Soil Survey of

WILLOW CREEK PROVINCIAL PARK Study Area

and Interpretation for Recreational Use

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PREFACE

This report is one of a series describing detailed and semi-detailed soil surveys which are being conducted in Alberta provincial parks and recreation areas. As well as the Willow Creek Provincial Park study area, a soil survey was conducted in Saskatoon Island Provincial Park west of Grande Prairie, during the summer of 1981. The total area surveyed was approximately 280 ha.

A general guidebook has been prepared to accompany soil survey reports written for Alberta provincial parks and recreation areas (Greenlee, 1981). It includes general discussions of the following: soil formation; the Canadian soil classification system; soil characteristics and other factors that affect the use of soils for recreational and related purposes; Luvisolic, Organic, and Solonetzic soils; soil erosion; methodology; soil and landscape maps that accompany the soil survey reports; an explanation of soil interpretations and guidelines for developing them; chemical and physical properties of soils; and the landform classification system used by Canadian soil pedologists. Also included is a glossary. Specific results and interpretations for the areas covered by this study are presented in the ensuing report.

ACKNOWLEDGEMENTS

The Alberta Research Council provided the staff, and the Outdoor Recreation Planning Branch of Alberta Recreation and Parks contributed the funds for the two soil survey projects conducted in provincial parks during 1981. Costs included field, office, laboratory, drafting, editing, and printing; as well as equipment and supplies. Office and laboratory space were provided by the Research Council.

Mrs. Sharon DeFelice typed and assisted in compiling and proof reading the report. Mr. David Hall edited the report. Mrs. J. Dlask drafted the soil, landform, and recreation maps while Mr. J. Beres determined the soil physical properties. The soil chemical analyses were determined by Messrs. A. Schwarzer and W. McKean. Able field assistance was given by Miss C. Smith.

SUMMARY

The study area comprises about 180 ha bordering Willow Creek on the north and south sides about 24 km northwest of the town of Claresholm. The mapped area lies on the western edge of the Western Alberta Plains physiographic region adjacent to the Porcupine Hills, and is characterized by a relatively smooth ground moraine surface, dissected by several erosional channels leading into the Willow Creek valley. The majority of the mapped area is covered by medium textured till, except for the Willow Creek floodplain which is comprised of medium to very coarse textured fluvial sediments. This region has a dry climate, in which there is an excess of evaporation over precipitation, and the average temperature of the warmest month is under 18° C. The study area is situated in the grasslands region, and the vegetation type is the western porcupine grass/wheatgrass type.

Twelve map units were recognized in the study area. The key profile types are Calcareous Dark Brown Chernozems, Orthic Dark Brown Chernozems, Rego Dark Brown Chernozems, Orthic Regosols, Gleyed Regosols, Rego Gleysols, Rego Gleysols saline phase, and a Gleyed Solonetz. These are distributed over the landscape in relation to landform, parent material, and drainage. Map units consist of single soil series, groupings of series (complexes), or catenas; and their distribution is shown on the soil map.

Soil erodibility ratings (K-values) and predicted water erosion hazards have been worked out for selected map units. Soil interpretations of each map unit are made for primitive camping areas, fully serviced campgrounds, picnic areas, lawns and landscaping, paths, trails, road location, source of roadfill, and source of sand or gravel. Soils of Map Unit 1 when found on suitable topography, and those of Map Unit 3 are the most favourable for recreational development in the mapped area. Portions of Map Units 4 and 5 soil areas are situated adjacent to Willow Creek under tree cover, and these soils have moderate limitations for recreational development

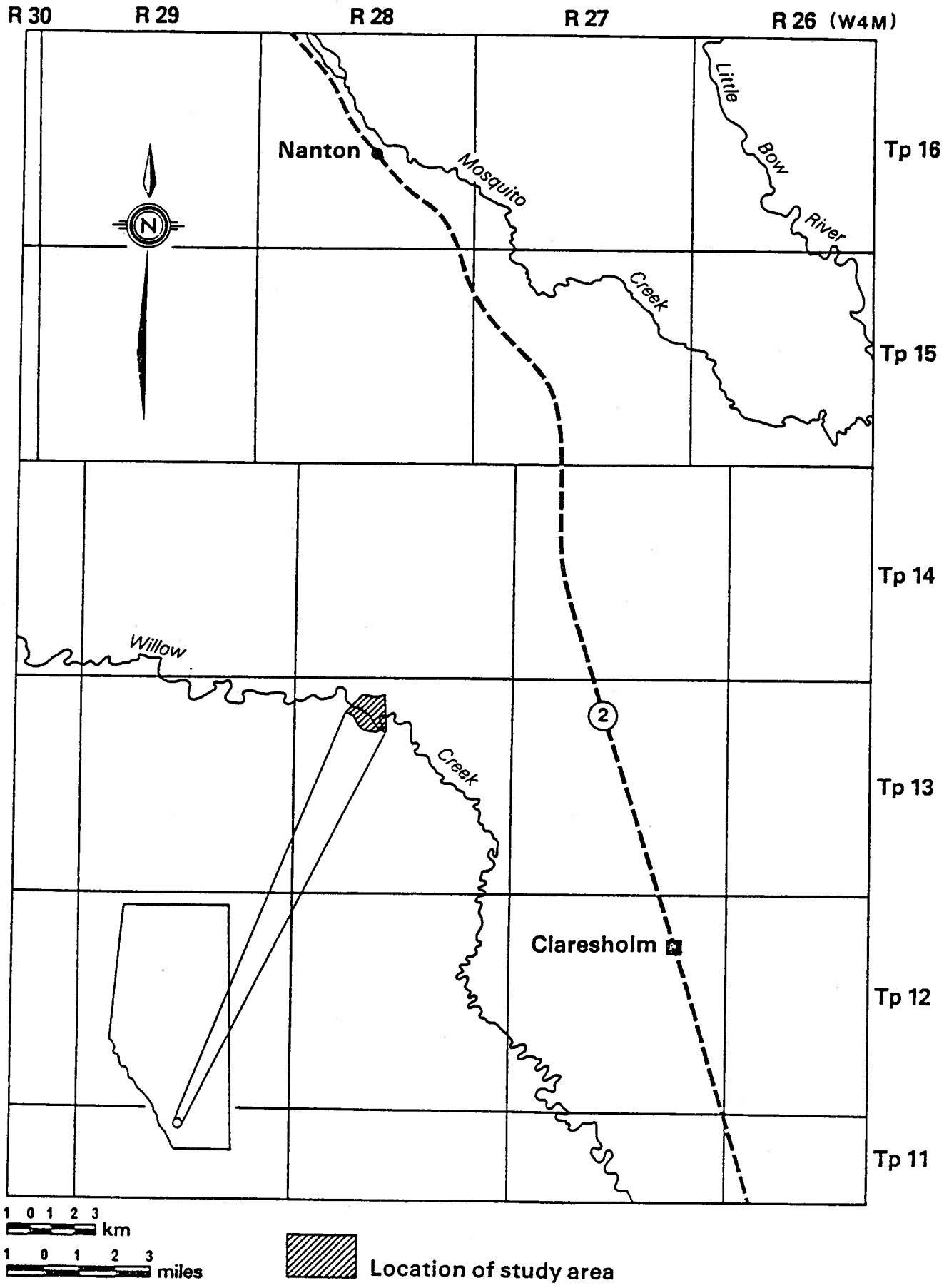
due to a flooding hazard. The soils of Map Unit 8, widespread in the upland north of Willow Creek, have severe limitations due to surface stoniness but are otherwise well suited for recreational development. Soils of most map units in the study area have severe limitations for road construction because of susceptibility to frost heave, and moderate limitations due to moderate shrink-swell potentials. Exceptions are soils of Map Units 5, 6, and 10; which have moderate limitations. Map Unit 5 soils constitute a good source of gravel; and soils of Map Units 4 and 6 are fair sources. Careful study of the soil map and tables 6 to 14 inclusive (soil limitation and suitability tables) will reveal areas suitable for particular uses.

A soil survey properly interpreted can be one of the most useful tools management has in making a proper design for a recreational area. However, all soil differences which occur in the field cannot be shown on the soil map. Thus for design and construction of specific recreational facilities, an on-site investigation is usually required.

INTRODUCTION

Size and Location

The study area comprises about 180 ha bordering Willow Creek on the north and south sides about 24 km northwest of the town of Claresholm (Figure 1), which in turn is located about 125 km south of Calgary along highway 2. The mapped area is situated in twp 13, rg 28, W4 th, and includes NW¼ sec 28, pt NE¼, pt NW¼ sec 29 (north side of road), pt SW¼, pt SE¼ sec 32 (south side of road), most SW¼, and pt NW¼ sec 33 (south side of road).


R 30
R 29
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Location of study area

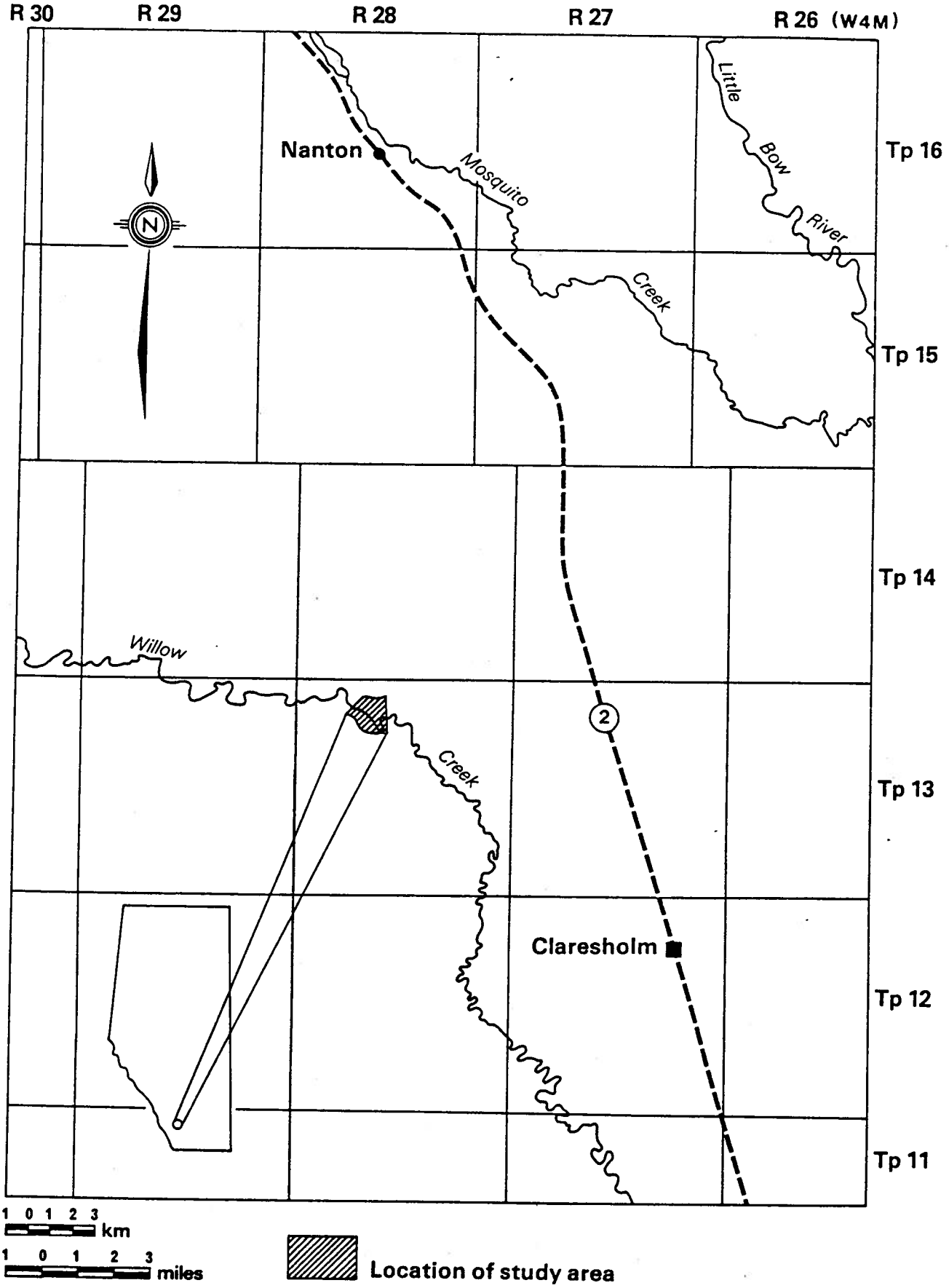


Figure 1. Map showing location of study area.

