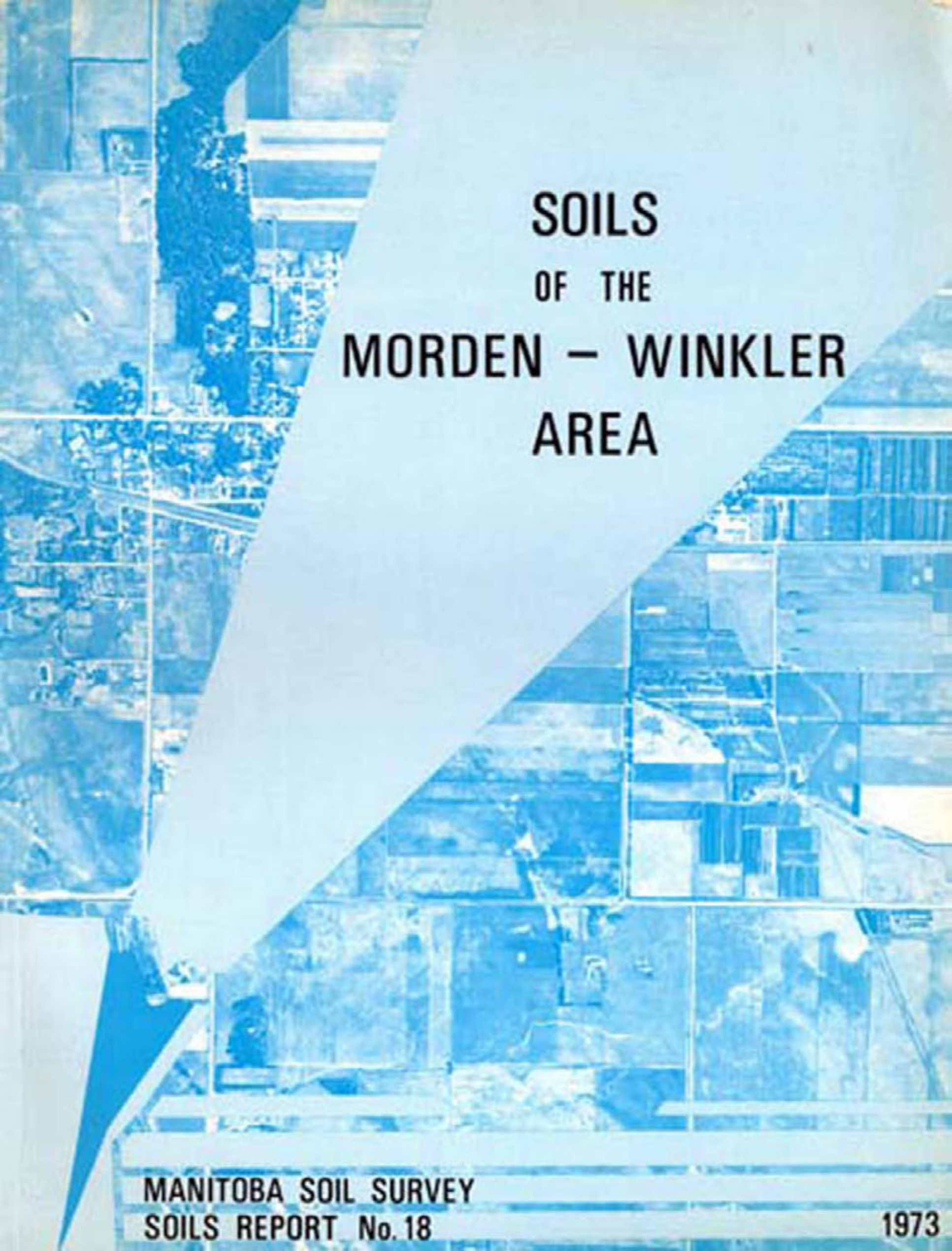

SOILS OF THE MORDEN – WINKLER AREA

MANITOBA SOIL SURVEY
SOILS REPORT No. 18

1973

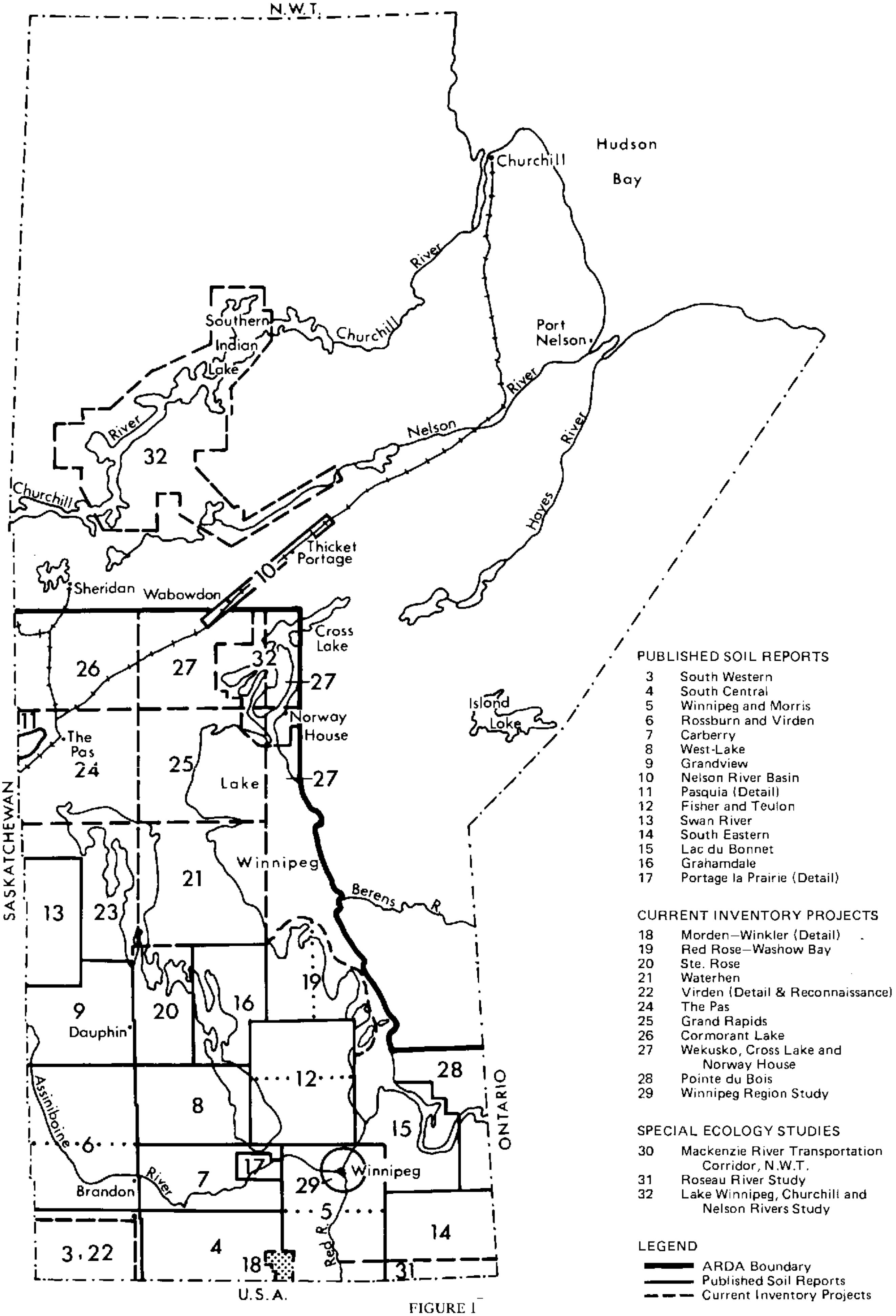

FIGURE 1

Sketch showing published Soil Survey Reports.

SOILS

of the

MORDEN-WINKLER AREA

by

R. E. SMITH, W. MICHALYNA

With a Section on

ENGINEERING AND LAND USE PLANNING

by

G. WILSON
Soils Research Institute, Ottawa

MANITOBA SOIL SURVEY

CANADA DEPARTMENT OF AGRICULTURE
MANITOBA DEPARTMENT OF AGRICULTURE
MANITOBA DEPARTMENT OF MINES AND NATURAL RESOURCES
DEPARTMENT OF SOIL SCIENCE, THE UNIVERSITY OF MANITOBA

Published by the Manitoba Department of Agriculture
Mosaic maps published by Canada Department of Agriculture

PREFACE

The report of the Morden-Winkler soil study is the second in a new series of soil surveys describing the nature of soils in Manitoba. This new series is intended to replace the old reconnaissance or low intensity surveys which, because of mapping scale, are too broad to show many important local soils, and which are out of date with respect to present state of knowledge of soils and systems of soil classification. This new survey benefits from advantages derived from more intensive examination of soils in the field, use of modern aerial photographs, improved methods of studying soils in the laboratory and improved methods of presenting such data to land managers.

The new survey not only recognizes the need for more detailed soils information necessary for a constantly changing industry such as agriculture, but also recognizes the ever broadening spectrum of non-agricultural uses to which such information can be applied.

This report of the detailed survey of the Morden-Winkler area contains information that can be applied in managing farms, judging suitability of tracts of lands for agriculture, assessing soil suitability for irrigation, evaluating the engineering properties of soils for building materials and construction sites, and evaluating soil properties for urban and recreational development.

All of the soils of the Morden-Winkler area are shown on the detailed map following the written report. The map consists of many sheets that are prepared from aerial photographs. Each sheet is numbered to correspond with numbers shown in the Index to Map Sheets. On each sheet of the map, soil areas are outlined and identified by symbol. All areas marked with the same symbol are the same kind of soil.

