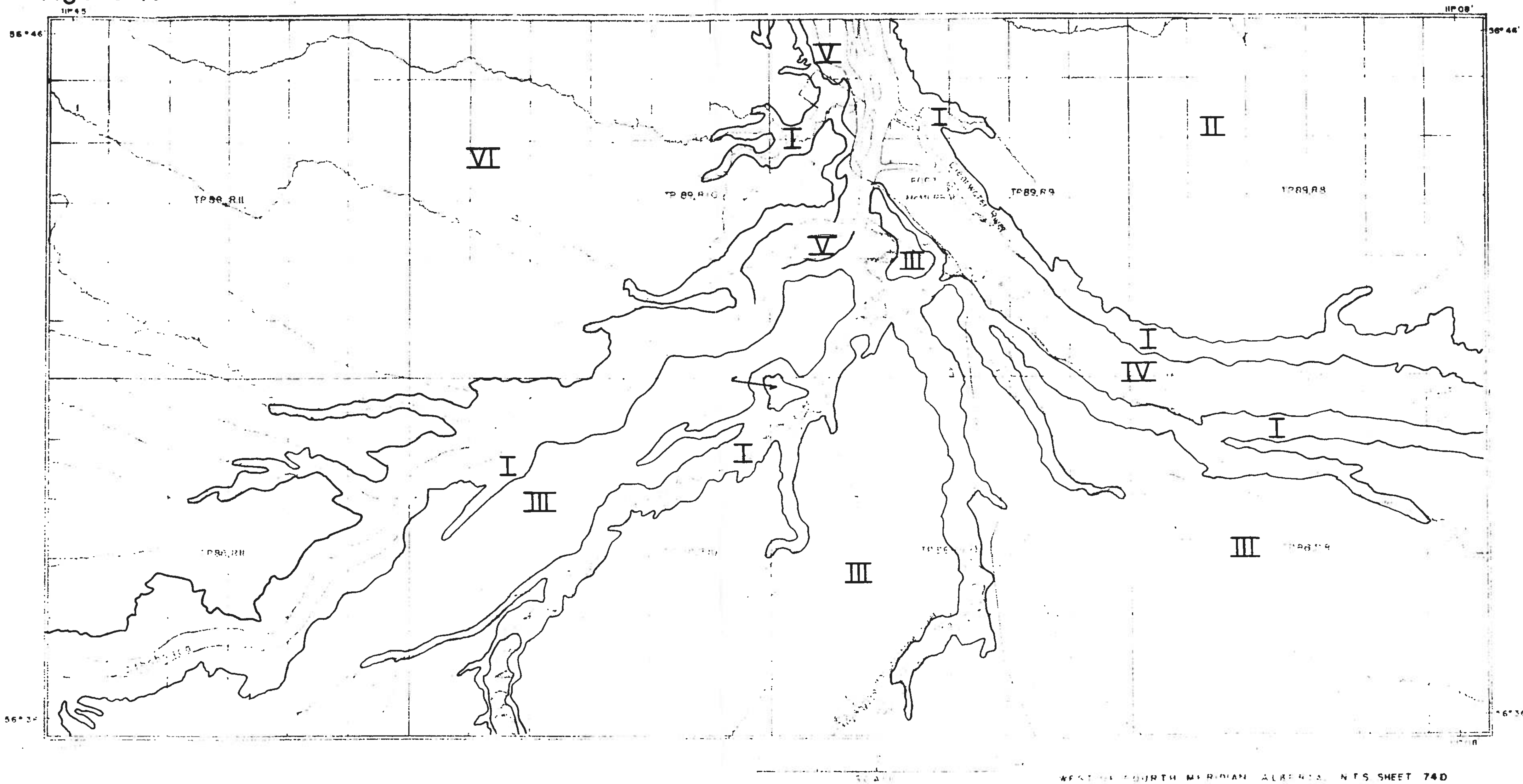