Physiography and Surficial Deposits

The mapped area lies on the western edge of the Western Alberta Plains physiographic region, adjacent to the Porcupine Hills (Government and the University of Alberta, 1969). It is characterized by a relatively smooth ground moraine surface (Ozoray and Lytviak, 1974), dissected by several erosional channels leading into the Willow Creek valley. The bedrock has been classified by Green (1972) as the Paleocene and Upper Cretaceous Willow Creek formation, which is non-marine. The average elevation of the uplands in the study area is about 1050 m. The difference between the highest and lowest points is only about 25 m. The highest elevation of about 1070 m is near the western edge, and the lowest of about 1045 m is near the eastern edge in the Willow Creek valley. The mapped area is drained by Willow Creek, which flows into the Oldman River about 70 km southeast of Willow Creek Park.

The majority of the mapped area is covered by medium textured till, except for the Willow Creek floodplain, which is comprised of medium to very coarse textured fluvial sediments. Also, two small patches of moderately coarse to moderately fine textured glaciofluvial sediments occur on the upland north of Willow Creek.

Climate

The climate of the study area is designated in Koppen's climatic classification as semi-arid or steppe (Trewartha, 1954). This is described as a dry climate, in which there is an excess of evaporation over precipitation, and the average temperature of the warmest month is under 18° C. Winter drought is normal, as at least ten times as much rain occurs in the wettest summer month as in the driest winter month.

Weather records for 1971 through 1980 from Claresholm at an elevation of 1018 m show the following values (Environment Canada): a mean annual temperature of 4.7° C. July is the warmest month with a mean temperature of 17.3° C, and January is the coldest with a mean temperature of -10.6° C. The mean annual precipitation is

445 mm with 66% falling as rain. The average frost free period is 106 days.

Vegetation

The mapped area is situated in the grasslands region, as classified by Hosie (1969). Trembling aspen forms groves or bluffs around wet depressions, and several other species of poplar are usually found along rivers and in moist locations with willows and some white spruce . The vegetation type in the study area is the western porcupine grass/wheatgrass type as classified by Wroe et al (1979). In this type the original grasslands were dominated by western porcupine grass with varying amounts of northern and western wheatgrasses, June grass, rough fescue, and on sandy soils blue grama.

Specifically in the study area, the vegetation throughout the upland portion is grass, with patches of wolf willow and buckbrush. Patches of choke cherry and saskatoon-berry occur on north facing slopes along the edge of the Willow Creek valley, and also on portions of the valley floor. Wooded portions of the floodplain are characterized by balsam poplar and plains cottonwood.

The Outdoor Recreation Planning Branch of Alberta Recreation and Parks carries out biological studies of provincial parks and recreation areas; and consequently the vegetation is not discussed extensively in this report. However, some of the more common plant species observed growing on different soils are indicated as part of the map unit descriptions, and these are listed as follows (Moss, 1959): native grass (various species), wolf willow *(Elaeagnus commutata)*, buckbrush *(symphoricarpos spp)*, wild rose *(Rosa spp)*, choke-cherry *(Prunus virginiana)*, saskatoon-berry *(Amelanchier alnifolia)*, wild gooseberry *(Ribes spp)*, Canadian buffalo-berry *(Shepherdia canadensis)*, shrubby cinquefoil *(Potentilla fruticosa)*, plains cottonwood *(Populus sargentii)*, narrow-leaf cottonwood *(Populus angustifolia)*, pasture sagewort *(Artemisia frigida)*, prairie sagewort *(Artemisia ludoviciana)*,

prairie crocus *(Anemone patens var wolfgangiana)*, cut-leaved anemone *(Anemone multifida)*, common yarrow *(Achillea millefolium)*, prairie onion *(Allium textile)*, pussy-toes *(Antennaria spp)*, golden bean *(Thermopsis rhombifolia)*, early yellow loco-weed *(Oxytropis sericea var spicata)*, purple milk vetch *(Astragalus agrestis)*, narrow-leaved milk vetch *(Astragalus pectinatus)*, three-flowered avens *(Geum triflorum)*, pale comandra *(Comandra pallida)*, wild lupine *(Lupinus spp)*, yellow puccoon *(Lithospermum spp)*, sweet clover *(Melilotus spp)*, black-eyed susan *(Rudbeckia serotina)*, smooth blue beard-tongue *(Pentstemon nitidus)*, blue-eyed grass *(Sisyrinchium montanum)*, common mullein *(Verbascum thapsus)*, northern bedstraw *(Galium boreale)*, vetch *(Vicia spp)*, gumweed *(Grindelia squarrosa)* slough grass *(Beckmannia syzigachne)*, sedge *(Carex spp)*, other forbs.

SOILS

Twelve map units were recognized in the study area. The soils of six were classified in the Chernozemic Order, three in the Regosolic Order, two in the Gleysolic Order, and one in the Solonetzic Order in the Canadian soil classification system (Canada Soil Survey Committee, 1978). The system is outlined in Greenlee (1981). Pertinent features of the map units are outlined in Table 1.

Soils of the Chernozemic Order are well to imperfectly drained mineral soils of good structure, with very high natural fertility and productive capacity. They are characterized by dark colored surface virgin (Ah or Ahe) or cultivated (Ap) horizons, darkened by the accumulation of organic matter (humus) from the decomposition of grasses and forbs representative of grassland communities or of grassland-forest communities with associated shrubs and forbs. The A horizon is commonly referred to as "topsoil" and ranges from 10 to 25 cm in thickness. In some regions it is much thicker. Chernozemic soils are further divided into four major divisions, the Brown, Dark Brown, Black and Dark Gray Great Groups. These are distinguished by measurable differences in color of the A horizons, which together with other associated features of depth, organic matter

Table 1. Key to the Soils.

Map Unit	Classification	Parent Material	Surface Texture	Slope (class & gradient)	Surface Stoniness	Drainage	Comments and Limitations
1	Calcareous Dark Brown Chernozem - 70% Orthic Dark Brown Chernozem - 30%	medium to moderately coarse textured till	loam	b, C, c, d, F, f (> 0.5 to 30%)	1 to 2	well drained	1) Lime in B of the Calcareous Dark Browns is the difference between these and the Orthic Dark Browns. 2) Fragments of soft weathered shale, weathered sandstone, sandstone slabs, sand and gravel pockets, silty clay loam to silty clay textured materials all occur in Cca horizons. Slight to severe limitations, poor source of roadfill, very poor source of sand or gravel-surface stoniness, excessive slopes, erosion hazard, high lime content (soil nutrient imbalance), susceptibility to frost heave, moderate shrink-swell potential.
2	Orthic Black Chernozem, Calcareous Black Chernozem, Orthic Regosol	medium to moderately fine textured till.	loam to sandy clay loam	G (>30 to 60%)	1	well drained	These soils occur on steep north facing slopes bordering the Willow Creek valley on the south. Severe to very severe limitations, poor source of roadfill, very poor source of sand or gravel-excessive slope, erosion hazard.
3	Calcareous Dark Brown Chernozem	medium to moderately fine textured fluvial sediments.	loam	b (>0.5 to 2%)	0	well drained	Occasional sand or fine gravel lenses occur. Slight to severe limitations, poor source of roadfill, sand, or gravel-susceptibility to frost heave, moderate shrink-swell potential, erosion hazard of subsoil if exposed at the surface.
4	Rego Dark Brown Chernozem	medium to moderately coarse textured fluvial sediments	loam	b (>0.5 to 2%)	0	well drained	1) 2 sand lenses common in the soil profile. 2) Gravel usually 90 to more than 120 cm below the soil surface. Moderate to severe limitations, poor source of roadfill and sand, fair source of gravel-flooding hazard (overflow), high lime content (soil nutrient imbalance), susceptibility to frost heave, moderate shrink-swell potential, erosion hazard of subsoil if exposed at the surface.

Table 1. Key to the Soils.

Map Unit	Classification	Parent Material	Surface Texture	Slope (class & gradient)	Surface Stoniness	Drainage	Comments and Limitations
5	Orthic Regosol	medium to moderately coarse textured fluvial sediments, overlying very coarse textured fluvial sediments (gravel)	very fine sandy loam	b (>0.5 to 2%)	0 to 1	well to rapidly drained	1) Profile textures range from loam to sandy loam, sand lenses occasionally found. 2) Gravel occurs 25 to 60 cm below surface. Moderate to severe limitations, good source of roadfill and gravel, poor source of sand-flooding hazard (overflow), lack of Ah horizon, rapid permeability (droughtiness), high lime content (soil nutrient imbalance).
6	Gleyed Regosol	medium to moderately coarse textured fluvial sediments	loam	b (>0.5 to 2%)	0	imperfectly drained	1) Silt loam or silty clay loam textured horizons sometimes found. 2) Depth to gravel 50 to more than 120 cm below surface. Slight to moderate limitations, fair source of roadfill and gravel, unsuitable as a source of sand-seasonally high ground-water table, flooding hazard (overflow), lack of Ah horizon, high lime content (soil nutrient imbalance).
7	Rego Gleysol	medium to moderately fine textured fluvial sediments.	silt loam	a (0 to 0.5%)	0	poorly drained	Depth to water table 0 to 60 cm below surface, surface water occurs in the most depressional portions of this soil landscape. Severe to very severe limitations, poor source of road-fill and gravel, unsuitable as a source of sand-seasonally high groundwater table or surface ponding, flooding hazard (overflow), slippery or sticky when wet, high lime content (soil nutrient imbalance), lack of Ah horizon, susceptibility to frost heave.

Table 1. Key to the Soils.

Map Unit	Classification	Parent Material	Surface Texture	Slope (class & gradient)	Surface Stoniness	Drainage	Comments and Limitations
8	Orthic Dark Brown Chernozem	moderately coarse to moderately fine textured cobbly stony till.	loam	c, d, E, e, F (>2 to 30%)	3	well drained	1) Occasional pockets of silty clay loam textured material in Cca horizon. 2) Till contains sandstone slabs, pockets of soft sandstone and small shale fragments. Moderate to severe limitations, poor source of roadfill, unsuitable as a source of sand or gravel-surface stoniness, excessive slope, erosion hazard, susceptibility to frost heave, moderate shrink-swell potential.
9	Orthic Regosol - 60% Calcareous Dark Brown Chernozem - 40%	moderately coarse to moderately fine textured cobbly stony till	loam to sandy clay loam	G (>30 to 60%)	3 to 4	well to rapidly drained	These soils occur on steep south and west facing slopes. Regosols occur on the upper portions, and Chernozems on the lower portions. Severe to very severe limitations, poor source of roadfill, unsuitable as a source of sand or gravel-excessive slope, erosion hazard, surface stoniness, high lime content (soil nutrient imbalance), susceptibility to frost heave.
10	Orthic Dark Brown Chernozem	moderately coarse to moderately fine textured glaciofluvial sediments.	fine sandy loam	E, F (>9 to 30%)	0	well drained	Textures in the Cca horizon range from sandy loam to clay loam. Slight to severe limitations, good source of roadfill, very poor source of sand, unsuitable as a source of gravel-excessive slope, erosion hazard.
11	Rego Gleysol, saline phase	medium to very coarse textured fluvial sediments.	loam	a (0 to 0.5%)	0	poorly drained	1) Numerous spots covered with a surface white salt crust are devoid of vegetation. 2) Water occurs 75 cm below the surface. Severe limitations, poor source of roadfill, sand, or gravel-seasonally high groundwater table or surface ponding, surface soil salinity, high lime content (soil nutrient imbalance).