Individual colored maps showing the relative suitability or limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretive maps not included in the report can be developed by grouping the soils according to their suitability or limitations for a particular use. Farmers and those who work with farmers can learn about use and management of soils in the chapter on "Agriculture". Engineers and builders will find, under "Engineering and Land Use Planning", tables that give engineering descriptions of soils in the area and soil features that affect engineering practices and structures. Community planners and others can read about the soil properties that affect the choice of residential sites, industrial sites, schools, parks in the section on "Soils and Community Development" and "Soils and Recreation". Scientists, students, teachers and others can read about how the soils were formed and how they were classified in the chapters on "Factors Affecting Soil Formation" and "Soil Formation, Classification and Morphology of Soils". Newcomers to the area may be especially interested in the section "General Description of the Area" and the "General Soil Map of the Morden-Winkler Area" where broad patterns of soils are described. In all, the map and report provide a valuable introduction to the soil resources of the Morden-Winkler area

ACKNOWLEDGEMENTS

The report of the Soils of the Morden-Winkler Area was conducted as a joint project of the Research Branch, Canada Department of Agriculture; the Manitoba Department of Agriculture; the Manitoba Department of Mines, Resources and Environmental Management; and the University of Manitoba.

Grateful acknowledgement is made to the following persons and agencies:

Dr. W. A. Ehrlich, as Director of the Manitoba Soil Survey (retired), who, from 1955 to 1964, provided valuable guidance and assistance in conducting the study in the early stages of the project.

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Mr. M. Rutulis, Water Resources Division, Department of Mines, Resources and Environmental Management for information regarding the groundwater characteristics of the Morden-Winkler map area.

The Manitoba Crop Insurance Corporation, and especially Mr. J. Ewanek, for assistance in compiling crop yield data for the area.

Mr. R. Milne of the Soil Science Section of the Lethbridge Research station, Canada Department of Agriculture, for assistance in the field and laboratory investigations of the soils to determine their suitability for irrigation.

The Cartographic Section, Soil Research Institute, Ottawa, for publishing the soil maps.

The Manitoba Department of Agriculture for publishing the written report.

The soils in the map area were mapped by L. E. A. Pratt, the late F. P. LeClaire, W. Michalyna, and F. Wilson assisted by D. Anderson, G. Beke, K. Kirkpatrick and D. A. Sturrock. Laboratory analyses were conducted by E. St. Jacques and J. G. Mills. Preparation of map manuscripts and sketches were compiled by Messrs. R. DePape, B. Lezak, N. Lindberg and J. Griffiths. Miss B. Stupak provided assistance in compiling the report and typing the manuscript for publication.

SUMMARY

The Morden-Winkler soil study covers an area of approximately 177,920 acres located in the fertile western section of the Red River Valley Plain, immediately north of the International Boundary in Townships 1 to 3 and Ranges 3 to 6W.

The cool, subhumid, continental climate of the area is favorable for a wide range of agricultural crops. Average values for maximum and minimum temperature, degree days above 42°F, growing season above 42°F, freeze free period, are among the highest for the province. Approximately 60 percent of the average annual precipitation of about 20 inches occurs between May and October.

Soil parent material overlying Mesozoic and Paleozoic bedrock formations are characteristic of off-shore lacustrine sediments of Glacial Lake Agassiz. They are dominantly strongly calcareous, range in texture from moderately coarse sandy to very fine clayey and are dominantly somewhat poorly to poorly drained. The topography is smooth level to very gently sloping. Surface runoff is slow, as is internal drainage, due to slow permeability of 75 percent of the soils in the area.

Somewhat poorly drained Gleyed Black (73 percent), Orthic Black (15 percent) and Gleyed Cumulic Regosols (8 percent) are the dominant kinds of soils found in the area. Gleyed Saline Blacks comprise only 3 percent of the area, while poorly drained Rego Humic Gleysols, the remaining 1 percent.

The Morden-Winkler area has some of the most productive soils in the Province on which excellent yields of cereals, grain, corn, sunflower, rapeseed, sugar beets and other horticultural crops are realized. Most of the soils are in Soil Capability Classes I to III, with none to moderate limitations for the growing of regional crops. The dominant management problems in the area are maintaining adequate surface drainage, adequate fertility and tilth and preventing the erosion of organic matter-rich surface horizons by wind. The moderately coarse to moderately fine textured soils are used for cereal grain in rotation with horticultural crops, while the fine textured soils are used for cereal grains and forage.

Classification of the soils in the Morden-Winkler area for irrigation suitability places approximately 25 percent as very good, 35 percent as good, 13 percent as fair and 25 percent as unsuitable. The dominant landscape features and properties of soils affecting suitability for irrigation are slow surface runoff, slow to very slow permeability of the sediments and high groundwater conditions that exist in the Morden-Winkler area.

Most of the problems in the use of the soils for engineering projects and urban development purposes are related to the high shrink-swell properties of the medium to fine textured soils of the area, the high content of non-granular material and slow to very slow permeability of the soil material, the high seasonal groundwater levels predominant in the area, slow surface runoff and the periodic threat of inundation by spring meltwater runoff. About 75 percent of the soils of the area fall in the A-4 to A-7 textural categories in the AASHO system, and ML to CH categories in the Unified System.

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Soils of the MORDEN-WINKLER AREA

GENERAL DESCRIPTION OF AREA

LOCATION AND EXTENT

The Morden-Winkler detailed soil study covers an area of 177,920 acres situated immediately north of the International Boundary, and east of the Manitoba Escarpment including part of the municipalities of Rhineland and Stanley. It covers all of townships 1, 2, and 3, ranges 3 and 4W, township 3, range 5W, sections 36, 35, 25 and 24 of township 3, range 6W; sections 36, 35, 34, 33, 28, 27, 26, 25, 24, 23, 22, 15, 14, 13, 12, 11, 10, and 1 of township 2, range 5W, and sections 36, 25, 24, and 13 of township 1, range 5W (Figure 1).

POPULATION

According to the 1971 census, the Study Area had a population of approximately 11,390 people. This represents a population density of 41.0 people per square mile. However, 59.0 percent of the population is concentrated in the towns of Morden, Winkler, and Plum Coulee; while 15 percent live in unincorporated villages, and 26 percent live on farms.

TABLE 1

Population of Towns and Villages of the Morden-Winkler Area

Morden	3266	Freidensruh	78
Winkler	2983	Reinland	188
Plum Coulee	480	Blumenfeld	135
Neuhorst	94	Hochfeld	130
Rosengart	71	Osterwick	166
Schoenweise	66	Neuenberg	86
Rosenort	102	Chortitz	203
Gnadenthal	183	Schanzenfeld	106
Blumenort	418	Reinfeld	192
Haskett	51		

HISTORY OF LAND SETTLEMENT[1]

The history of land settlement in the Morden-Winkler map area is the history of Mennonite settlement in Manitoba that began in 1873. In the short span of three years approximately 7,500 people emigrated "lock, stock and barrel" from their villages in the Russian Ukraine when exemption from compulsory military service was revoked by the Russian Imperial Government. The Canadian Government, anxious to consolidate its newly acquired territory in Manitoba, welcomed the approach of these well recognized farm folk and by Order-in-Council in 1873 and again in 1876 set aside two blocks of land for their exclusive colonization.

The first Mennonites settled in the "East Reserve" or present day Hanover Municipality located east of the Red River. The second much larger "West Reserve" or present day Rhineland Municipality and portions of Stanley, Roland and Morris Municipalities was established west of the Red River along the international boundary toward Pembina Hills.

The colonization of the West Reserve was the first major settlement ever established on the open plains of western Canada without direct access to a major lake or stream or woodland. The thriving agriculture of this area today is a testament to these people for their ability to adjust to life on the open prairies. They knew how to find water from level ground, to build and heat huts without wood, plant shelter belts for protection against prairie winds and introduced a system of cultivation suited to the plains.

Within the map area, Anglo-Saxon settlements were established at Mountain City, located on the southeast quarter of Section 24 in Township 2-6 west and at Nelsonville about 5 miles north of present day Morden at the foot of Pembina Hills. When these settlements were by-passed by a branch of the CPR in 1882 their inhabitants moved to Morden. Morden has since become an important rural business and cultural center for Mennonite and Anglo-Saxon groups.

The advent of the railroad changed the commercial structure of the West Reserve and gave rise to such non-Mennonite railroad towns as Morden, 1882; Plum Coulee, 1884 and Winkler in 1892. A mixture of Anglo-Saxon, but more particularly German Lutheran, Ruthenian and Jewish immigrants were drawn to these rural Mennonite areas because of their knowledge of these folk and their customs. By 1921 Winkler had become the capital of the West Reserve. Hasket and Horndean, smaller rural trade centers, were established in 1906 and 1911, respectively. Altona, located about 6 miles east of the map area, and founded in 1895, has become the seat of the rural municipality of Rhineland and an important center of Mennonite business and cultural activities.

In the colonization of the reserves the Mennonites established within the framework of the square system of survey, a pattern of small nucleated villages and a form of cooperative, open-

[1] The authors have drawn freely from the published works of E. K. Francis, "In Search of Utopia, The Mennonites in Manitoba", 1955 and J. Warkentin, "Manitoba Settlement Patterns", papers read before the Historical and Scientific Society of Manitoba, Series III, No. 17, pp. 62-77.

field, strip farming which they brought with them from Russia. A group of approximately 20 settlers would pool their 160 acre homesteads to form village land, from which they would select a central site for a village habitat and divide land into arable, hay meadow and pasture fields. Further subdivision provided individual fields for individual use. The sectional survey and the homestead regulations controlled the size of these open field villages. Some 120 villages were established between 1874 and 1894, but not more than 80 functioned. Today only a few such village settlements remain. The open field or strip system of farming proved to be inefficient. Fragmented fields forced excessive, wasteful travelling. It also limited individual expansion. Many found it too confining under such a system. As a consequence, movement away from the villages to individual farmsteads occurred almost from the beginning of settlement. The rapid development of the railway system in western Canada and the greatly increased efficiency of production due to improvement in agricultural technology in the decade of the 1880's accelerated the break-up of many villages. While some strip farming is still practised today, most farmers now go out to quarter sections or multiples of quarters from individual farmsteads.