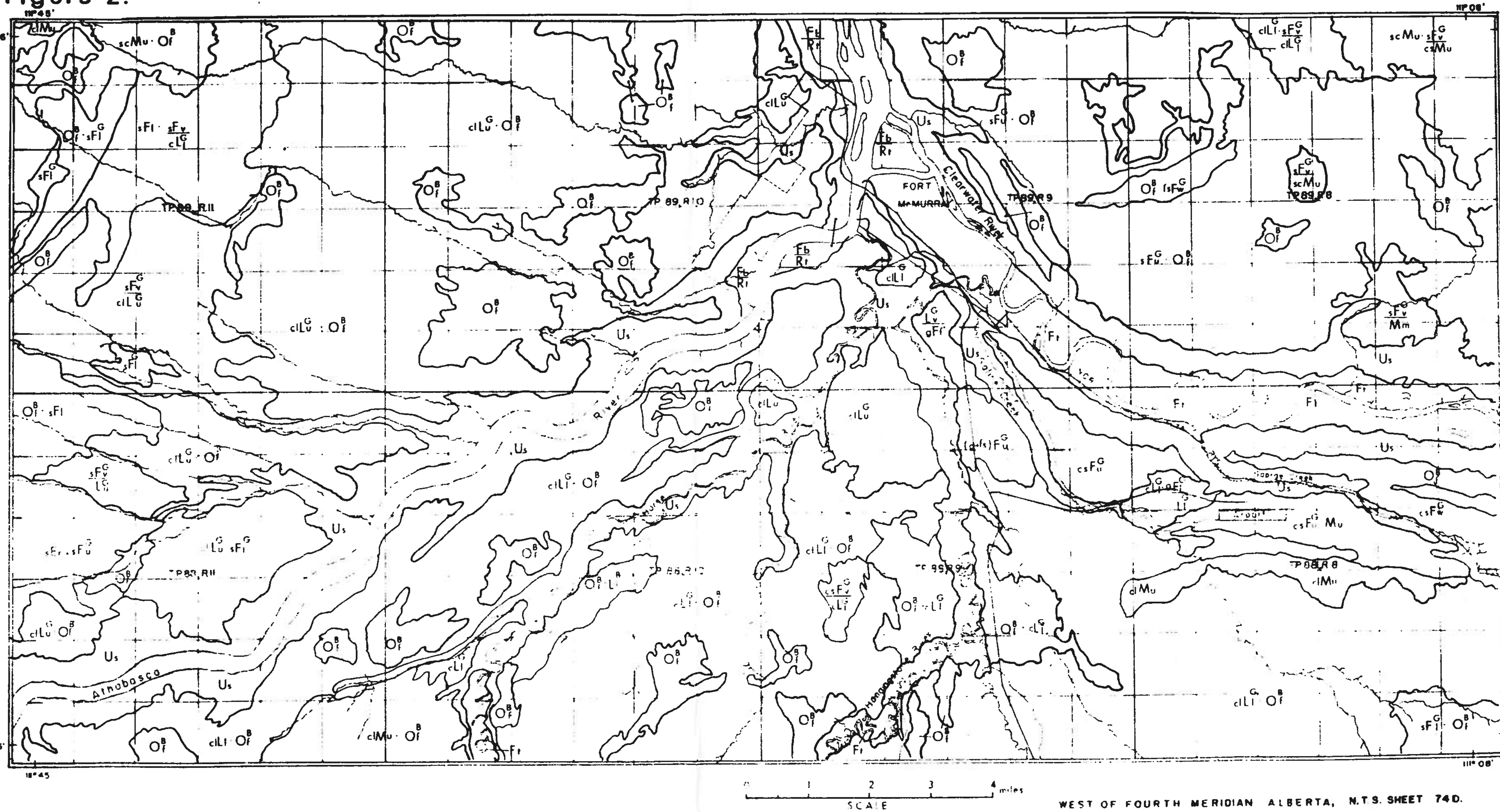