Table 1. Key to the Soils.

Map Unit	Classification	Parent Material	Surface Texture	Slope (class & gradient)	Surface Stoniness	Drainage	Comments and Limitations
12	Gleyed Solonetz	fine textured lacustro-till	silty clay loam	b (>0.5 to 2%)	1	imperfectly drained	Very small pebbles in soil profile. Severe limitations, poor source of roadfill, unsuitable as a source of sand or gravel-solonetzic soil, high clay content, slow permeability, slippery or sticky when wet, thin Ah horizon, susceptibility to frost heave, high shrink-swell potential.

content, and structure reflect significant differences in the climates and vegetation under which they have developed, and which continue to influence and distinguish their characterisitics and relative use capabilities.

In general, Brown Chernozemic soils have A horizons that are lower in organic matter content, lighter in color and thinner than those of the other Chernozemic Great Groups; and are found in southern and south-eastern Alberta. Black Chernozemic soils have A horizons that are higher in organic matter content, darker in color and thicker than those of the other great groups; and are found in central and east-central Alberta. Dark Brown Chernozemic soils have A horizons with characteristics intermediate between those of the Browns and the Blacks; and are found in south-central and east-central Alberta. Dark Gray Chernozemic soils have A horizons with variable colors, thicknesses and modifications of structural pattern indicative of degradation of the typical Chernozemic A horizon. Under virgin conditions, the Dark Grays usually have leaf mats (L-H horizons) overlying the mineral soil, and degradation of the A horizons frequently causes a banded or "salt and pepper" effect. The organic matter content varies with the degree of degradation, from high accumulations in slightly degraded soils, comparable to that of Blacks; to significantly lower amounts in the more strongly degraded types. These latter types are intergrades to Dark Gray Luvisolic soils of the Luvisolic Order. Dark Gray Chernozemics are found primarily in transitional areas of grassland and forest in north-central Alberta and in the Peace River region.

Well drained Dark Brown Chernozemic soils developed on medium to moderately coarse textured till are found throughout most of the upland portion of the study area. Also, well drained Dark Brown Chernozemic soils occur in a portion of the Willow Creek floodplain. Some have developed on medium to moderately fine textured fluvial

sediments, and some have developed on medium to moderately coarse textured fluvial sediments. Two small patches of well drained Dark Brown Chernozemic soils are found on moderately coarse to moderately fine textured glaciofluvial sediments in the upland north of Willow Creek.

Soils of the Regosolic Order are rapidly to imperfectly drained mineral soils with profile development too weakly expressed to meet the requirements for classification in any other order. They lack any expression of a B horizon, and therefore, reflect essentially the characteristics of the C horizons and the parent materials from which they are formed.

Well to rapidly drained Regosolic soils occur on medium to very coarse textured fluvial deposits throughout much of the Willow Creek floodplain, adjacent to the creek. Two small patches of imperfectly drained Regosolic soils developed on medium to moderately coarse textured fluvial sediments are also found. These floodplain deposits are of relatively recent deposition and insufficient time has elapsed for any marked soil profile development, except gleying in positions of restricted drainage. Well drained Regosolic soils occur on medium to moderately fine textured till on steep banks along the boundaries of the Willow Creek valley, and along a drainage channel in the northeastern portion of the mapped area. Most surface moisture runs off these steep slopes, and very little perolates down through the soil profile. Thus profile development is retarded or prevented, and soil erosion probably also occurs.

Soils of the Gleysolic Order are poorly drained mineral soils whose profiles reflect the influence of waterlogging for significant periods. Water saturation causes reducing conditions due to a lack of aeration. These conditions result in gleyed horizons having dull gray to olive, greenish or bluish-gray moist colors, frequently

accompanied by prominent usually rust-colored mottles resulting from localized oxidation and reduction of hydrated iron oxides.

One patch of Gleysolic soils occurs on medium to moderately coarse textured fluvial sediments in the Willow Creek valley. Also a few patches are found on medium to very coarse textured fluvial sediments of drainage coarses in the upland north of Willow Creek.

Soils of the Solonetzic Order are well to imperfectly drained mineral soils having Solonetzic B horizons and slaine C horizons. A Solonetzic B is characterized by a columnar (round or flat-topped) or prismatic macrostructure that can usually be broken into a blocky mesostructure. These blocks, which have hard to very hard consistence when dry and are relatively impermeable, usually show dark surface stains or coatings. Chemically, the Solonetzic B horizons show evidence of alkalinization and have ratios of exchangeable calcium to exchangeable sodium of 10 or less, which is significantly lower than that for other, non-Solonetzic B horizons. The C horizons are generally saline and usually show an accumulation of salts.

Solonetzic soils are further divided into three major divisions, the Solonetz, Solodized Solonetz, and Solod Great Groups Solonetz and Solodized Solonetz soils have Solonetzic B horizons that are essentially intact and have not undergone significant breakdown. Generally, an abrupt break appears between the A and B horizons, and the A horizon is usually thin in relation to the B. Solodized Solonetz soils are characterized by the presence of an acidic Ae horizon, which is lacking in Solonetz soils. Solod soils are characterized by a greater development of this acidic Ae horizon and an AB transitional horizon in which the former Solonetzic B structure is in the process of physical disintegration. A horizons are generally thicker in relation to B horizons than in associated Solonetz and Solodized Solonetz soils. The contact between the AB and Solonetzic B horizons is not well defined, and the remnant B horizons are more easily broken into darkly stained aggregates

than in Solonetz and Solodized Solonetz soils.

Structural limitations of Solonetzic B horizons, which tend to become sticky and plastic when wet and very hard when dry, restrict moisture penetration and root development. Rainwater usually remains at or near the surface, and much is lost by evaporation. Because of the proximity of saline and alkaline subsoils, periodic salinization of surface horizons occurs when these soils are irrigated. This presents further limitations to healthy plant growth and to water availability. Consequently, Solonetzic soils are usually distinctly inferior in productivity to other associated soils. Another limitation of Solonetzic soils is their high erodibility, due to unstable soil aggregates caused by high sodium contents. In Solod soils, the limitations of structure and salinity are moderate in comparison to those for Solonetz and Solodized Solonetz soils. Solods, although somewhat inferior, more closely approach the associated Chernozemic soils in general productivity. Management problems in the cultivation of Solonetzic soils involve the timely use of tillage equipment to conserve moisture, and to prevent caking of surface clods and dessication of the underlying B horizon.

Only one small patch of imperfectly drained Solonetzic soils developed on fine textured lacustro-till was found in the west-central portion of the study area.

Very minor differences exist among some map units. However, the differences are usually significant with regard to a particular recreational or engineering use, and thus justify separation of different map units. They are described in chronological order, and horizon thicknesses represent averages. Thicknesses of comparative horizons in identical soil profiles often vary as much as 10 to 40 percent from the norm at different points in the landscape.

The dominant plant species are listed, using common names. These are very general lists, and not attempts at complete species lists.

Map Unit 1

Classification: Calcareous Dark Brown Chernozem - 70%
Orthic Dark Brown Chernozem - 30%

Parent material: medium to moderately coarse textured till.

Landform: hummocky morainal (Mh), inclined morainal (Mi), level morainal (Ml), undulating morainal (Mu).

Slope: gently sloping and gently undulating to steeply sloping and strongly rolling (>0.5 to 30%).

Surface stoniness: slightly to moderately stony (1 to 2).

Drainage: well drained.

Vegetation: native grass; pasture sagewort, prairie crocus, prairie onion, narrow-leaved milk vetch, northern bedstraw, wild lupine, vetch, golden bean, early yellow loco-weed, pussy-toes, common mullein, other forbs; some patches of wolf willow.

Profile description: Orthic Dark Brown

Horizon	Thickness (cm)	Lab Texture	Structure	Consistence	pH $CaCl_2$	OM[1] %
Ah	10	loam	granular	very friable, moist	7.3	10.5
Bm	5	fine sandy loam	prismatic	very friable, moist	7.2	4.6
Cca_1	35	fine sandy loam	prismatic	very friable, moist	7.8	nd[2]
Cca_2	50	loam	amorphous	firm, moist	7.9	nd

[1]OM - organic matter, [2]nd - not determined

Comments: (1) The difference between the Calcareous and Orthic Dark Browns is the occurrence of a Bmk horizon in the Calcareous soils, as compared to a Bm horizon in the Orthics. The difference between these two horizons is the presence of lime in the Bmk.

(2) Numerous small fragments of soft weathered shale, sandstone slabs, and fragments of weathered sandstone occur in the Cca horizon, as well as some pockets of sand and gravel. Occasional pockets of silty clay loam - to silty clay-textured materials are also found.

Limitations: Slight to severe-slight on suitable topography for camping and picnic areas, paths, and trails; moderate on suitable topography for lawns and landscaping; severe for road location; poor source of roadfill; unsuitable as a source of sand or gravel because of unsuitable textures. Other limitations include surface stoniness, excessive slopes, erosion hazard on steep slopes, high lime content (soil nutrient imbalance), susceptibility to frost heave, moderate shrink-swell potential.

Map Unit 2

Classification: Orthic Black Chernozem, Calcareous Black Chernozem, Orthic Regosol (The Chernozemic soils occur under thick shrubs, and the Regosolic soils occur under grass with only scattered shrubs. The two Chernozemic Subgroups are intimately and unpredictably associated).

Parent Material: medium to moderately fine textured till.

Landform: inclined morainal (Mi).

Slope: very steeply sloping (>30 to 60%)

Surface stoniness: slightly stony (1)

Drainage: well drained.

Vegetation: (Chernozemics) - choke cherry, wild rose, saskatoon-berry, Canadian buffalo-berry, wild gooseberry, grass, forbs.
(Regosols) - grass, forbs; scattered saskatoon-berry, Canadian buffalo-berry, shrubby cinquefoil, wild rose, wolf willow.

Profile description: Orthic Black.

Horizon	Thickness (cm)	Field Texture	Structure	Consistence
Ah	75	loam	granular	very friable, moist
Bm	25	loam to sandy clay loam	prismatic	friable, moist
Cca	at 100	loam to sandy clay loam	amorphous	firm, moist

Calcareous Black

Horizon	Thickness (cm)	Field Texture	Structure	Consistence
Ah	20	loam	granular	very friable, moist
Bmk	15	loam to sandy clay loam	amorphous	very friable to firm, moist
Cca	65	loam to sandy clay loam	amorphous	firm, moist

Orthic Regosol

Horizon	Thickness (cm)	Field Texture	Structure	Consistence
Cca	100	loam to sandy clay loam	amorphous	firm, moist

Comments: Soils of this map unit occur on steep north facing slopes bordering the Willow Creek valley on the south.

Limitations: Severe to very severe-severe for primitive camping areas, and trails; very severe for fully serviced campgrounds, picnic areas, lawns and landscaping, paths, and road location; poor source of roadfill; unsuitable as a source of sand or gravel due to unsuitable textures. Other limitations include excessive slopes, and erosion hazard.

Map Unit 3

Classification: Calcareous Dark Brown Chernozem.

Parent Material: medium to moderately fine textured fluvial sediments.

Landform: Fluvial terraces (Ft)

Slope: gently undulating (>0.5 to 2%)

Surface Stoniness: stone free (0)

Drainage: well drained

Vegetation: native grass, pussy-toes, prairie crocus, prairie onion, blue-eyed grass, three-flowered avens, cut-leaved anemone, common mullein, other forbs.