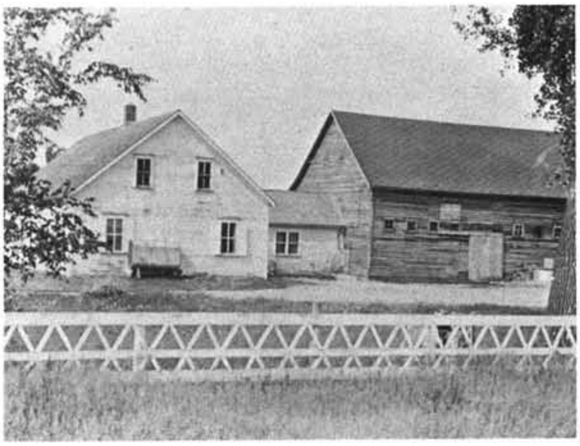

FIGURE 2
Village house and barn, Chortitz. Today only a few such habitats are found in the district.

TRANSPORTATION AND MARKETS

The Winkler Area is well provided with road and rail facilities that converge upon Winnipeg. An improved earth or all weather road surrounds most sections. In addition, the area is traversed from east to west by provincial highways 3 and 14, and from north to south by highways 3 and 22. The Canadian Pacific Railway traverses the area, passing through Morden, Winkler, and Plum Coulee (Figure 3).

Much of the agricultural produce is marketed outside the area. Locally grown peas, corn and beans are processed at canning plants located at Morden and Winkler. Sugar beets are grown under contract from the Manitoba Sugar Company in Winnipeg 80 miles northeast of the map area, and sunflowers are processed at Altona just to the east of the map area. Most of the potatoes and onions grown are marketed in Winnipeg. Creameries are located at Morden and Winkler for processing of dairy products. A poultry processing plant is also in operation at Morden.

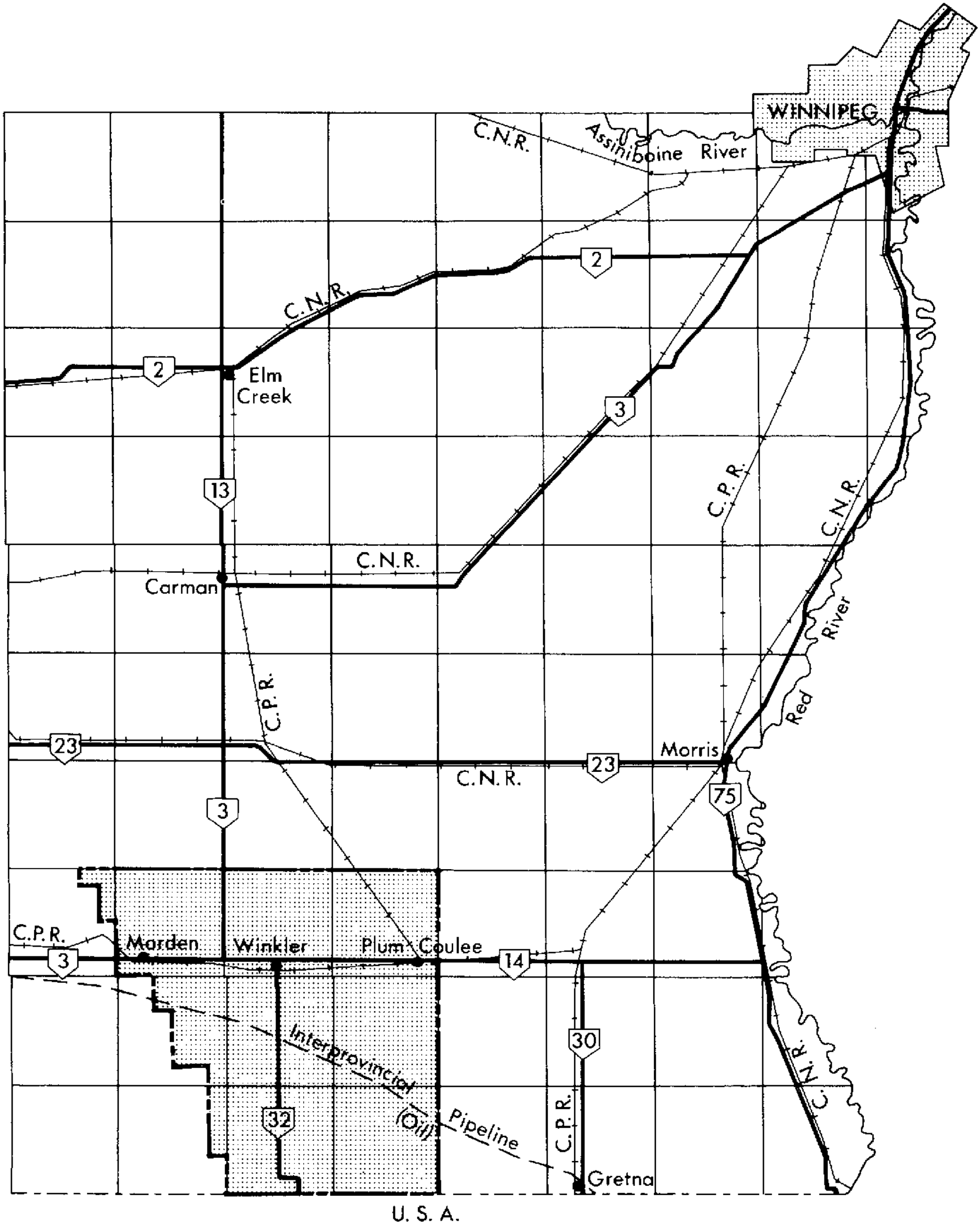

FIGURE 3

Towns, Villages and Main Transportation Routes located in the Morden-Winkler Area in relation to Winnipeg.

FACTORS AFFECTING SOIL FORMATION

GEOLOGY AND SOIL PARENT MATERIALS

Precambrian rock in this area is overlain by deposits of paleozoic and mesozoic age (Figure 4). The rocks of the mesozoic era are comprised of the Amaranth, Sundance, Swan River, Ashville, Favel, and Vermillion River formations. However, only the rocks of the Vermillion River formation outcrop in this area along the face of the Manitoba Escarpment and in the valleys of deeply incised streams issuing from it. This formation is made up of three beds - the Pembina beds, the Boyne beds, and the Morden beds. The Pembina beds are dark grey to black non-calcareous shale with numerous bands of bentonite near its base. Underlying these beds are the Boyne beds consisting of calcareous shale with a few beds of bentonite and some dark grey non-calcareous shale. The Morden beds lie below the Boyne beds and are not exposed in this area. They consist of calcareous speckled shale over non-calcareous dark grey to black blocky type shale[1].

Overlying the bedrock is glacial till deposited by continental glaciers during the Pleistocene era. This till varies in thickness from a few feet to as much as 240 feet where it was deposited in a preglacial valley running through Winkler and Roland[2]. The average thickness seems to be 20 to 30 feet, but varies from 5 to 20 feet thick along the Manitoba Escarpment to about 50 feet thick along the eastern part of the area. This till is composed of shale and clay mixed with stones and rock flour derived from granitic and limestone rocks carried into the area by glaciers (see Figures 4 and 5).

Recession of the ice resulted in the formation of Lake Agassiz. Beaches formed along the edge of this lake at elevations of 1230 to 1022 feet A.S.L. measured at the International Boundary. These beaches have been named the Herman, Norcross, Tintah and Campbell beaches[3]. Most of the lacustrine sediments found in this area were deposited during the higher stages of the lake. Thickness of the clay varies from about 160 feet in the eastern part to about 50 feet in the western part, with an average thickness of about 125 feet[2]. With the lowering of the lake to the Campbell beach stage (1022 feet A.S.L.), a broad delta of sandy textured material was deposited overlying the clay. These materials lie immediately adjacent to the Manitoba Escarpment, and have subsequently been modified by wave action as the level of the lake receded. The most notable feature of this modification in the Morden-Winkler area is the Emerado beach which runs diagonally southeast-northwest through 5-1-3W and 36-3-5W. This beach, which corresponds roughly to the 900 foot contour, forms a division in the delta. Sediments at elevations above the beach to the west are somewhat coarser, deeper, and more uniform in texture than those below the beach, which are finer textured, shallower, more stratified and more saline.

Dates directly related to Glacial Lake Agassiz sediments suggest that deposition occurred between 8,000 and 12,000 years ago[4]. Since then, the level of the lake has been receding until the only major remnants now remaining are Lake Winnipeg, Lake Manitoba and Lake Winnipegosis.

Subsequent erosion and stream action has carried clay materials from the shaly material of the Manitoba Escarpment and deposited it as alluvial fans over the sandy materials immediately adjacent to the escarpment. Similar deposition of alluvial fans also occurred in areas below the Emerado Beach to the east. Dates for this alluvial material are younger than those of Glacial Lake Agassiz, suggesting that recent deposition began some 3,000 to 6,000 years ago[4].

RELIEF AND DRAINAGE

The most prominent relief feature in the Morden-Winkler area is the Manitoba Escarpment. Here elevation rises 400 feet in a horizontal distance of about 1 mile to 1500 feet A.S.L. The Shannon Creek, Dead Horse Creek, Plum Coulee Creek, Reinland Creek, and several smaller streams provide good surface drainage (Figure 6).

From the Manitoba Escarpment to the Emerado Beach, the elevation drops 10 to 15 feet per mile. The above mentioned streams and several additional ones traverse the area. These streams have eroded channels 12 to 15 feet deep. Surface runoff and internal drainage in this area is good because of slope and fairly rapid permeability of the sediments. Numerous shallow depressions occur, but these hold water only for short periods in the spring or after heavy summer rains.

From the Emerado Beach eastward, the terrain falls very gradually at a rate of about 3 to 5 feet per mile. The topography is smooth and level to gently sloping. The streams lack the well-developed courses they have above the Emerado Beach. Surface runoff and internal drainage is not as good below the beach as it is above the beach because of reduced slope and slow permeability of the sediments. Construction of road ditches and drainage ditches since settlement has greatly improved drainage throughout this section of the map area.

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[1]Tovell, W. M. 1951. Preliminary Report of the Geology of the Pembina Valley — Deadhorse Creek Area. Dept. of Mines and Natural Resources, Province of Manitoba.