Figure 2.

FORT McMURRAY REGION



WEST OF FOURTH MERIDIAN ALBERTA, N.T.S. SHEET 74D.

Figure 3.

FORT McMURRAY REGION

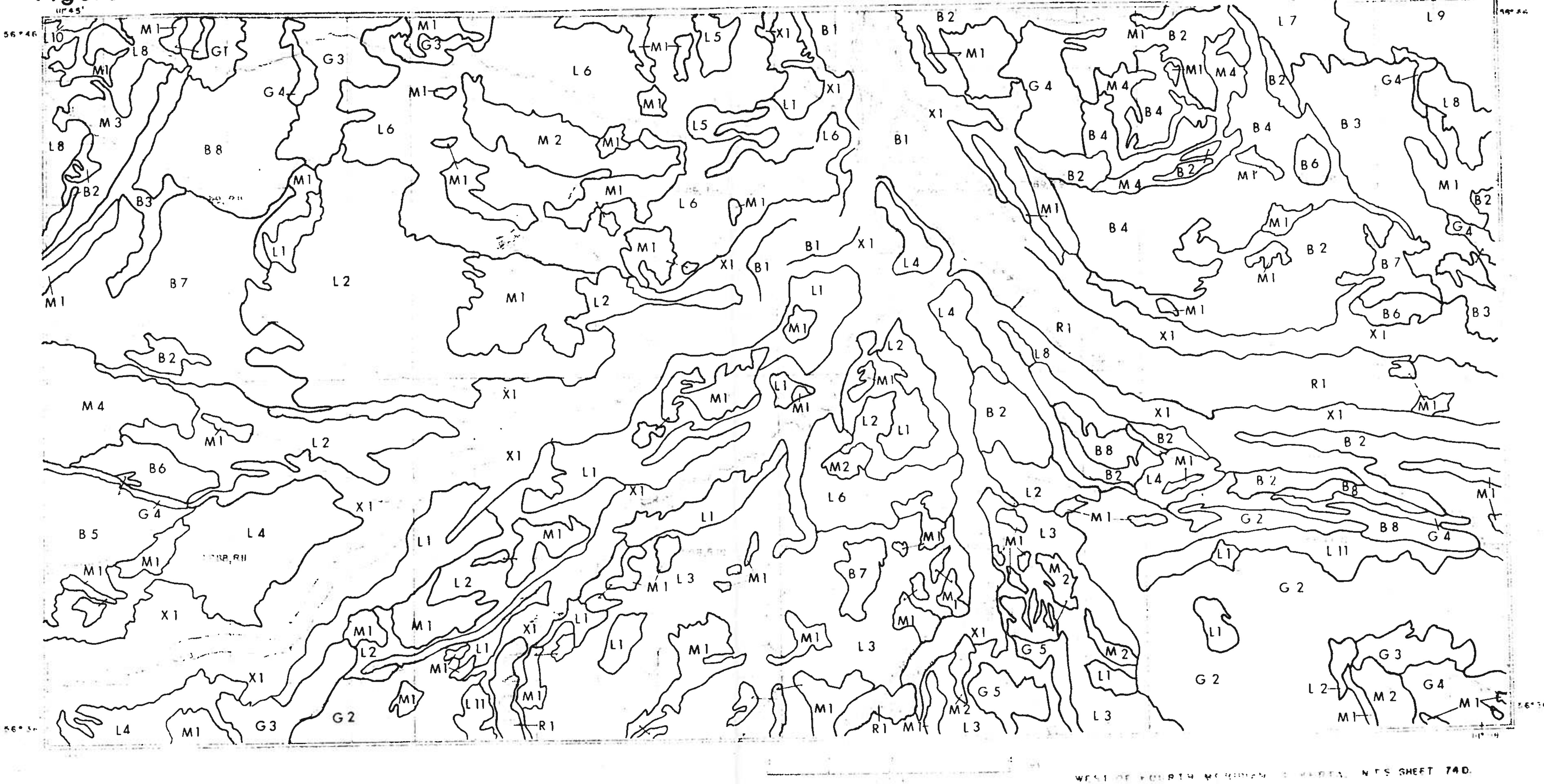


Figure 6. FORT McMURRAY REGION

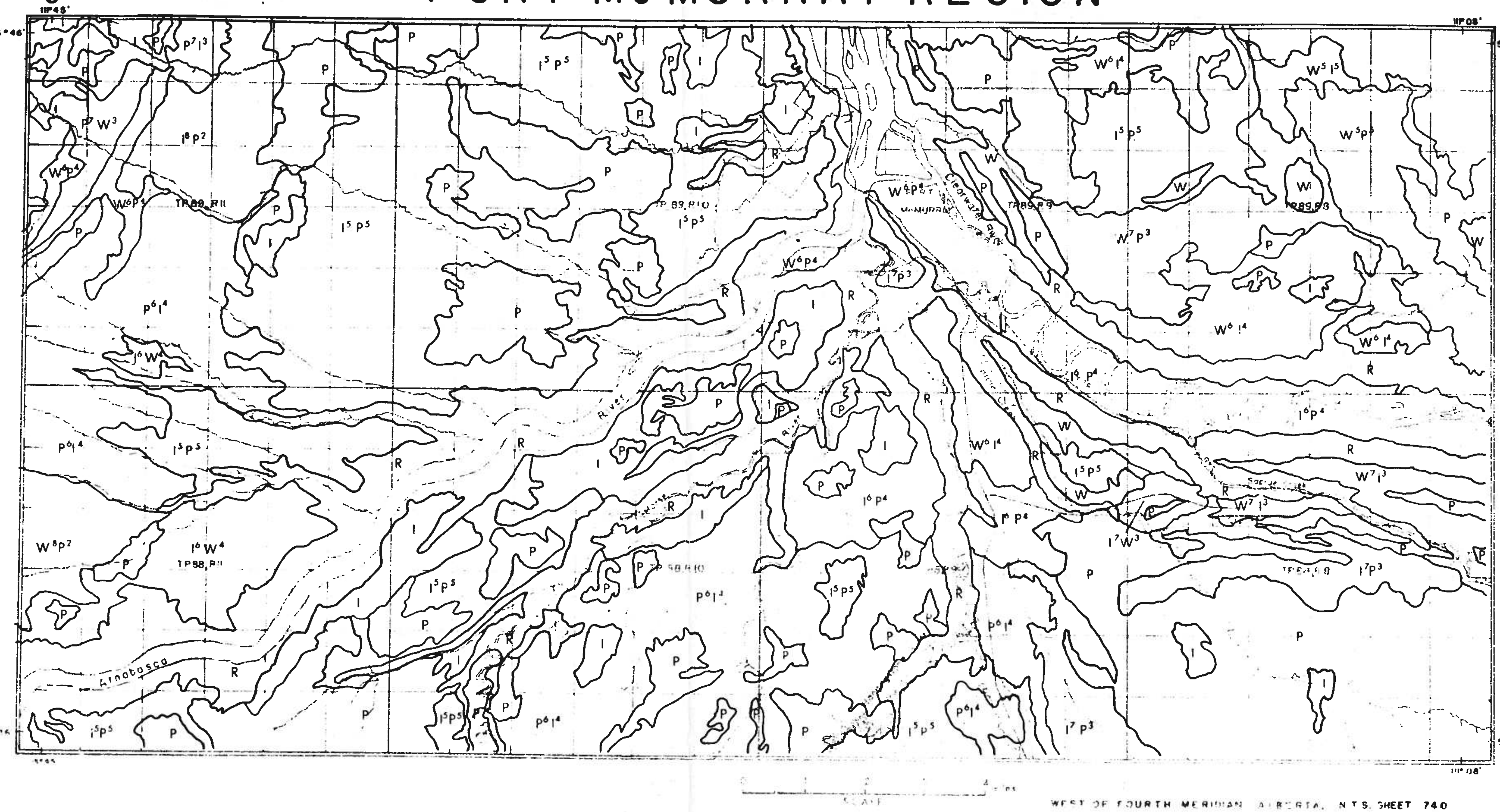


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