Profile description: Calcareous Dark Brown

Horizon	Thickness (cm)	Lab Texture	Structure	Consistence	pH $CaCl_2$	OM[1] %
Ah	12	loam	prismatic, breaking to granular	very friable, moist	7.1	8.0
Bmk	16	loam	prismatic	very friable, moist	7.8	3.6
Cca1	29	silt loam to loam	prismatic	very friable, moist	7.9	nd[2]
Cca2	33	silty clay loam	granular	friable, moist	8.0	nd
Cca3	10	loam	amorphous	slightly hard, dry	8.1	nd

[1]OM - organic matter, [2]nd - not determined

Comments: Occasional lenses of sand or fine gravel, about 10 cm thick, are found.

Limitations: Slight to severe-slight for camping and picnic areas, lawns and landscaping, paths, and trails; severe for road location; poor source of roadfill; poor source of sand due to unsuitable textures; poor source of gravel due to excessive overburden. Other limitations include susceptibility to frost heave, moderate shrink-swell potential, erosion hazard of subsoils if exposed at the surface.

Map Unit 4

Classification: Rego Dark Brown Chernozem

Parent material: medium to moderately coarse textured fluvial sediments.

Landform: Fluvial terraces (Ft)

Slope: gently undulating (>0.5 to 2%)

Surface stoniness: stone free (0)

Drainage: well drained.

Vegetation: mostly open areas - native grass, golden bean, vetch, black-eyed susan, prairie onion, pale comandra, prairie crocus, early yellow loco-weed purple milk vetch, three-flowered avens, common mullein, other forbs; patches of buckbrush, wild rose, wolf willow; some wild gooseberry, some wooded areas-plains cottonwood, balsam poplar, buckbrush, wolf willow, wild gooseberry, golden bean, sweet clover, wild blue flax, pussy-toes, prairie sage-wort, yellow puccoon, early yellow loco-weed, smooth blue beard-tongue, black-eyed susan, common yarrow, cut-leaved anemone, other forbs, native grass.

Profile description: Rego Chernozem

Horizon	Thickness (cm)	Lab Texture	Structure	Consistence	pH $CaCl_2$	OM[1] %
Ahk	10	loam	granular	very friable, moist	7.4	5.8
Cca_1	19	loam	prismatic	friable, moist	7.7	2.5
Cca_2	24	loam to fine sandy loam	prismatic	friable, moist	7.8	nd[2]
Cca_3	19	fine sandy loam	amorphous	loose, moist	7.9	nd
Cca4	28	loam	amorphous	very friable moist	7.9	nd

[1]OM - organic matter, [2]nd - not determined

Comments: (1) Two sand lenses (loamy sand), 8 to 20 cm thick and 5 to 30 cm apart, commonly occur in the soil profile.

(2) Gravel is usually found 90 to more than 120 cm below the surface, and is occasionally only 30 cm.

Limitations: Moderate to severe-severe for road location; moderate for all other uses; poor source of roadfill; poor source of sand due to unsuitable textures; fair source of gravel

(excessive overburden). Other limitations include flooding hazard (overflow), high lime content (soil nutrient imbalance), susceptibility to frost heave, moderate shrink-swell potential, erosion hazard of subsoil if exposed at the surface.

Map Unit 5

Classification: Orthic Regosol

Parent material: medium to moderately coarse textured fluvial sediments, overlying very coarse textured fluvial sediments (gravel).

Landform: fluvial terraces (Ft)

Slope: gently undulating (>0.5 to 2%)

Surface stoniness: stone free to slightly stony (0 to 1)

Drainage: well to rapidly drained.

Vegetation: mostly wooded areas - plains cottonwood, balsam poplar, buckbrush, wolf willow, wild gooseberry, golden bean, sweet clover, wild blue flax, pussy-toes, prairie sagewort, yellow puccoon, early yellow loco-weed, smooth blue beard-tongue, black-eyed susan, common yarrow, cut-leaved anemone, other forbs, native grass; some open areas - native grass, golden bean, vetch, black-eyed susan, prairie onion, pale comandra, prairie crocus, early yellow loco-weed, purple milk vetch, three-flowered avens, common mullein, other forbs; patches of buckbrush, wild rose, wolf willow; some wild gooseberry.

Profile description: Orthic Regosol.

Horizon	Thickness (cm)	Lab Texture	Structure	Consistence	pH $CaCl_2$	OM[1] %
Cca_1	12	very fine sandy loam	amorphous	very friable, moist	7.6	1.3
Cca_2	18	very fine sandy loam	amorphous	very friable, moist	7.7	1.1
Cca_3	70	gravel	amorphous	loose, moist	nd[2]	nd

[1]OM - organic matter, [2]nd - not determined

Comments: (1) Soil profile textures range from loam to sandy loam, and sand lenses (sand to loamy sand) 5 to 25 cm thick are occasionally found.

(2) Gravel usually occurs 25 to 60 cm below the surface, but is found at the surface in a few spots.

Limitations: Moderate to severe-severe for lawns and landscaping; moderate for all other uses; good source of roadfill; poor source of sand due to unsuitable textures; good source of gravel. Other limitations include flooding hazard (overflow), lack of an Ah horizon, rapid permeability (droughtiness), high lime content (soil nutrient imbalance).

Map Unit 6

Classification: Gleyed Regosol

Parent material: medium to moderately coarse textured fluvial sediments.

Landform: fluvial terraces (Ft)

Slope: gently undulating (>0.5 to 2%)

Surface stoniness: stone free (0)

Drainage: imperfectly drained.

Vegetation: grass, forbs; patches of buckbrush, wolf willow, wild rose, wild gooseberry.

Profile description: Gleyed Regosol.

Horizon	Thickness (cm)	Field Texture	Structure	Consistence
Ck	0-8	loam	amorphous	very friable, moist
Ccag	92-100	loam to fine sandy loam	amorphous	very friable, moist

Comments: (1) Horizons of silt loam textured materials (amorphous, friable, moist), or silty clay loam textured materials (amorphous, firm, moist), 15 to 35 cm thick, are sometimes found.

(2) The depth to gravel ranges from 50 to more than 120 cm below the surface.

Limitations: Slight to moderate-slight for picnic areas, paths, and trails; moderate for camping areas, lawns and landscaping, road location; fair source of roadfill; unsuitable as a source of sand due to unsuitable textures; fair source of gravel (excessive overburden). Other limitations include seasonally high groundwater table, flooding hazard (overflow), lack of an Ah horizon, high lime content (soil nutrient imbalance).

Map Unit 7

Classification: Rego Gleysol

Parent Material: medium to moderately fine textured fluvial sediments.

Landform: level fluvial (Fl)

Slope: nearly level (0 to 0.5%)

Surface stoniness: stone free (0)

Drainage: poorly drained

Vegetation: grass, sedge, forbs; slough grass in the most depressional portions.

Profile description: Rego Gleysol

Horizon	Thickness (cm)	Field Texture	Structure	Consistence
$Ccag_1$	75	silt loam	amorphous	friable, moist
$Ccag_2$	25	silty clay loam	amorphous	firm, moist

Comments: The depth to a water table ranges from 0 to 60 cm below the surface. Surface water is present in the most depressional portions of this soil landscape, where slough grass grows.

Limitations: Severe to very severe-very severe for road location; severe for all other uses; poor source of roadfill; unsuitable as a source of sand due to unsuitable textures; poor source of gravel (excessive overburden). Other limitations include a seasonally high groundwater table or surface ponding, flooding hazard (overflow), slippery or sticky when wet, high lime content (soil nutrient imbalance), lack of an Ah horizon, susceptibility to frost heave.

Map Unit 8

Classification: Orthic Dark Brown Chernozem

Parent material: moderately coarse to moderately fine textured cobbly stony till.

Landform: hummocky morainal (Mh), inclined morainal (Mi), undulating morainal (Mu).

Slope: undulating to steeply sloping (>2 to 30%).

Surface stoniness: very stony (3)

Drainage: well drained

Vegetation: native grass, golden bean, prairie crocus, pasture sagewort, pussy-toes, prairie sagewort, wild lupine, groundsel, other forbs; patches of wolf willow and buckbrush.

Profile description: Orthic Dark Brown

Horizon	Thickness (cm)	Lab Texture	Structure	Consistence	pH $CaCl_2$	OM[1] %
Ah	12	loam	granular	very friable, moist	6.5	6.1
Bm	8	loam	prismatic	very friable, moist	6.9	5.1
Cca_1	15	loam (gravelly and cobbly)	subangular blocky	very friable, moist	7.8	nd[2]
Cca_2	25	loam (very gravelly and stony) (field texture)	amorphous	very friable, moist	nd	nd
Cca_3	40	sandy clay loam(very cobbly and stony) (field texture)	amorphous	firm, moist	nd	nd

[1]OM - organic matter, [2]nd - not determined

Comments: (1) Occasional pockets of silty clay loam textured materials (amorphous, firm, moist) occur in the Cca horizon.

(2) The till contains numerous sandstone slabs and pockets of soft sandstone, also some pockets of small shale fragments.

Limitations: Moderate to severe-moderate on suitable topography for picnic areas, and trails; severe for all other uses; poor source of roadfill; unsuitable as a source of sand or gravel due to unsuitable textures. Other limitations include surface stoniness, excessive slope, erosion hazard on steep slopes, susceptibility to frost heave, moderate shrink-swell potential.

Map Unit 9

Classification: Orthic Regosol - 60%
Calcareous Dark Brown Chernozem - 40%

Parent material: moderately coarse to moderately fine textured cobbly stony till.

Landform: inclined morainal (Mi)

Slope: very steeply sloping (>30 to 60%)

Surface stoniness: very stony to exceedingly stony (3 to 4).

Drainage: well to rapidly drained

Vegetation: grass and forbs

Profile description: Orthic Regosol

Horizon	Thickness (cm)	Field Texture	Structure	Consistence
Cca	100	fine sandy loam to sandy clay loam (very gravelly, cobbly and stony)	amorphous	very friable to firm, moist

Calcareous Dark Brown

Horizon	Thickness (cm)	Field Texture	Structure	Consistence
Ah	10	loam to fine sandy loam	granular	very friable, moist
Bmk	10	loam	prismatic	very friable, moist
Cca	80	fine sandy loam to sandy clay loam (very gravelly, cobbly and stony)	amorphous	very friable to firm, moist

Comments: These soils are found on steep south and west facing slopes. The Regosols occur on the upper portions of the slopes, and the Chernozems occur on the lower portions.

Limitations: Severe to very severe-severe for primitive camping areas, and trails; very severe for all other uses; poor source of roadfill; unsuitable as a source of sand or gravel due to unsuitable textures. Other limitations include excessive slope, erosion hazard, surface stoniness, high lime content (soil nutrient imbalance), susceptibility to frost heave.

Map Unit 10

Classification: Orthic Dark Brown Chernozem.

Parent material: moderately coarse to moderately fine textured glaciofluvial sediments.

Landform: inclined glaciofluvial (F_i^G)

Slope: strongly to steeply sloping (>9 to 30%)

Surface stoniness: stone free (o)

Drainage: well drained

Vegetation: grass, forbs; patches of wolf willow, and buckbrush.

Profile description: Orthic Dark Brown

Horizon	Thickness (cm)	Field Texture	Structure	Consistence
Ah	10-15	fine sandy loam	granular	very friable, moist
Bm	10-55	loam to fine sandy loam	prismatic	very friable, moist
Cca	72-92	ranges from loam and sandy loam to sandy clay loam, silty clay loam, and clay loam	amorphous	very friable to firm, moist

Comments: Thicknesses of the various textured sediments in the Cca horizon range from 20 to 55 cm.