[2]Charron, J. E. 1961. Geological Survey of Canada, Dept. of Mines and Technical Surveys Paper 60-22.

[3]Upham, W. 1890. Glacial Lake Agassiz in Manitoba. Geological and Natural Survey of Canada.

[4]Life, Land and Water. Proceedings of the 1966 Conference on Environmental Studies of the Glacial Agassiz Region. Edited by W. J. Mayer-Oakes, University of Manitoba Press, Winnipeg, Manitoba.

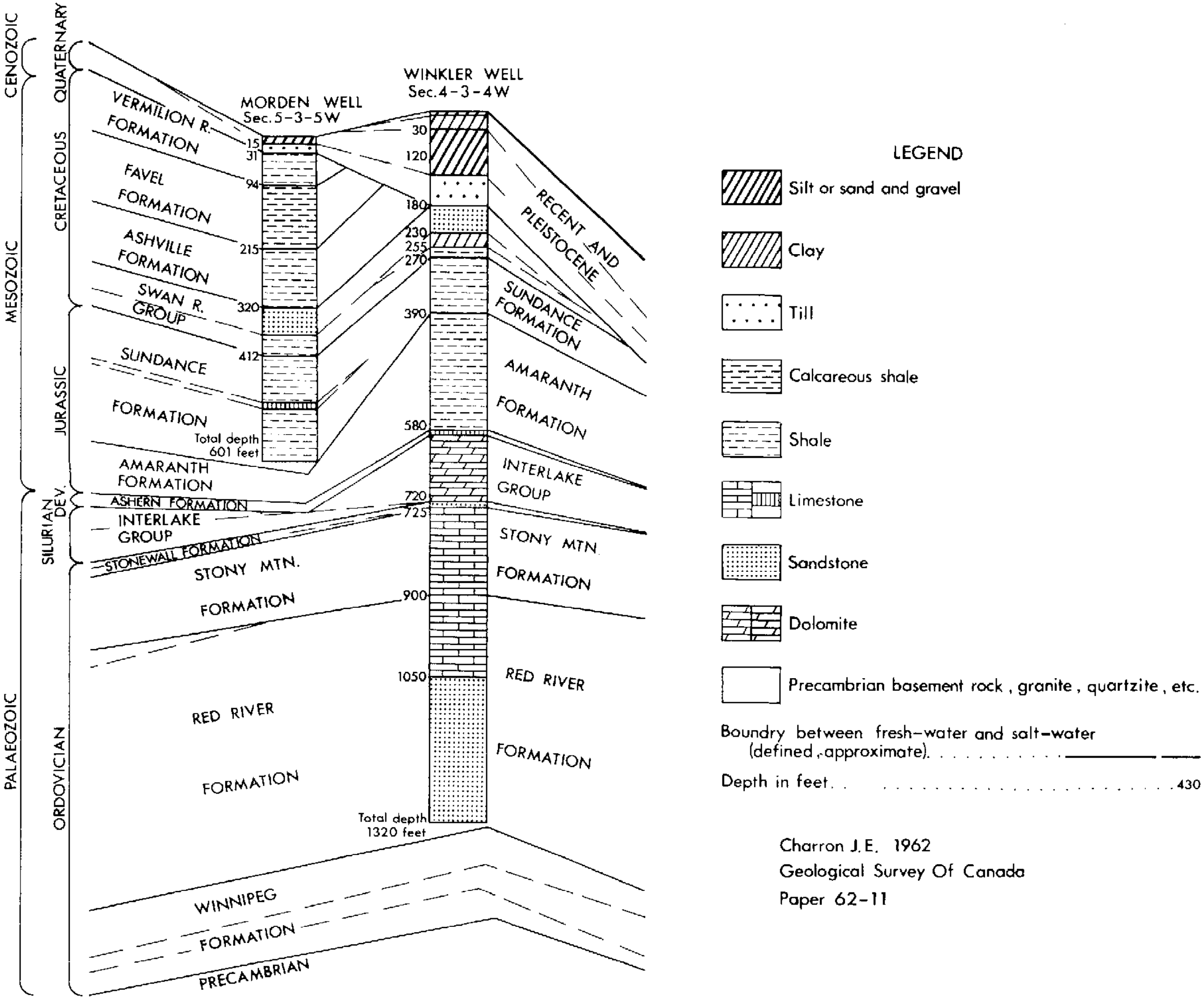

FIGURE 4
Bedrock formations underlying surface deposits.

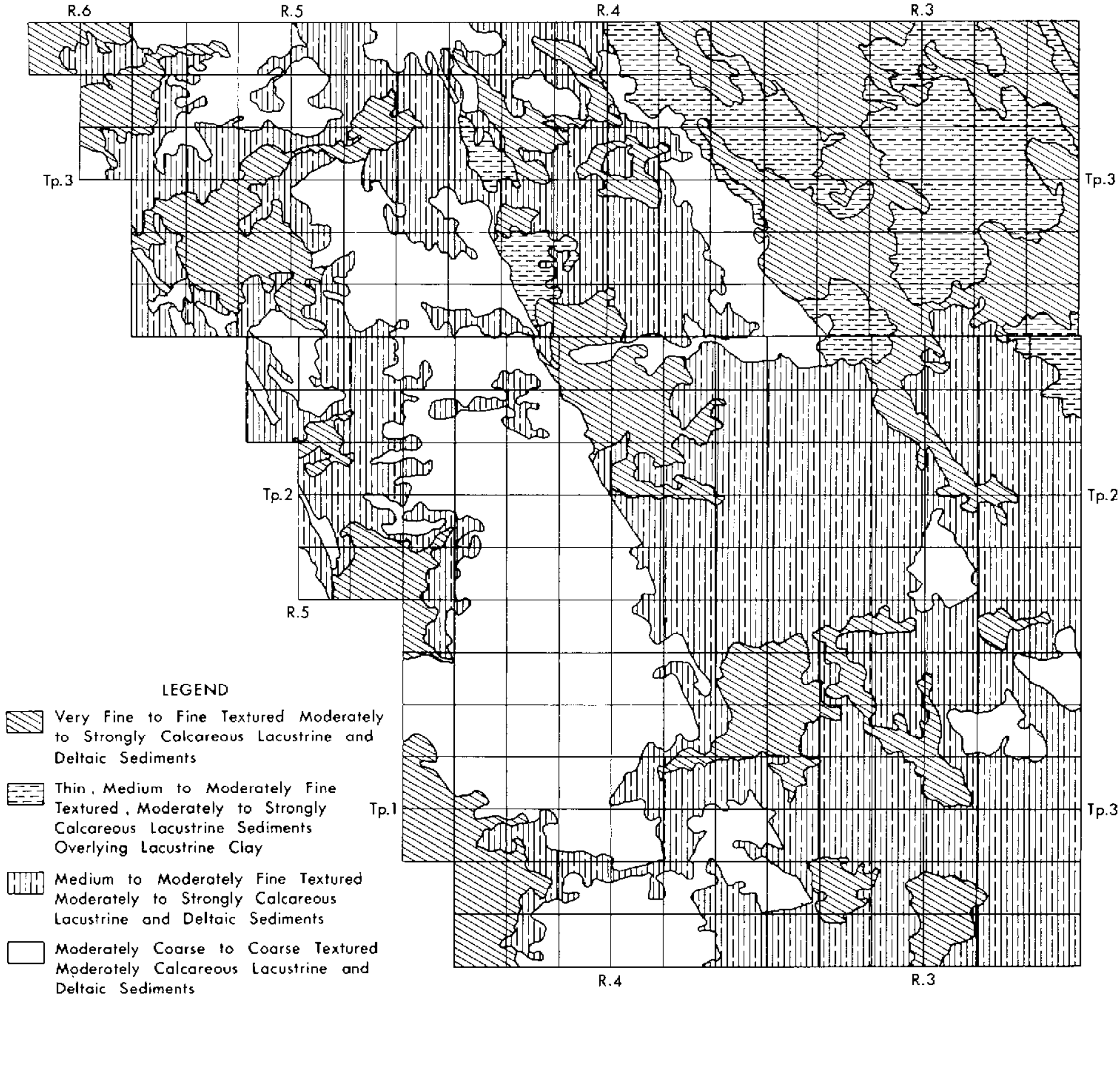

FIGURE 5
Distribution of surface deposits.