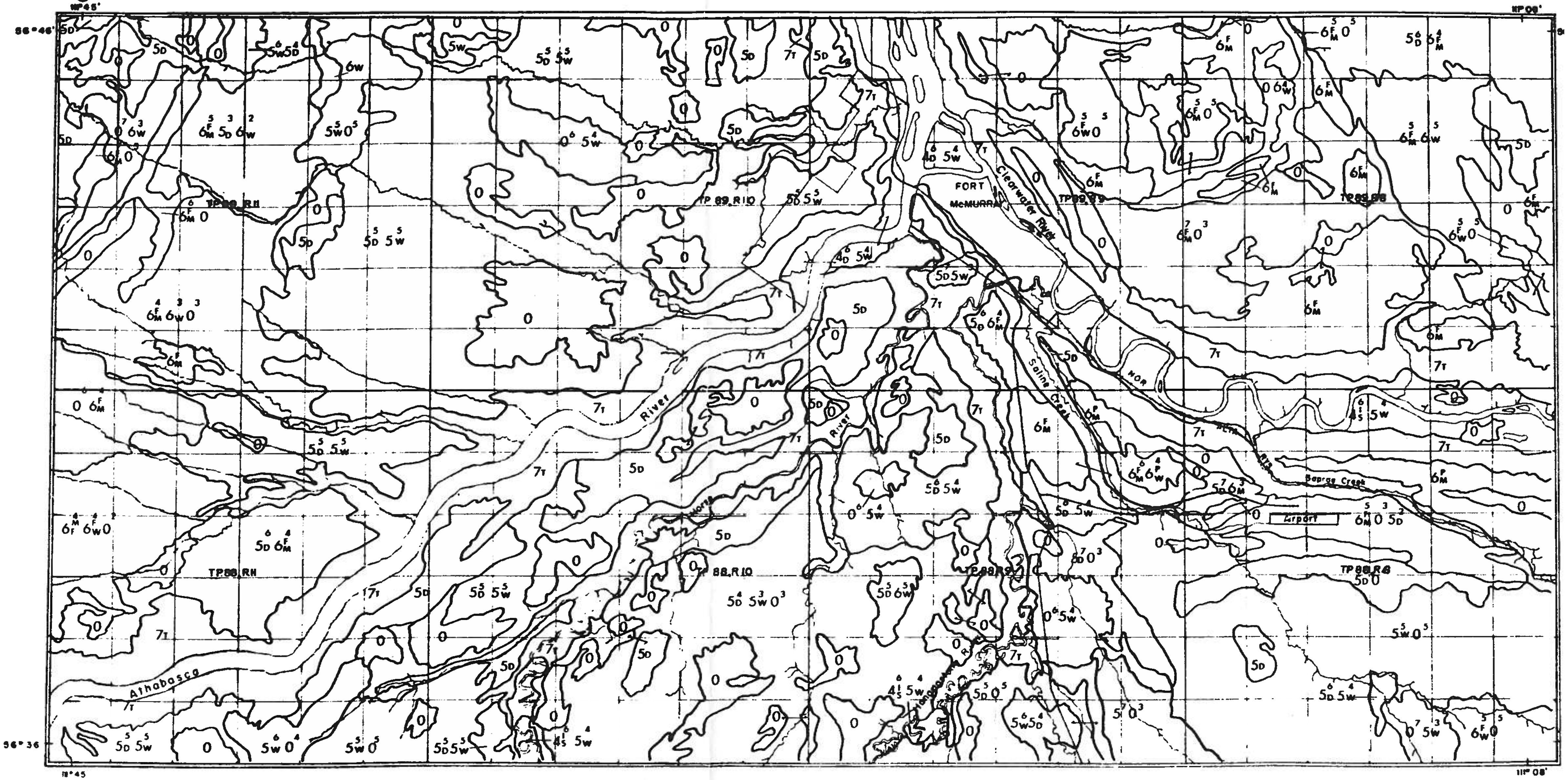
Figure 7. FORT McMURRAY REGION



WEST OF FOURTH MERIDIAN ALBERTA, N.T.S. SHEET 74D.