Limitations: Slight to severe-slight on suitable topography for primitive camping areas, and trails; moderate on suitable topography for all other uses; good source of roadfill on suitable topography; very poor source of sand, and unsuitable as a source of gravel due to unsuitable textures. Other limitations include excessive slope, and erosion hazard.

Map Unit 11

Classification: Rego Gleysol, saline phase

Parent material: medium to very coarse textured fluvial sediments.

Landform: level fluvial (F1)

Slope: nearly level (0 to 0.5%)

Surface stoniness: stone free (0)

Drainage: poorly drained

Vegetation: grass, sedge

Profile description: Rego Gleysol, saline phase

Horizon	Thickness (cm)	Field Texture	Structure	Consistence
Ccasg1	60	loam	amorphous	firm, moist
Ccasg2	30	loamy sand	amorphous	loose, moist
Ccasg3	20	sand	amorphous	loose, moist
Ccasg4	10	loam	amorphous	very friable, moist

Comments: (1) Numerous spots are covered with a surface white salt crust, and these are devoid of vegetation.

(2) A water table occurs about 75 cm below the surface.

Limitations: Severe for all uses; poor source of roadfill; poor source of sand because of only a thin deposit; poor source of gravel due to excessive overburden. Other limitations include seasonally high groundwater table or surface ponding, surface soil salinity, high lime content (soil nutrient imbalance).

Map Unit 12

Classification: Gleyed Solonetz

Parent material: fine textured lacustro-till.

Landform: level morainal (M1)

Slope: gently undulating (0.5 to 2%)

Surface stoniness: slightly stony (1)

Drainage: imperfectly drained.

Vegetation: grass, gumweed, other forbs.

Profile description: Gleyed Solonetz

Horizon	Thickness (cm)	Field Texture	Structure	Consistence
Ah	5	silty clay loam	granular	friable, moist
Bntg	55	silty clay	columnar, breaking to subangular blocky	very firm, moist
Ccag	40	silty clay	amorphous	very firm, moist; very dense

Comments: Very small pebbles occur in the soil profile.

Limitations: Severe for all uses; poor source of roadfill; unsuitable as a source of sand or gravel due to unsuitable textures. Other limitations include solonetzic soil, high clay content, low permeability, slippery or sticky when wet, thin Ah horizon, susceptibility to frost heave, high shrink-swell potential

SPECIAL FEATURES

The soils in Alberta have been classified into broad general zones (Figue 2) as established by Alberta Soil Survey during the normal course of soil surveys, and correlated with temperature and precipitation records. Annual precipitation amounts change gradually from one soil zone to another, and are not abrupt changes at the point where a zone boundary has been located. Thus a zone boundary is a broad transitional belt, which can be many kilometres across. Topsoil colors reflect this gradual change. For example, in the centre of the Brown Soil Zone (annual precipitation about 30 to 33 cm), topsoil colors are brown. Similarly in the centre of the Dark Brown Soil Zone (annual precipitation about 38 cm), topsoil colors are dark brown. Between these two zones, topsoil colors are brown to dark brown, and annual precipitation is about 35 cm. The boundary between the two soil zones has been placed approximately at that midpoint.

Zonal soils are soils with well developed soil characteristics that reflect the zonal or normal influences of climate and living organisms, mainly vegetation, as active factors of soil genesis. Examples are Brown, Dark Brown, or Black soils of the Brown, Dark Brown, or Black Soil Zones respectively. Intrazonal soils are soils with morphology that reflects the influence of some local factor of relief, parent material, or age; rather than of climate and vegetation. An example is Solonetzic soils, which develop as a result of salinization. This may originate internally from a saline parent material, or from saturation by external saline waters. Solonetzic soils are found across many soil zones (Figure 2). Azonal soils are soils without distinct genetic horizons, and are represented by Regosolic soils in Canada.

The study area is situated in the Dark Brown soil zone and most of the soils are classified as Dark Brown Chernozemic, which are zonally normal. Exceptions are the Regosolic soils, which are

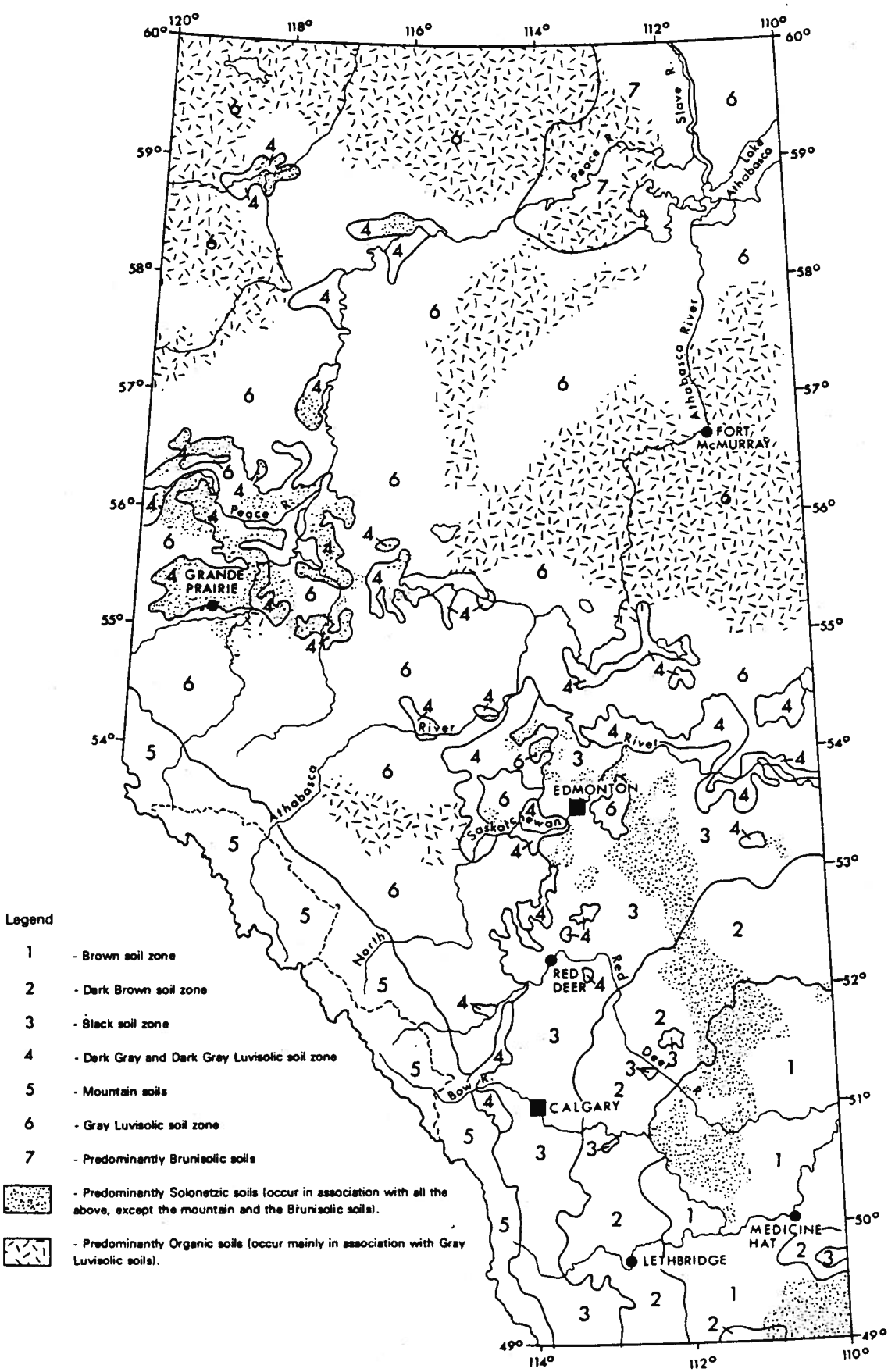
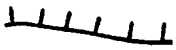


Figure 2. Map showing soil zones of Alberta (from Soil Group Map of Alberta, Alberta Institute of Pedology).

azonal; and the Gleysolic and Solonetzic soils, which are intrazonal. Soils of the latter three orders occur across all the soil zones. Soils of the study area can be considered typical, both locally and for the region, as compared to other soils found nearby and further away within the general region (Wyatt et al, 1960; Kocaoglu, 1977).

Special features of soils in the mapped area are their generally high lime content, and the lack of Ah horizons in the Regosolic soils. High lime contents may restrict the availability of certain nutrients to plants, resulting in deficiencies and imbalances in plant nutrition (Greenlee, 1981). High rates of certain fertilizers may be required to attain desired levels of plant growth. Ah horizons generally have relatively high contents of organic matter and available nutrients, are well aggregated, and resilient to compaction. These desirable features of surface soils are absent wherever Ah horizons are lacking, and plant growth is difficult to maintain in park use areas.

MISCELLANEOUS SYMBOLS


This symbol indicates escarpments.

gv. This symbol indicates gravel bars bordering the creek bed along Willow Creek. These consist chiefly of fluvial gravel deposits, and a few small patches of sandy overlays (sand to loamy sand) zero to 25 cm thick also occur. The soils are classified as Orthic Regosols; and the vegetation is sparse, consisting of grass, forbs, wolf willow, and narrow-leaf cottonwood. These soils have very severe limitations for all uses due to the extreme flooding hazard. They are poor sources of roadfill, sand, or gravel for the same reason. Also only thin patchy sand deposits occur.


This symbol indicates slope direction.

SOIL INTERPRETATIONS

An explanation of soil interpretations and definitions of the soil limitation and suitability ratings are given in Greenlee (1981). The results of soilchemical and physical analyses are given in Tables 2 and 3.

Soil erodibility ratings (K values) and predicted water erosion hzards of selected map units are presented in Tables 4 and 5. As well as surface horizons, values have been worked out for soil parent materials, because they may be exposed during construction activities.

Soils of Map Unit 1 when found on suitable topography, and those of Map Unit 3 are the most favourable for recreational development in the mapped area. Map Unit 1 soils occur in the upland south of Willow Creek; and Map Unit 3 soils occur in the Willow Creek valley, although not adjacent to the creek and not under trees. Portions of Map Units 4 and 5 soil areas are situated adjacent to the creek under tree cover, and these soils have moderate limitations for recreational development due to a flooding hazard. The soils of Map Unit 8, widespread in the upland north of Willow Creek, have severe limitations due to surface stoniness but are otherwise well suited for recreational development. Soils of various other less widespread map units have moderate to very severe limitations due to factors such as seasonally high groundwater tables or surface ponding, flooding hazard, slippery or sticky when wet, excessive slopes, erosion hazard, solonetzic soil, and slow permeability.

Soils of most map units in the study area have severe limitations for road construction because of susceptibility to frost heave, and moderate limitations due to moderate shrink-swell potentials. Exceptions are soils of Map Units 5, 6, and 10. Map Unit 5 soils have moderate limitations due to a flooding hazard;

Table 2. Chemical and Physical Analyses of Selected Map Units.