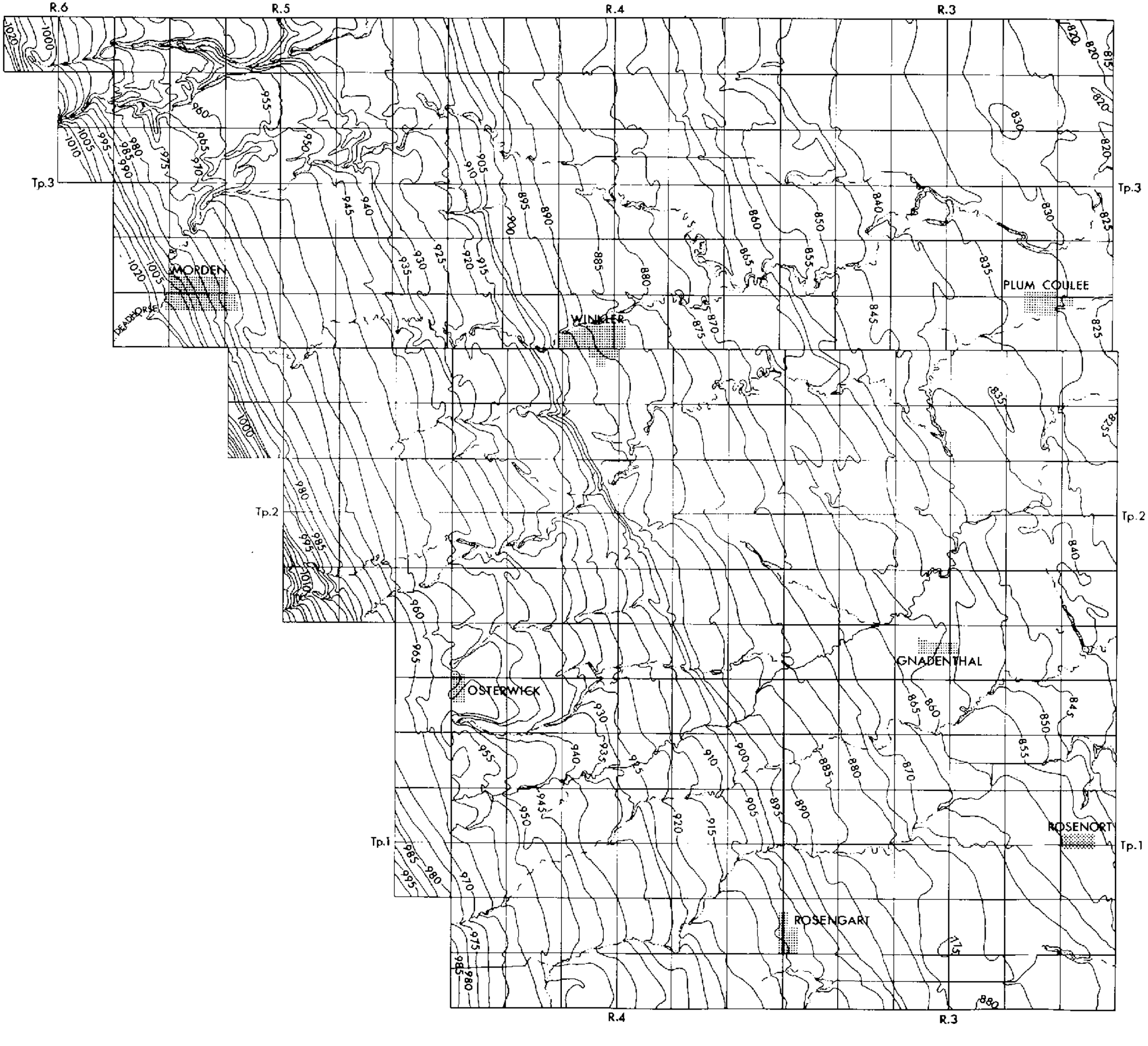

FIGURE 6
Drainage systems and contour map.

CLIMATE

The climate of the Winkler area has been designated by Koppen as Dfb[1], subhumid with a definite summer precipitation maximum. Due to its location in the centre of the continent, winter temperatures are lower and summer temperatures higher than the world average for the same latitude.

Some of the climatic characteristics of the Morden-Winkler area are summarized in Tables 2 to 5.

Williams-Hopkins Agroclimatic Estimates for three points in the vicinity of the map area (Table 2) show that temperature characteristics over all of the map area are very uniform and very favorable for a wide range of agricultural crops. Average values for maximum and minimum temperature, degree days above 42°F, growing season above 42°F, freeze-free season are among the highest for the province.

Risk analysis of date of the last critical spring frost and date of the first critical autumn frost (Tables 3 and 4) were taken from Risk Analyses of Weekly Climatic Data for Agricultural and Irrigation Planning, Morden, Manitoba, 1968, by M.C. Coligado, W. Baier and W.K. Sly, Agrome-

[1]Koppen, W. and Geiger, "Handbuch der Klimatologie," Band I, Teil C. Gebruder, Borntraeger, Berlin, 1936.

TABLE 2

Williams/Hopkins Agroclimatic Estimates for Three Points in the Vicinity of the Morden-Winkler Map Area*

1. Lat. 49° 0', Long. 97° 30', elevation 819 feet A.S.L. (near Gretna)

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Maximum Monthly Temperatures °F	12	16	30	50	66	75	81	79	68	55	33	19	49
Mean Minimum	-7	-3	10	29	41	51	57	54	44	34	17	2	27
Degree Days Above 42°F	0	0	8	143	361	627	840	773	418	168	56	0	3394

Total Degree Days May 1st to Sept. 30th = 3019

Season Above 42.0° from April 20 to Oct. 20, 183 days, 2679 hours daylight

Freeze-free season (32°F) from May 21 to Sept. 18, 120 days, 1833 hours daylight

Freeze-free season (28°F) from May 11 to Sept. 29, 141 days, 2120 hours daylight

2. Lat. 49° 21', Long. 97° 44', Elevation 809 feet A.S.L. (near Roland)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Maximum Monthly Temperatures °F	11	16	29	50	66	74	81	79	67	54	32	19	48
Mean Minimum Monthly Temperatures °F	-7	-4	10	28	41	51	57	54	44	34	17	1	27
Degree Days Above 42°F	0	0	16	144	353	616	829	760	413	165	44	0	3340

Total Degree Days May 1st to Sept. 30th = 2971

Season Above 42°F from April 21 to Oct. 19, 181 days, 2654 hours daylight

Freeze-free season (32°F) from May 21 to Sept. 18, 120 days, 1833 hours daylight

Freeze-free season (28°F) from May 11 to Sept. 29, 141 days, 2120 hours daylight

3. Lat. 49° 21', Long. 98° 8', Elevation 928 feet A.S.L. (near Miami)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Maximum Monthly Temperatures °F	11	16	29	50	66	74	81	79	67	54	32	19	48
Mean Minimum Monthly Temperatures °F	-7	-4	9	28	40	51	56	54	43	33	16	1	27
Degree Days Above 42°F	0	0	8	140	349	603	826	754	406	164	47	0	3302

Total Degree Days May 1st to Sept. 30th = 2943

Season Above 42°F from April 21 to Oct. 18, 180 days, 2643 hours daylight

Freeze-free season (32°F) May 22 to Sept. 17, 118 days, 1805 hours daylight

Freeze-free season (28°F) May 12 to Sept. 28, 139 days, 2093 hours daylight

*Williams-Hopkins Agroclimatic Estimates for 1160 Points on Canadian Great Plains. Prepared by Agrometeorology Section, Plant Research Institute, Research Branch, C.D.A., Ottawa 3, June, 1968. Values were calculated using daily temperature data for the period 1931 to 1960.

teorology Section. Plant Research Institute, C.D.A., Ottawa. These values were calculated from daily records from the Morden Research Station for the period 1931 to 1960. The data suggests, for example, that in 50 years out of 100, the date of the last minimum critical temperature of 32°F will be May 22nd and that the date of the first minimum critical temperature of 32°F in autumn will be September 22nd.

Temperature and moisture relationships for the summer period May 1st to September 30 (Table 5) of importance to agriculture, were extracted from "A Report on Climatic Analysis of Weather Stations in Manitoba" by C.F. Shaykewich, Dept. of Soil Science, University of Manitoba. Average values for maximum temperatures range from about 60°F in the spring and fall to about 82°F in mid July and early August. Average values for minimum temperatures range from just above freezing in early spring and late fall to about 58°F in mid July. Temperature variability is greatest in spring and fall and least during the mid summer months of July and August.

Average weekly totals of precipitation are greatest during the first two weeks in June, and then again in the first week in August and the first week in September. Variability of rainfall is also greatest during these peak periods and least during late fall. Average total rainfall of about 12.7 inches during this summer period represents about 60 percent of the average total annual precipitation of 20.3 inches.

Of great importance to agriculture is the yearly variability of rainfall. In the Morden-Winkler area, based on records from 1885 to 1964, precipitation for the summer period May 1 to September 30 has ranged from less than 6 inches to more than 18 inches.

Most of the precipitation in summer is due to a northeasterly flow of maritime air from the Gulf of Mexico region. This moist unstable air mass

TABLE 3

Spring Date of Last Critical Freeze for a Given Risk Temperature — Degrees Fahrenheit at Morden*

Critical Temperature		20°F	24°F	28°F	32°F	40°F
Percent Risk**	Earliest	April 10	April 11	April 25	May 8	May 16
90		April 8	April 13	April 30	May 9	May 29
70		April 16	April 22	May 6	May 16	June 7
50		April 22	May 29	May 10	May 22	June 14
30		April 28	May 5	May 14	May 27	June 20
10		May 6	May 14	May 19	June 3	June 29
	Latest	May 12	May 28	May 30	June 21	July 13

*M. C. Coligado, W. Baier and W. Sly. Risk Analyses of Weekly Climatic Data for Agriculture and Irrigation Planning, Morden, Manitoba. Agrometeorology Section, Plant Research Institute, C.D.A., Ottawa 3, 1968.

**Number of years out of 100 in which minimum temperature exceeds critical temperature on given dates.

TABLE 4

Autumn Date of First Critical Freeze for a Given Risk Temperature — Degrees Fahrenheit at Morden*

Critical Temperature		40°F	32°F	28°F	24°F	20°F
Percent Risk**	Earliest	July 19	Sept. 2	Sept. 15	Sept. 15	Sept. 25
10		Aug. 11	Sept. 9	Sept. 18	Sept. 24	Oct. 3
30		Aug. 22	Sept. 17	Sept. 26	Oct. 4	Oct. 14
50		Aug. 30	Sept. 22	Oct. 2	Oct. 12	Oct. 21
70		Sept. 7	Sept. 28	Oct. 7	Oct. 19	Oct. 28
90		Sept. 19	Oct. 6	Oct. 16	Oct. 29	Nov. 8
	Latest	Sept. 20	Oct. 8	Nov. 5	Nov. 17	Nov. 17

*Ibid.

**Percent Risk means the number of years out of 100 in which minimum temperature exceeds critical temperature on given dates.

brings the familiar thunderstorms when it contacts the cooler polar air along a front that oscillates over southern Manitoba during the summer season. Hail that sometimes accompanies thunderstorms occurs most frequently in the months of June to August.

Water balance or a condition in which available water supply (precipitation) is equal to the amount plants require for optimum growth is seldom achieved in the Morden-Winkler area. For plants to have all the moisture they require in a given year, sufficient precipitation must occur to offset losses due to loss by runoff, infiltration and percolation beyond the rooting zone, the amount lost by evaporation at the surface and the amount lost by transpiration from plant surfaces. In the smooth level portions of the Morden-Winkler area where medium to fine textured soils are dominant, loss due to runoff and percolation are negligible. Potential evapotranspiration (PE) is a term used to denote loss of water to plants from evaporation and transpiration. In the Morden-Winkler area average weekly values for PE exceeds average weekly total precipitation throughout the May 1st to September 30th period (Table 5) indicating a moisture deficit situation. Average weekly deficits are greatest during July and August and least in early spring and late fall.