Map Unit	Horizon	Depth cm	pH $CaCl_2$	Exchangeable cations [1]meq/100 gm soil				[2]CEC meq/100 gm	[3]OC %	$CaCO_3$ equiv %	Mech Analysis % from frac<2mm diam			[4] %	[5] %	Texture	
				Na+	K+	Ca++	Mg++				sand	silt	clay	VFS	CF	Lab det	Field est
1	Ah	0-9	7.3	[6]nd	nd	nd	nd	nd	6.2	nd	41	36	23	7	5	L	L
	Bm	9-15	7.2	nd	nd	nd	nd	nd	2.7	nd	54	27	19	16	5	FSL	L
	Cca_1	15-50	7.8	nd	nd	nd	nd	nd	nd	15.1	61	23	16	19	5	FSL	L
	Cca_2	50-100	7.9	nd	nd	nd	nd	nd	nd	17.0	28	48	24	nd	15	L	CL
3	Ah	0-12	7.1	nd	nd	nd	nd	nd	4.7	nd	38	42	20	19	0	L	SiL
	BmK	12-28	7.8	nd	nd	nd	nd	nd	2.1	9.9	35	41	24	18	0	L	SiL
	Cca1	28-57	7.9	nd	nd	nd	nd	nd	nd	11.6	33	50	17	17	0	SiL-L	SiCL
	Cca_2	57-90	8.0	nd	nd	nd	nd	nd	nd	11.9	5	58	37	0	0	SiCL	SiCL
	Cca_3	90-100	8.1	nd	nd	nd	nd	nd	nd	10.4	43	39	18	27	0	L	L
4	AhK	0-10	7.4	nd	nd	nd	nd	nd	3.4	4.0	39	44	17	23	0	L	VFSL
	Cca_1	10-29	7.7	nd	nd	nd	nd	nd	1.5	9.2	36	48	16	24	0	L	VFSL
	Cca_2	29-53	7.8	nd	nd	nd	nd	nd	nd	7.8	52	36	12	21	5	L-FSL	FSL
	Cca_3	53-72	7.9	nd	nd	nd	nd	nd	nd	7.6	62	28	10	22	0	FSL	LS
	Cca_4	72-100	7.9	nd	nd	nd	nd	nd	nd	9.0	48	41	11	27	0	L	VFSL

[1]meq - milliequivalents, [2]CEC - cation exchange capacity, [3]OC - organic carbon, [4]VFS - very fine sand,
[5]CF - coarse fragments (>2 mm diam)(field estimate), [6]nd - not determined

Table 2. Chemical and Physical Analyses of Selected Map Units.

Map Unit	Horizon	Depth cm	pH $CaCl_2$	Exchangeable cations [1]meq/100 gm soil				[2]CEC meq/100 gm	[3]OC %	$CaCO_3$ equiv %	Mech Analysis % from frac<2mm diam			[4] %	[5] %	Texture	
				Na+	K+	Ca++	Mg++				sand	silt	clay	VFS	CF	Lab det	Field est
5	Cca_1	0-12	7.6	[6]nd	nd	nd	nd	nd	0.79	8.1	60	32	8	27	0	VFSL	LFS
	Cca_2	12-30	7.7	nd	nd	nd	nd	nd	0.67	8.1	60	29	11	28	0	VFSL	FSL
	Cca_3	at 30	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	90	nd	[7]GV
8	Ah	0-12	6.5	0.01	0.81	17.4	2.8	20.9	3.6	nd	50	31	19	23	5	L	FSL
	Bm	12-20	6.9	0.01	0.66	19.3	2.7	21.5	3.0	nd	49	31	20	22	10	L	FSL
	Cca_1	20-35	7.8	nd	nd	nd	nd	nd	nd	32.2	49	38	13	20	40	L	[7]gv L
	Cca_2	35-60	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	60	nd	[7]vgv L
	Cca_3	60-100	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	85	nd	vgv SCL

[1]meq - milliequivalents, [2]CEC - cation exchange capacity, [3]OC - organic carbon, [4]VFS - very fine sand,
[5]CF - coarse fragments (>2 mm diam) (field estimate), [6]nd - not determined, [7]GV - gravel, gv - gravelly, vgv - very gravelly

Table 3. Physical Analyses of Selected Map Units (1)

Map Unit	Depth cm	Field Moisture %	Mechanical Analysis											Liquid Limit	Plasticity Index	Optimum Moisture %(2)	Maximum Dry Density lb/ft.^{3} (2)	Classification		
			Percentage Passing Sieve							Percentage Smaller Than								AASHO	Unified	USDA
			1 inch	3/4 inch	5/8 inch	#4 (4.7 mm.)	#10 (2.0 mm.)	#40 0.42 mm.)	#200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.	0.001 mm.							
1	120-150	11	100	98	97	95	93	88	69	67	34	26	22	26	10	14	115.0	A-4(7) to A-6(7)	CL	L

(1) Map Units developed on similar parent material: 1, 8, and 9.

(2) These values are obtained from charts worked out by the Alberta Transportation Testing Laboratory.

Table 4. Soil Erodibility Ratings (K-values) of Selected Map Units

Map Unit	Horizon	K-value(1)	Map Unit	Horizon	K-value(1)
1	(2) Ah	0.20	4	Ahk	0.43
	Cca_1	0.42		Cca_3	0.54
	Cca_2	0.38		Cca_4	0.70
3	Ah	0.38	5	Cca_1	0.64
	Cca_1	0.72		Cca_2	0.60
	Cca2	0.40	8	Ah	0.32
	Cca_3	0.70		Cca_1	0.64

(1) The K-values were determined from data provided in this report using the soil erodibility nomograph presented in Figure 5 of Greenlee (1981).

(2) Where the percent organic matter was more than 4, it was taken as 4 for the purposes of the nomograph; and where it was not determined, it was assumed to be 0.

Table 5. Predicted Water Erosion Hazards of Selected Map Units.

Map Unit	Horizon	Erosion risk(1)
1/b1 1/b2	Ah	L
	Cca_1	L
	Cca_2	L
1/C1 1/c1 1/c2	Ah	L
	Cca_1	L-M
	Cca_2	L-M
1/d1 1/d2	Ah	L
	Cca_1	M
	Cca_2	M
1/F2 1/f2	Ah	L-M
	Cca_1	H
	Cca_2	H
3/bo	Ah	L
	Cca_1	M
	Cca_2	L
	Cca_3	M
4/bo	AhK	L
	Cca_3	L-M
	Cca_4	M
5/bo 5/b1	Cca_1	L-M
	Cca_2	L-M
8/c3	Ah	L
	Cca_1	M
8/d3	Ah	L-M
	Cca_1	M-H
8/E3 8/e3	Ah	M
	Cca_1	H
8/F3	Ah	M-H
	Cca_1	H

(1) L = Low erosion risk, M = Moderate erosion risk, H = High erosion risk. These ratings were derived by applying the K-values from Table 4 to the graph presented in Figure 6 of Greenlee (1981).

Map Unit 6 soils have moderate limitations due to a seasonally high groundwater table and a flooding hazard; and Map Unit 10 soils have moderate to severe limitations due to excessive slopes, and erosion hazards. None of these map units are widespread in the study area.

Map Unit 5 soils constitute a good source of gravel; and soils of Map Units 4 and 6 are fair sources. Soils of these latter two have excessive overburdens, and Map Unit 6 soils have a seasonally high groundwater table. The soils of Map Units 3 and 7 are poor sources due to excessive overburdens; and Map Unit 7 soils have a flooding hazard and a seasonally high groundwater table or surface ponding. The soils of most other map units are unsuitable as sources of sand or gravel because of unsuitable textures.

Specific limitations and suitabilities of the various soils for selected uses are shown in tables 6 to 14 inclusive. The ratings were determined on the basis of morphological, physical, and chemical properties of the soils, as well as steepness of slope. The principal limiting properties are indicated, and are generally listed in decreasing order of importance.

Limitations due to slope are not further subdivided once the slope becomes steep enough to cause a very severe limitation for a specified use. It follows, however, that the steeper the slope, the more severe the limitation, and this fact should be kept in mind while using the soil interpretation tables. In tables 6 to 12 inclusive, the soil limitations for various uses have been designated as none to slight, moderate, severe, and very severe. In tables 13 and 14, the suitability of soils as sources of roadfill and as sources of sand and gravel respectively, have been designated as good, fair, poor, and very poor.

Table 6. Soil Limitations for Primitive Camping Areas

Map Symbol[1]	Degree of Limitation[2]
1/b1 1/c1 1/c1 1/d1	SL
1/b2 1/c2 1/d2	M - Stony
1/F2 1/f2	M - Slope, Stony, Er
2/G1	S - Slope, Er
3/b0	SL
4/b0	M - Flood
5/b0 5/b1	M - Flood
6/b0	M - Wet, Flood
7/a0	S - Wet, Flood, Slip

Map Symbol	Degree of Limitation
8/c3 8/d3 8/E3 8/e3	S - Stony, otherwise SL
8/F3	S - Stony M - Slope, Er
9/G3 9/G4	S - Slope, Er, Stony
10/Eo	SL
10/Fo	M - Slope, Er
11/a0	S - Wet
12/b1	S - Solz, Sl Perm, Slip

1. For explanation, See Soil Map.
2. SL - None to slight, M - Moderate, S - Severe, VS - Very severe

Abbreviations

BR - Shallow depth to bedrock
Clay - High clay content
Er - Erosion hazard
Flood - Flooding hazard (overflow)
Org - Organic Soil
Org Surf - Organic surface layer >15 cm thick
Sandy - Sandy surface texture
Slip - Slippery or sticky when wet
Slope - Excessive slope
Sl Perm - Slow permeability
Solz - Solonetzic soil
Stony - Surface stoniness
Wet - Seasonally high groundwater table or surface ponding

Table 7. Soil Limitations for Fully Serviced Campgrounds.

Map Symbol[1]	Degree of Limitation[2]
1/b1 1/C1 1/c1 1/d1	SL
1/b2 1/c2 1/d2	M - Stony
1/F2 1/f2	S - Slope, M - Stony, Er
2/G1	VS - Slope, Er
3/bo	SL
4/bo	M - Flood
5/bo 5/b1	M - Flood
6/bo	M - Wet, Flood
7/ao	S - Wet, Flood, Slip
8/c3 8/d3	S - Stony, otherwise SL
8/E3 8/e3	S - Stony M - Slope, Er
8/F3	S - Slope, Stony, Er
9/G3 9/G4	VS - Slope, Er, Stony
10/Eo	M - Slope, Er
10/Fo	S - Slope, Er
11/ao	S - Wet
12/b1	S - Solz, Sl Perm, Slip

1. For explanation, see Soil Map.
2. SL - None to slight, M - Moderate, S - Severe, VS - Very severe

Abbreviations

BR - Shallow depth to bedrock
Clay - High clay content
Er - Erosion hazard
Flood - Flooding hazard (overflow)
Org - Organic soil
Org Surf - Organic surface layer >15 cm thick
Sandy - Sandy surface texture
Slip - Slippery or sticky when wet
Slope - Excessive slope
Sl Perm - Slow permeability
Solz - Solonetzic soil
Stony - Surface stoniness
Wet - Seasonally high groundwater table or surface ponding

Table 8. Soil Limitations for Picnic Areas

Map Symbol[1]	Degree of Limitation[2]
$\frac{1}{b1}$ $\frac{1}{b2}$ $\frac{1}{c1}$ $\frac{1}{c1}$ $\frac{1}{c2}$ $\frac{1}{d1}$ $\frac{1}{d2}$	SL
$\frac{1}{F2}$ $\frac{1}{f2}$	S - Slope, Er
$\frac{2}{G1}$	VS - Slope, Er
$\frac{3}{bo}$	SL
$\frac{4}{bo}$	M - Flood
$\frac{5}{bo}$ $\frac{5}{b1}$	M - Flood
$\frac{6}{bo}$	SL
$\frac{7}{ao}$	S - Wet, Slip, Flood
$\frac{8}{c3}$ $\frac{8}{d3}$	M - Stony, otherwise SL
$\frac{8}{E3}$ $\frac{8}{e3}$	M - Slope, Er, Stony
$\frac{8}{F3}$	S - Slope, Er, Stony
$\frac{9}{G3}$ $\frac{9}{G4}$	VS - Slope, Er, Stony
$\frac{10}{Eo}$	M - Slope, Er
$\frac{10}{Fo}$	S - Slope, Er
$\frac{11}{ao}$	S - Wet
$\frac{12}{b1}$	S - Solz, Sl Perm, Slip

1. For explanation, see Soil Map.
2. SL - None to slight, M - Moderate, S - Severe, VS - Very Severe

Abbreviations

Clay - High clay content
Er - Erosion hazard
Flood - Flooding hazard (overflow)
Org - Organic soil
Org Surf - Organic surface layer >15 cm thick
Sandy - Sandy surface texture
Slip - Slippery or sticky when wet
Slope - Excessive Slope
Sl Perm - Slow permeability
Solz - Solonetzic soil
Stony - Surface stoniness
Wet - Seasonally high groundwater table or surface ponding

Table 9. Soil Limitations for Lawns and Landscaping.

Map Symbol[1]	Degree of Limitation[2]
1/b1 1/c1 1/c1 1/d1	M - Lime
1/b2 1/c2 1/d2	M - Stony, Lime
1/F2 1/f2	S - Slope, Er M - Stony, Lime
2/G1	VS - Slope, Er
3/bo	SL
4/bo	M - Flood, Lime
5/bo 5/b1	S - Thin Ah, R Perm, Lime
6/bo	M - Thin Ah, Lime
7/ao	S - Wet, Lime, Thin Ah
8/c3 8/d3	S - Stony, otherwise SL
8/E3 8/e3	S - Stony M - Slope, Er
8/F3	S - Slope, Er, Stony
9/G3 9/G4	VS - Slope, Er, Lime
10/Eo	M - Slope, Er
10/Fo	S - Slope, Er
11/ao	S - Wet, Saline, Lime
12/b1	S - Solz, Sl Perm, Thin Ah

1. For explanation, see Soil Map.
2. SL - None to slight, M - Moderate, S - Severe, VS - Very severe

Abbreviations

BR - Shallow depth to bedrock
Clay - High clay content
Er - Erosion hazard
Flood - Flooding hazard (overflow)
Lime - High lime content (soil nutrient imbalance)
Org - Organic Soil
Org Surf - Organic surface layer >15 cm thick
R Perm - Rapid permeability(droughtiness)
Saline - Surface soil salinity
Sandy - Sandy surface texture
Slope - Excessive slope
Sl Perm - Slow permeability
Solz - Solonetzic soil
Stony - Surface stoniness
Thin Ah - Thin or no Ah horizon
Wet - Seasonally high groundwater table or surface ponding

Table 10. Soil Limitations for Paths

Map Symbol[1]	Degree of Limitation[2]
1/bT 1/CT 1/cT 1/dT	SL
1/b2 1/c2 1/d2	M - Stony
1/F2 1/f2	S - Slope, Er M - Stony
2/GT	VS - Slope, Er
3/bo	SL
4/bo	M - Flood
5/bo 5/bT	M - Flood
6/bo	SL
7/ao	S - Wet, Slip, Flood
8/c3 8/d3	S - Stony, otherwise SL
8/E3 8/e3	S - Stony M - Slope, Er
8/F3	S - Slope, Stony, Er
9/G3 9/G4	VS - Slope, Er, Stony
10/Eo	M - Slope, Er
10/Fo	S - Slope, Er
11/ao	S - Wet
12/bT	S - Solz, Clay, Slip

1. For explanation, see Soil Map.
2. SL - None to slight, M - Moderate, S - Severe, VS - Very severe.

Abbreviations

Clay - High clay content
Er - Erosion hazard
Flood - Flooding hazard (overflow)
Org - Organic soil
Org Surf - Organic surface layer >15 cm thick
Sandy - Sandy surface texture
Slip - Slippery or sticky when wet
Slope - Excessive slope
Solz - Solonetzic soil
Stony - Surface stoniness
Wet - Seasonally high groundwater table or surface ponding

Table 11. Soil Limitations for Trails

Map Symbol[1]	Degree of Limitation[2]
1/bT 1/b2 1/CT 1/cT 1/c2 1/dT 1/d2	SL
1/F2 1/f2	M - Slope, Er
2/GT	S - Slope, Er
3/bo	SL
4/bo	M - Flood
5/bo 5/bT	M - Flood
6/bo	SL
7/ao	S - Wet, Slip, Flood
8/c3 8/d3	M - Stony, otherwise SL
8/E3 8/e3	M - Er, Stony
8/F3	S - Er, Slope, Stony
9/G3 9/G4	S - Slope, Er, Stony
10/Eo	SL
10/Fo	M - Slope, Er
11/ao	S - Wet
12/bT	S - Solz, Clay, Slip

1. For explanation, see Soil Map.
2. SL = None to slight, M - Moderate, S - Severe, VS - Very severe

Abbreviations

Clay - High clay content
Er - Erosion hazard
Flood - Flooding hazard (overflow)
Org - Organic soil
Org Surf - Organic surface layer >15 cm thick
Sandy - Sandy surface texture
Slip - Slippery or sticky when wet
Slope - Excessive slope
Solz - Solonetzic soil
Stony - Surface stoniness
Wet - Seasonally high groundwater table or surface ponding

Table 12. Soil Limitations for Road Location

Map Symbol[1]	Degree of Limitation[2]
1/b1 1/b2 1/C1 1/c1 1/c2	S - Frost, M Sh-Sw
1/d1 1/d2	S - Frost, M Sh-Sw, Er
1/F2 1/f2	S - Slope, Frost, Er
2/G1	VS - Slope, Er
3/bo	S - Frost, M Sh-Sw M - Er
4/bo	S - Frost, M Sh-Sw M - Flood, Er
5/bo 5/b1	M - Flood
6/bo	M - Wet, Flood
7/ao	VS - Flood, Wet, Frost
8/c3 8/d3	S - Frost, M Sh-Sw, Er
8/E3 8/e3	S - Frost, Er, Slope
8/F3	S - Slope, Frost, Er
9/G3 9/G4	VS - Slope, Frost, Er
10/Eo	M - Slope, Er
10/Fo	S - Slope, Er
11/ao	S - Wet
12/b1	S - Clay, Frost, Sh-Sw

1. For explanation, see Soil Map.
2. SL - None to slight, M - Moderate, S - Severe, VS - Very severe

Abbreviations

BR - Shallow depth to bedrock
Clay - High clay content
Er - Erosion hazard
Flood - Flooding hazard (overflow)
Frost - Susceptibility to frost heave
M Sh-Sw - Moderate shrink-swell potential
Org - Organic soil
Sh-Sw - High shrink-swell potential
Slope - Excessive slope
Stony - Surface stoniness
Wet - Seasonally high groundwater table or surface ponding

Table 13. Soil Suitability for Source of Roadfill.

Map Symbol[1]	Degree of Limitation[2]	Map Symbol	Degree of Limitation
1/bT 1/b2 1/CT 1/cT 1/c2	P - Frost, M Sh-Sw	8/F3	P - Frost, Er, Slope
		9/G3 9/G4	P - Slope, Frost, Er
1/dT 1/d2	P - Frost, M Sh-Sw, Er	10/Eo	G
1/F2 1/f2	P - Frost, Er, Slope	10/Fo	F - Slope, Er
2/GT	P - Slope, Er	11/ao	P - Wet
3/bo	P - Frost, M Sh-Sw F - Er	12/bT	P - Clay, Frost, Sh-Sw
4/bo	P - Frost, M Sh-Sw F - Er		
5/bo 5/bT	G		
6/bo	F - Wet		
7/ao	P - Flood, Wet, Frost		
8/c3 8/d3	P - Frost, M Sh-Sw, Er		
8/E3 8/e3	P - Frost, Er, M Sh-Sw		

1. For explanation, see Soil Map.
2. G - Good, F - Fair, P - Poor, VP - Very poor

Abbreviations

BR - Shallow depth to bedrock
Clay - High clay content
Er - Erosion hazard
Flood - Flooding hazard (overflow)
Frost - Susceptibility to frost heave
M Sh-Sw - Moderate shrink-swell potential
Org - Organic soil
Sh-Sw - High shrink-swell potential
Slope - Excessive slope
Stony - Surface stoniness
Wet - Seasonally high groundwater table or surface ponding

Table 14. Soil Suitability for Source of Sand or Gravel

Map Symbol[1]	Degree of Limitation[2]
1/b1 1/b2 1/C1 1/c1 1/c2 1/d1 1/d2 1/F2 1/f2	VP - Text
2/G1	VP - Text
3/bo	P - OB
4/bo	F - OB
5/bo 5/b1	G
6/bo	F - Wet, OB
7/ao	P - Flood, Wet, OB
8/c3 8/d3 8/E3 8/e3. 8/F3	VP - Text
9/G3 9/G4	VP - Text
10/Eo 10/Fo	VP - Text
11/ao	P - Wet, Thin, OB
12/b1	VP - Text, Wet

1. For explanation, see Soil Map.
2. G - Good, F - Fair, P - Poor, VP - Very poor

Abbreviations

Flood - Flooding hazard (overflow)
OB - Excessive overburden
Org - Organic soil
Text - Unsuitable texture
Thin - Thin deposit of sand or gravel
Wet - Seasonally high groundwater table or surface ponding

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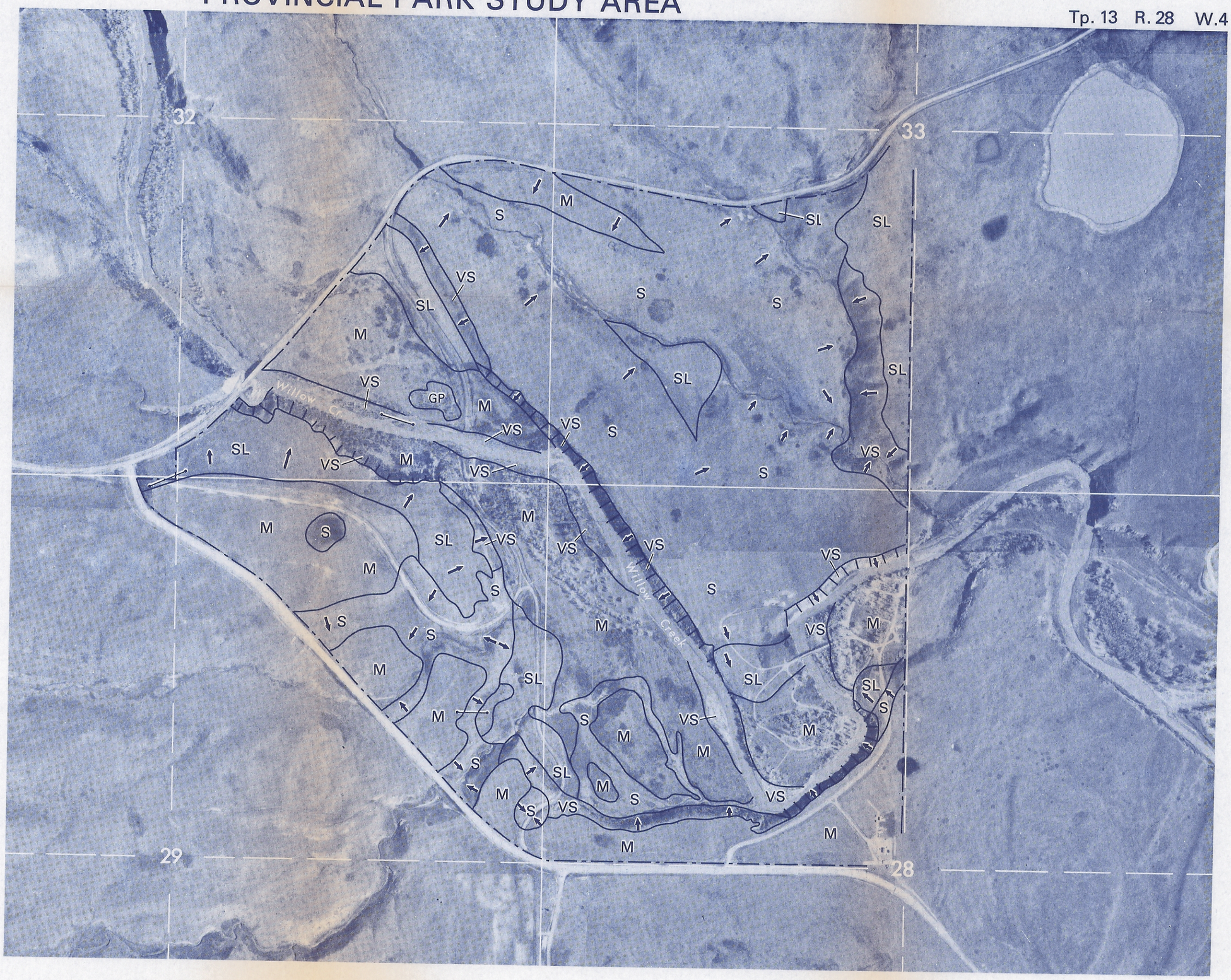
SOIL LIMITATIONS FOR RECREATION IN WILLOW CREEK PROVINCIAL PARK STUDY AREA