Very often it is useful to determine whether the climate of an area is suitable for growing a particular crop. Most plant processes are dependent, in part, on air temperature. One finds that for a particular plant, growth will not occur below a certain minimum temperature. Above this temperature growth begins and rate of growth increases with increasing temperature. Maximum rate of growth occurs at an optimum temperature. Further increases in temperature cause a decrease in growth rate.

To determine if the temperature requirements of the crop can be met, it is necessary to find some measure or standard which takes into account the way in which plant growth responds to temperature. Such a measure or standard has been developed for corn at Guelph, Ontario by Brown and

TABLE 5

Long-term Weekly Means of Maximum and Minimum Temperatures and Weekly Totals of Precipitation for the Period May 1st to September 30th*

Week Ending	Maximum Temperature		Minimum Temperature		Precipitation Inches		PE** Inches	Water Balance Precipitation / PE
	Mean	S.D.	Mean	S.D.	Mean	S.D.		
May 7	60.1	13.5	37.2	9.6	0.49	0.66	1.04	0.47
14	62.4	12.4	37.3	8.8	0.43	0.53	1.02	0.42
21	66.5	11.7	41.3	7.8	0.40	0.45	1.11	0.36
28	68.9	11.7	44.2	8.0	0.69	1.07	1.23	0.56
June 4	71.3	11.4	47.6	8.2	0.88	1.01	1.33	0.66
11	72.2	10.4	49.1	7.5	0.70	0.76	1.27	0.55
18	74.9	9.3	51.6	7.1	0.61	0.61	1.28	0.48
25	75.6	8.6	52.6	6.5	0.69	0.66	1.29	0.53
July 2	78.0	8.4	54.6	6.6	0.64	0.71	1.35	0.47
9	80.0	8.2	56.3	6.6	0.77	0.77	1.39	0.55
16	81.6	8.2	57.4	6.5	0.69	0.75	1.43	0.48
23	82.6	7.6	58.4	5.8	0.56	0.60	1.39	0.40
30	82.3	8.1	56.9	6.4	0.52	0.61	1.40	0.37
Aug. 6	82.0	8.2	57.1	5.7	0.81	0.82	1.35	0.60
13	80.3	8.9	55.4	6.7	0.56	0.64	1.27	0.44
20	79.6	8.9	54.1	6.9	0.51	0.71	1.22	0.42
27	77.3	9.6	53.4	7.4	0.48	0.63	1.09	0.44
Sept. 3	74.1	9.6	51.5	6.9	0.82	1.17	0.94	0.87
10	71.7	10.5	48.8	7.8	0.42	0.60	0.86	0.49
17	68.6	10.1	45.8	8.0	0.37	0.40	0.71	0.52
24	64.6	10.4	42.8	7.5	0.48	0.63	0.54	0.89
30	61.5	12.9	38.9	8.3	0.29	0.35	0.38	0.76

Other Weather Parameters

Average Precipitation May 1st to September 30th	–	12.7 inches
Average Annual Precipitation	–	20.3 inches
Corn Development Units (C.D.U.) May 15 to date of first killing frost in autumn	–	2497

*C. F. Shaykewich, Dept. of Soil Science, Univ. of Manitoba. Values were calculated using daily data from the Morden Research Station, C.D.A., for the period 1931 to 1968.

**PE = Potential evapotranspiration is the maximum quantity of water capable of being lost as water vapor in a given climate, by a continuous stretch of vegetation covering the whole ground and well supplied with water. PE was calculated on a daily basis by means of a formula that involved daily values of maximum temperature, temperature range, energy at the top of the atmosphere and vapor pressure deficit estimated from maximum and minimum temperatures.

his associates. This measure or standard is called the "Corn Development Unit" and is represented by the following mathematical formula:

$$C.D.U. = \frac{(T\ min - 40) + 4.39\ T\ max - .0256\ T^2\ max - 155.8}{2}$$

This unit recognizes that no growth occurs if minimum night time temperatures are below 40°F and maximum daytime temperatures are below 50°F. It also takes into account that most rapid growth takes place at a maximum daytime temperature of 86°F. When maximum temperature exceeds 86°F growth rate begins to decrease.

Corn development units are calculated daily and summed over the period of the growing season. For the Morden-Winkler area C.D.U. totaled 2497 (see Table 5). Late maturing varieties of corn require more than 2600 units to reach maturity or ripening of the kernels. Recent corn breeding programs in Manitoba have produced early maturing varieties that mature or ripen in 2000 units. When corn is grown for silage, the number of C.D.U. required is approximately 300 less than that required for grain.

VEGETATION

The native vegetation in the smooth level plain area that extends eastward from the escarpment was tall prairie and meadow-prairie grasses and herbs, but due to cultivation it has largely disappeared. Crops and planted windbreaks have largely replaced the native vegetation except where fringes of bush consisting of aspen, oak, elm, ash, Manitoba maple and shrubs such as hazel, dogwood and willow mark the larger meandering streams. Common grass and grass-like species found were blue grass, cord grass, june grass, sedges, spear grass, wheat grass; common herbaceous plants included prairie crocus, asters, banberry, cinquifoil, fireweed, sage, strawberry, thistle, violets and wormwood.

The benchlands and beach ridges which mark the western edge of the map area were originally wooded with deciduous trees and shrubs. Much of this area has also been replaced with crop and windbreaks.

The dry roadside shoulders and headlands are usually lined with a mixture of native species, bromegrass and weeds.

GROUNDWATER

In the Morden-Winkler area water obtained from bedrock is almost invariably saline and commonly under artesian pressure. An exception to this is along the Manitoba Escarpment where the shale bedrock is near the surface, and the cracks in the shale have been permeated by surface waters. Wells in these deposits yield water of low salt content, but in limited supply, sufficient only for stock watering and domestic use.

Most deep wells obtain water from glacio-fluvial sands and gravels associated with the till overlying the bedrock. The water in these wells is also saline due to salts being forced into the sands and gravels from the saline bedrock below. Wells flow at the surface in the area from north of Winkler southeast to Reinfeld, and including Friedensruh, Gnadenthal, Blumenort, and the northeast part of twp. 3, range 4W. These flowing wells yield saline water at approximately one gallon per minute.

Good water is obtained from a narrow band of glacio-fluvial sands extending from Rosengart through Reinland, Hochfeld, Neuenberg, Schanzenfeld to Winkler where it splits, one part extending almost straight west, the other extending northwest through the east part of twp. 3, range 5W. Yields from this aquifer are good, particularly the western branch which has yielded almost 600,000 gallons per day with a draw down of only 1.33 feet. Elsewhere, water from these glacio-fluvial sands are saline.

Surface groundwater levels rise in the spring as a result of snow melt and rainfall to about four feet from the surface. There is a tendency for water levels in soils west of the Emerado Beach to raise slightly higher than those below, due probably to their coarser texture and more permeable nature. Water levels reach their maximum height in the first half of June and, thereafter, recede at about 0.03 feet per day for six to eight weeks, later decreasing to about 0.01 feet per day. Late in the year, they reach a near static level of 8 to 10 feet from the surface, rising again in the following spring.

Local flooding in areas east of the Emerado Beach is common due in part to the flat nature of the topography and in part to frost which remains in the soil until the first week of June. The frost is not completely impermeable at all times, but does often result in a perched water table above the frozen layer. This condition is more marked east of the Emerado Beach where soils are generally more moist. The effects of the perched water table is reflected by the greater abundance of iron mottles in the upper portion of soil profiles in this area.

The surface goundwater west of the Emerado Beach is usually nonsaline except in some depressions and in areas where clay has been deposited. These areas are subject to contamination by seepage waters from the Escarpment and is probably the source of local salinity. Areas of clay textured soils, or where the underlying clay is close to the surface, are commonly saline. Salinity of the groundwater tends to be slightly lower in the spring due probably to dilution effects of spring meltwaters.

SOIL FORMATION, CLASSIFICATION AND MORPHOLOGY OF SOILS

SOIL DEVELOPMENT

The factors affecting soil formation are climate, vegetation, parent material, relief, and drainage. The kind of soil formed in any one place is dependent on interaction of these forces, the length of time they have been active, and modifications resulting from the work of man.

The most important factors in soil formation are the temperature and moisture conditions within the soil (i.e. the soil climate). Under native conditions, the soil climate determines the type of biological life which in turn determines the type of, and the manner in which organic matter is added to the soil. The soil climate also determines the microorganism activity, the rate of production and decomposition of organic matter, the rate and extent of mineral weathering, and the rate at which products of weathering are accumulated in, or removed from the soil.

Climatic conditions in the Morden-Winkler area have been favorable for the growth of tall prairie grasses, and it was under this vegetation that most of the soils of the area formed. Organic matter was added to the soil from the decomposition of a cyclical growth of grass and grass-like plants and tend to accumulate in fairly large amounts in the surface horizons. Consequently, the surface Ah horizons of most of the soils in the area are dark coloured, ranging from black when moist to very dark grey when dry.

The soil climate may differ within relatively short distances because of differences in topography and drainage. Knolls or sloping areas are usually "locally arid" as a portion of the precipitation may runoff. Depressions are often "locally humid" as they collect water and are wetter and cooler than surrounding soils. Thus topographical position, and external and internal drainage affect the soil climate. In the Morden-Winkler area topographic effect on drainage and soil profile expression is slight resulting in the development of soils with A, B, C horizons on slightly better drained sites and soils with only A and C horizons in level to depressional areas.