Tp. 13 R. 28 W.4



LEGEND:

SL	- none to slight soil limitations
M	- moderate soil limitations
S	- severe soil limitations
VS	- very severe soil limitations
———	- soil limitation line
—— - ——	- boundary of mapped area
←	- direction of slope
⊥⊥⊥⊥⊥	- escarpment
GP	- gravel pit

APPROXIMATE SCALE 1:8000

666 0 666 1332 1998 Feet

160 0 160 320 480 Metres

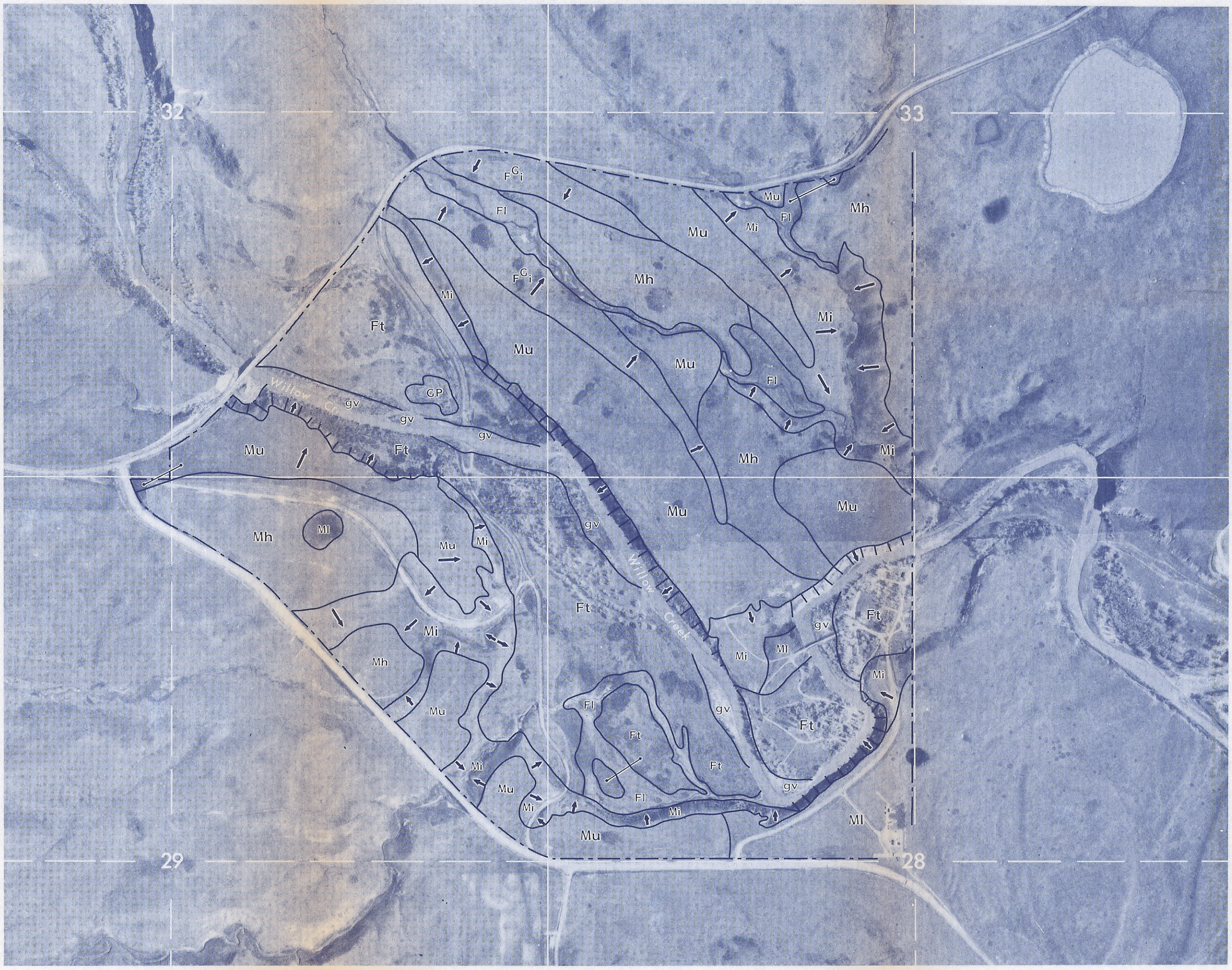
Compiled on uncontrolled mosaic
Mapped and Compiled by:
G.M. Greenlee, P. Ag.
Soils Department
1982

Alberta
RESEARCH COUNCIL

1983-7 1/3

LANDFORM MAP OF WILLOW CREEK PROVINCIAL PARK STUDY AREA

Tp. 13 R. 28 W.4



LEGEND:

F - Fluvial

- Fl - level fluvial
- Ft - fluvial terrace
- F^{G}_{i} - inclined glaciofluival

M - Morainal

- Mh - hummocky morainal
- Mi - inclined morainal
- Ml - level morainal
- Mu - undulating morainal

- landform line
- boundary of mapped area
- direction of slope
- escarpment

gv - gravel bar

GP - gravel pit

APPROXIMATE SCALE 1:8000

666 0 666 1332 1998 Feet

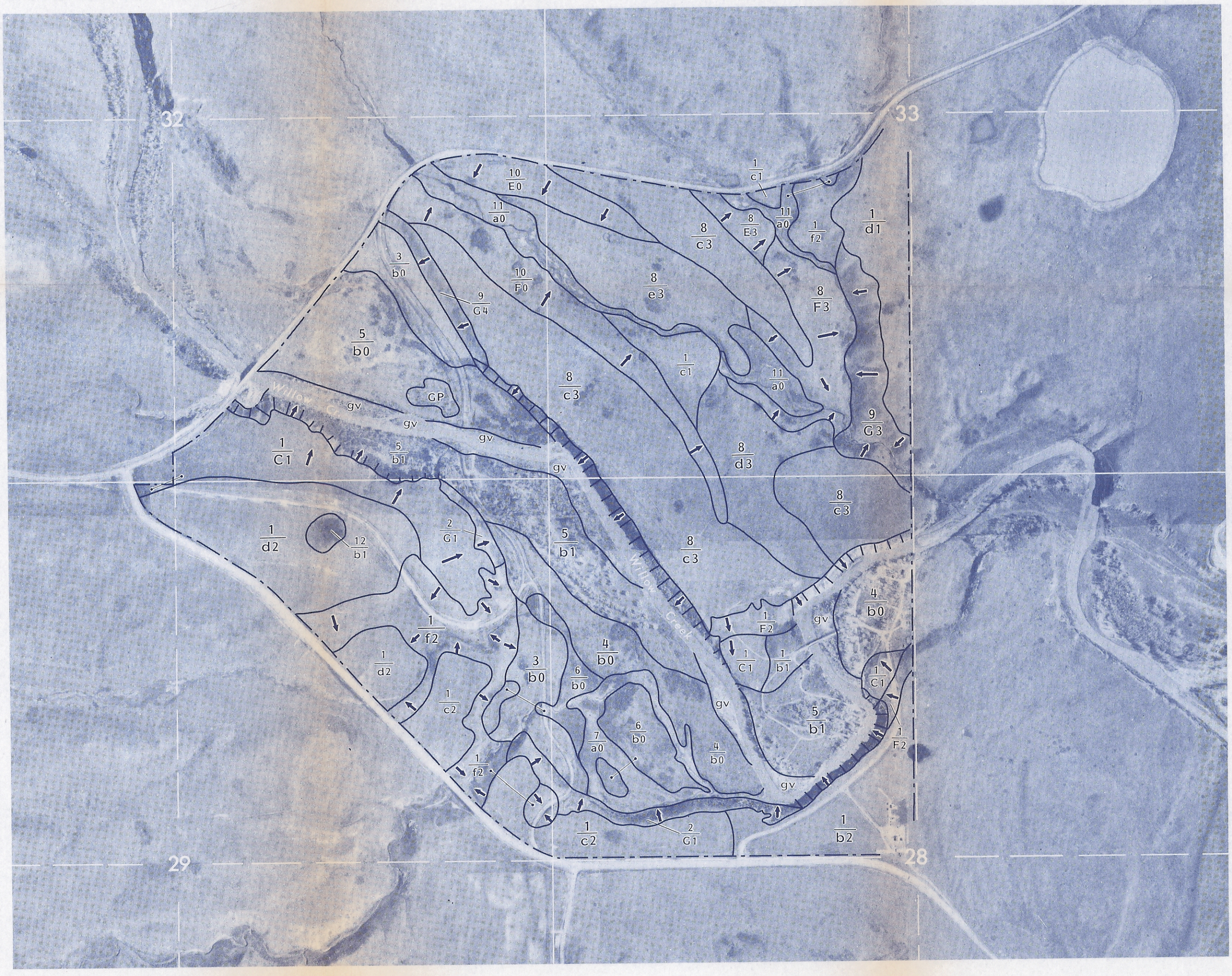
160 0 160 320 480 Metres

Compiled on uncontrolled mosaic
Mapped and Compiled by:
G.M. Greenlee, P. Ag.
Soils Department
1982

Alberta
RESEARCH COUNCIL

SOIL MAP OF WILLOW CREEK PROVINCIAL PARK STUDY AREA

Tp. 13 R. 28 W.4



SOIL CLASSIFICATION			
MAP UNIT	SOIL ORDER	SOIL SUBGROUP	SOIL PARENT MATERIAL
1	Chernozemic	Calcareous Dark Brown - 70% Orthic Dark Brown 30 %	medium to moderately coarse textured till
2	Chernozemic	Orthic Black and Calcareous Black	medium to moderately fine textured till
	Regosolic	Orthic Regosol	
3	Chernozemic	Calcareous Dark Brown	medium to moderately fine textured fluvial sediments
4	Chernozemic	Rego Dark Brown	medium to moderately coarse textued fluvial sediments
5	Regosolic	Orthic Regosol	medium to moderately coarse textured fluvial sediments, overlying very coarse textured fluvial sediments (gravel)
6	Regosolic	Gleyed Regosol	medium to moderately coarse textured fluvial sediments
7	Gleysolic	Rego Gleysol	medium to moderately fine textured fluvial sediments
8	Chernozemic	Orthic Dark Brown	moderately coarse to moderately fine textured cobbly stony till
9	Regosolic	Orthic Regosol - 60%	moderately coarse to moderately fine textured cobbly stony till
	Chernozemic	Calcareous Dark Brown - 40%	
10	Chernozemic	Orthic Dark Brown	moderately coarse to moderately fine textured glaciofluvial sediments
11	Gleysolic	Rego Gleysol, saline phase	medium to very coarse textured fluvial sediments
12	Solonetzic	Gleyed Solonetz	fine textured lacustro-till

LEGEND:

Map Symbol:

4/e0 — map unit; surface stoniness rating; topographic class

- soil line
- boundary of mapped area
- direction of slope
- escarpment
- gv - gravel bar
- GP - gravel pit

APPROXIMATE SCALE 1:8000

666 0 666 1332 1998 Feet

160 0 160 320 480 Metres

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