In the same climatic area, soils may show differences due to texture and mineralogical composition of the parent material. West of the Emerado Beach soils are primarily moderately coarse to medium in texture except in areas of local flooding, where heavier textured material has been deposited. East of the Emerado Beach textures are primarily medium or fine, often with a clay textured substrate. Most of the Orthic Black soils or well drained black soils having A, B, C horizons occur on loamy fine sand textured material in the better drained positions above the Emerado Beach. Gleyed Black and Gleyed Carbonated Rego Black soils or moist black soils having A, C horizons predominate throughout the remainder of the area.

Soils progress from youth through maturity to old age. Although these stages of development are not entirely related to the length of time during which soil forming factors have been at work, it still takes time for soil forming factors to show their effect in the profile. In terms of years the soils of the Morden-Winkler area are very young, all of them dating back to about 7,000 to 8,000 years ago. Dates of alluvium deposition younger than those of Lake Agassiz suggest that soil formation in some sections of this area could have started as recently as 6,000 years ago[1].

Cultivated soils on medium textured material often have a mottled appearance on the surface due to differences in lime carbonate content. This may be due, in part, to differences in lime content of the parent material and in part to the effects, either direct or indirect of cultivation. Cultivated soils are often kept at or near field capacity until about the first week of June by a frozen layer in the soil. The effect of this practice tends to promote capillary rise of carbonated groundwater and is intensified by a high water table. This is reflected by color and intensity of iron mottling in the soil profile. Construction of road and drainage ditches has facilitated surface drainage, but the affects of this on soil profile development is not apparent.

THE SOIL PROFILE

A soil that has come into equilibrium with its environment develops characteristics or morphology unique to itself and is considered a mature soil. Those that have not come into equilibrium with their environment are considered immature. A mature soil when viewed in vertical cross-section, consists of soil layers called soil horizons (see Figure 7).

The main or master horizons have been designated by the letters L, F, H, for organic layers and A, B, C for mineral horizons. Lower case suffixes are used to indicate the type of master horizons and arabic numerals are used when further division into subhorizons are required. If the soil profile is developed from non-conforming parent materials, Roman numeral prefixes are used to indicate lithologic changes.

The A and B horizons are a reflection of the genetic forces operating on the parent material and together they form what soil surveyors call the solum of the soil. No simple definition of master horizons is possible since there are so many different kinds (see Glossary). In general, A horizons

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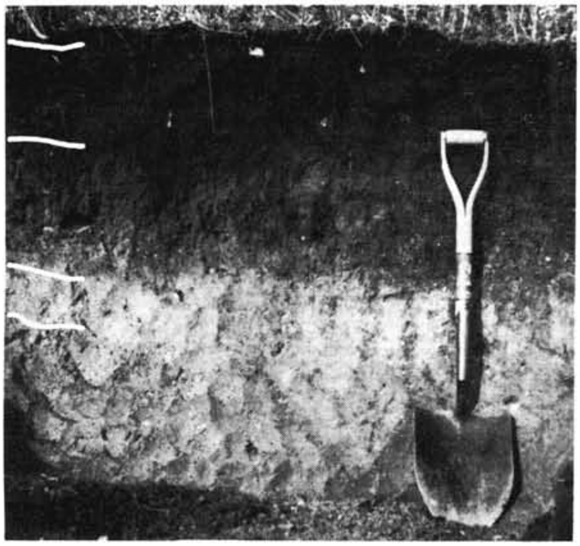
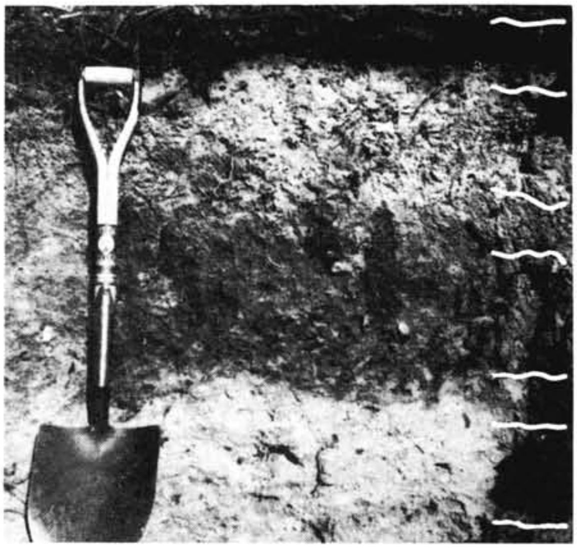
[1]Life, Land and Water. Proceedings of the 1966 Conference on Environmental Studies of the Glacial Agassiz Region. Edited by W. J. Mayer-Oakes, University of Manitoba Press, Winnipeg, Manitoba.

FIGURE 7

Examples of the use of soil horizon nomenclature.



Black soil profile showing subdivision into soil horizons.



Grey Luvisol soil profile showing subdivision into soil horizons.

or surface layers are subjected to the greatest amount of weathering and leaching or organic matter accumulation. The B horizons, lying immediately below the A horizon, contain most of the material leached from A horizons or have had other changes brought about by soil forming forces. The C horizons represent the relatively unweathered underlying geological deposits from which the sola has developed.

SOIL CLASSIFICATION

Sixty-six kinds of soils have been identified and mapped in the Morden-Winkler area, each having a combination of characteristics unique to itself. The properties of these different soils reflect the effect produced by soil forming forces discussed in the previous section.

The basic unit in the system of soil classification in Canada is the *soil series*. A soil series is defined as a naturally occurring soil body such that any soil profile within the body has a similar number and arrangement of horizons, whose color, texture, structure, consistence, thickness, reaction and composition are within a narrowly defined range. Soil series are very often subdivided into *types* and *phases*. *Soil types* are subdivisions of series based on minor variation in the texture of the surface horizon; Winkler clay, Winkler Clay loam, and Winkler loam are examples of types of the Winkler Series whose dominant texture in the profile is clay. *Phases* of soil series are based on variations of such features as degree of erosion of the profile, topographic change or stoniness to name a few; Reinland overblown phase, Chortitz gently undulating phase are examples of soil phases.

Soil series, soil types and soil phases are all three dimensional bodies that occupy a geographic location on the landscape. Since soil is a continuum there are no sharp boundaries between series, types and phases. However, we need to identify, sample and describe these bodies so their properties can be compared and predictions can be made about their use and management. Therefore, limits are placed on the range allowed in the characteristics that differentiate these bodies. These limits are wide enough to permit delineation of them over a practical sized area on a map. Usually, it is impractical to draw exact boundaries between the limits of one soil series and another because of time and mapping scale limitations. Consequently, each delineated area may contain small segments comprising less than 15 percent of other soil series. It can be seen, that the concept of a soil series as a taxonomic unit is related to, but is not strictly speaking, the same as the soil body delineated on a map. Therefore, the soil area delineated on the map is designated as a soil series mapping unit.

Generally mappable differences in any property or group of properties that have significance in soil formation or plant growth are the basis for separating soil series. Differences in soil parent material, drainage, topographic variation, salinity and textural variation have been the key characteristics employed to differentiate soil series mapping units in the Morden-Winkler area (see Tables 6, 7 and 8).

Such mapping units form a very useful basis for evaluating and predicting behavior of soils for such purposes as growing agricultural crops under dryland and irrigation conditions, engineering projects and planning for community services. A discussion of such evaluations and interpretations of the soils in the map area are found in other sections of the report.

Eigenhof – Orthic Black

Rosengart – Orthic Black

Morris – Gleyed Solonetzic Black

Gnadenthal – Gleyed Rego Black

Neuhorst – Gleyed Rego Black

Osterwick – Carbonated Rego Humic Gleysol

TABLE 6

Classification of Soils in the Morden-Winkler Map Area into Subgroups, Great Groups and Orders According to the System of Soil Classification for Canada, 1970

Order	*Great Group*	*Subgroup*	*Series*
CHERNOZEMIC SOILS. Soils with chernozemic Ah horizons and with B or C horizons of high base saturation with divalent cations, calcium usually being dominant. Well to imperfectly drained soils developed under xero- or meso- phytic grasses and forbs or under grassland forest transition.	BLACK SOILS. Soils with Ah horizons of Munsell color value darker than 3.5 moist or dry, and with chroma of 1.5 or less when moist, of sufficient thickness to produce 6 inches (15 cm) of mixed surface or Ap horizon of similar value and chroma. Usually associated with a mesophytic vegetation of grasses and forbs.	ORTHIC BLACK. Profile type – Ah, (Ap), Bm or Btj, C, (Cca), (Ck)	Edenburg Eigenhof Hobson Hochfeld Huddlestone Jordan Reinfeld Roseisle Rosengart Winkler
		GLEYED BLACK. Profile type – Ah (Ap), Bgj, Bmgj, Cg, (Ccag), (Ckg)	Horndean Plum Coulee Rignold
		CALCAREOUS BLACK. Profile type – Ah, Bmk, Cca or Ck	Birkenhead
		GLEYED CARBONATED REGO BLACK. Profile type – Ahk, Ckg, (ACkgj), (Cca)	Deadhorse Dugas Glencross Gnadenthal Graysville Neuenberg Neuhorst Newton Siding Red River Reinland Rosebank
		GLEYED SOLONETZIC BLACK. Profile type – Ah, Bntjgj, Cgj (Ckgj), (Ccagj), (Cag)	Morris
GLEYSOLIC SOILS. Soils with organic horizons less than 16 inches (40 cm) of mixed peat or up to 24 inches (60 cm) of fibric moss peat. They may or may not have an A and B horizon. These soils are saturated with water and under reducing conditions continuously or at some period of the year unless they are artificially drained. They have, within 20 inches (50 cm) of the mineral surface, matrix colors of low chroma as a result of reducing conditions and they may have distinct or prominent mottles of high chroma, presumably as a result of localized oxidation of ferrous iron and the deposition of hydrated ferric oxides.	HUMIC GLEYSOL. Soils with an Ah horizon more than 3 inches (8 cm) thick under virgin conditions and when mixed to a depth of 6 inches (15 cm) has more than 3 percent organic matter and a rubbed Munsell color darker than 3.5 when moist (5.0 when dry), and is at least 1.5 units of value darker than the next underlying horizon (B or C) if the value of the underlying horizon is 4 or more, or at least 1 unit lower than that of the next underlying horizon if the value of the underlying horizon is less than 4.	CARBONATED REGO HUMIC GLEYSOL. Profile type – (LH) Ahk, Ckg or Ccag, Ckg	Blumenfeld Blumenort Osborne Osterwick
REGOSOLIC SOILS. Well and imperfectly drained mineral soils with good to moderate oxidizing conditions having horizon development too weak to meet the requirements of soils in any other order. Soils with non-chernozemic Ah horizons may be included.	Same as the Order.	GLEYED CUMULIC REGOSOL Profile type – Cg, Ahbg, Cg or Ckg	Blumengart Chortitz Elias

TABLE 7

Key to the Soils of the Morden-Winkler Area and Their Estimated Acreage

		Map Symbol	Approx. Ac.	% of Area
1.	Soils developed on deep fine textured, moderately to strongly calcareous lacustrine sediments			
	(a) Imperfectly drained			
	Red River clay (Gleyed Carbonated Rego Black)	Rr	2,180	1.23
	Morris clay (Gleyed Solonetzic Black)	Mo	2,178	1.22
	(b) Poorly drained			
	Osborne clay (Rego Humic Gleysol)	Oc	1,152	.65
2.	Soils developed on fine textured, somewhat stratified, moderately to strongly calcareous deltaic and lacustrine sediments			
	(a) Moderately well drained			
	Winkler clay (Orthic Black)	Wa	576	.32
	Winkler clay loam	Wb	1,005	.56
	Winkler loam	Wc	307	.17
	(b) Imperfectly drained			
	Deadhorse clay (Gleyed Carbonated Rego Black)	Da	4,973	2.78
	Deadhorse clay, slightly saline phase	Db	1,408	.79
	Deadhorse clay loam	Dc	960	.53
	Deadhorse clay loam, slightly saline phase	Dd	493	.27
	Deadhorse loam	De	211	.11
	Plum Coulee clay (Gleyed Orthic Black)	Pa	4,563	2.56
	Plum Coulee clay loam	Pb	2,278	1.28
	Plum Coulee loam	Pc	301	.17
3.	Soils developed on thin fine textured, moderately to strongly calcareous lacustrine clay overlying coarse to medium deposits			
	(a) Moderately well drained			
	Jordan clay (Orthic Black)	Ja	678	.39
	Jordan clay loam	Jb	467	.26
	(b) Imperfectly drained			
	Dugas clay (Gleyed Carbonated Rego Black)	Df	5,005	2.82
	Dugas clay, slightly saline phase	Dg	102	.05
	Dugas clay loam	Dh	710	.39
	Dugas loam	Dk	218	.12
	Dugas loam, slightly saline phase	Dl	45	.02
	Horndean clay (Gleyed Orthic Black)	He	3,898	2.18
	Horndean clay loam	Hf	3,930	2.20
	Horndean loam	Hh	90	.05
4.	Soils developed on moderately fine textured, moderately to strongly calcareous, deltaic and lacustrine sediments			
	(a) Moderately well drained			
	Eigenhof clay loam (Orthic Black)	Ec	550	.30
	(b) Imperfectly drained			
	Neuhorst clay loam (Gleyed Carbonated Rego Black)	Ne	496	.28
	Neuhorst clay loam, slightly saline phase	Nf	358	.20
	Neuhorst loam	Ng	57	.03
	Neuhorst clay	Nh	64	.03
5.	Soils developed on thin moderately fine textured, moderately to strongly calcareous deltaic and lacustrine sediments overlying coarse to moderately coarse textured sandy sediments			
	(a) Moderately well drained			
	Edenburg (Orthic Black)	Ed	1,600	.89
	(b) Imperfectly drained			
	Newton Siding clay loam (Gleyed Carbonated Rego Black)	Nj	2,490	1.40
	Newton Siding clay loam, slightly saline phase	Nk	378	.21
	Newton Siding clay	Nl	122	.07
	Newton Siding clay, slightly saline phase	Nm	90	.05
6.	Soils developed on medium grading to stratified, medium to moderately fine textured, moderately to strongly calcareous deltaic and lacustrine sediments			
	(a) Moderately well drained			
	Reinfeld loam (Orthic Black)	Re	1,837	1.03
	(b) Imperfectly drained			
	Gnadenthal loam (Gleyed Carbonated Rego Black)	Ga	21,571	12.13
	Gnadenthal loam, slightly saline phase	Gb	2,259	1.26
	Gnadenthal clay loam	Gc	224	.12
	Gnadenthal clay	Gd	301	.16
	(c) Poorly drained			
	Blumenfeld loam (Carbonated Rego Humic Gleysol)	Bb	486	.27

TABLE 7 (Cont'd)

		Map Symbol	Approx. Ac.	% of Area
7.	Soils developed on thin medium grading to moderately fine textured deltaic and lacustrine sediments overlying stony, moderately to strongly calcareous water-worked till			
	(a) Well to moderately well drained			
	Roseisle loam (Orthic Black)	Rh	282	.16
	Roseisle loam, stony phase	Ri	422	.24
	(b) Imperfectly drained			
	Glencross loam (Gleyed Carbonated Rego Black)	Gg	493	.28
8.	Soils developed on thin medium grading to moderately fine textured, moderately to strongly calcareous deltaic and lacustrine sediments overlying calcareous lacustrine clay			
	(a) Imperfectly drained			
	Rignold loam (Gleyed Orthic Black)	Rg	3,866	2.17
	Graysville loam (Gleyed Carbonated Rego Black)	Gf	6,355	3.58
9.	Soils developed on medium grading to moderately coarse textured, moderately to strongly calcareous deltaic and lacustrine sediments			
	(a) Moderately well drained			
	Rosengart very fine sandy loam (Orthic Black)	Rn	3,443	1.93
	Rosengart loam	Rm	1,043	.59
	(b) Imperfectly to moderately well drained			
	Neuenberg very fine sandy loam (Gleyed Carbonated Rego Black)	Na	11,699	6.57
	Neuenberg very fine sandy loam, imperfectly drained phase	Nb	14,893	8.47
	Neuenberg loam	Nc	5,830	3.27
10.	Soils developed on sandy, moderately coarse to coarse textured, moderately calcareous deltaic and lacustrine sediments			
	(a) Well drained			
	Hochfeld fine sandy loam (Orthic Black)	Hb	12,819	7.20
	Hochfeld, fine sandy loam, eroded phase	Hc	102	.06
	Hochfeld, fine sandy loam, overblown phase	Hd	1.34	.07
	(b) Imperfectly drained			
	Reinland fine sandy loam (Gleyed Carbonated Rego Black)	Ra	20,948	11.77
	Reinland, fine sandy loam, eroded phase, drained	Rb	224	.12
	Reinland, fine sandy loam, overblown phase	Rc	499	.28
	Reinland, fine sandy loam, phreatic phase	Rd	7,789	4.38
	(c) Poorly drained			
	Osterwick fine sandy loam (Carbonated Rego Humic Gleysol)	Oa	358	.20
11.	Soils developed on thin, sandy moderately coarse to coarse textured, moderately calcareous, deltaic and lacustrine sediments overlying calcareous lacustrine clay			
	(a) Well drained			
	Hobson fine sandy loam (Orthic Black)	Hj	96	.05
	(b) Imperfectly drained			
	Rosebank fine sandy loam (Gleyed Carbonated Rego Black)	Rj	365	.20
12.	Soils developed on thin sandy moderately coarse to coarse, moderately calcareous deltaic and lacustrine sediments overlying stony, moderately to strongly calcareous, loamy water-worked till			
	(a) Well drained			
	Huddlestone loamy fine sand (Orthic Black)	Hk	90	.05
13.	Soils developed on sandy and gravelly coarse textured, moderately to strongly calcareous beach and outwash deposits			
	(a) Well drained			
	Birkenhead loamy sand (Calcareous Black)	Ba	1,165	.65
14.	Soils developed on dominantly fine textured, recently deposited, shaly alluvium			
	(a) Imperfectly drained			
	Blumengart clay (Gleyed Cumulic Regosol)	Bd	2,317	1.31
	Elias clay (Gleyed Cumulic Regosol)	Ef	480	.26
	(b) Poorly drained			
	Blumenort clay (Carbonated Rego Humic Gleysol)	Be	102	.05
15.	Soils developed on moderately fine to moderately coarse textured recent alluvium			
	(a) Imperfectly drained			
	Chortitz Series (Gleyed Cumulic Regosol)	Ca1	1,159	.65
	Chortitz, gently undulating phase	Ca2	9,312	5.33
16.	Miscellaneous			
	Town of Winkler and Lagoon		563	.31
	Town of Morden and Lagoon		461	.25
			177,920	100.00

SOIL MAPPING

Soil mapping was conducted by soil scientists making three to five foot traverses through each section, examining the soil profile to a depth of four feet at 500 foot intervals along each traverse. Crop growth differences and land suitability for agriculture and other uses were noted as well. Individual soils were delineated on aerial photographs having a scale of 4 inches equals one mile, showing shelter belts, buildings, field borders and other details that greatly helped in drawing boundaries accurately.

In preparing detailed soil maps, soil scientists had problems delineating areas where different soils were so intricately mixed and so small in size that it was not practical to show them separately on the map. They showed this mixture of soils as one mapping unit and called it a soil complex. A soil complex is named for the major kinds of soils in it, for example, Red River-Morris complex.

While the soil survey was in progress, samples of soils were taken, as needed, for laboratory measurements.

TABLE 8

Soil Series of the Morden-Winkler Map Area Grouped into Soil Families According to the System of Soil Classification for Canada, 1973*

Soil Series	Soil Family	Subgroup
Birkenhead	Coarse sandy, mixed, strongly calcareous, cool subhumid**	Calcareous Black
Blumenfeld	Fine loamy, mixed, strongly calcareous, cool subhumid	Carbonated Rego Humic Gleysol
Blumengart	Clayey, montmorillonitic, strongly calcareous, cool subhumid	Gleyed Cumulic Regosol
Blumenort	Clayey, montmorillonitic, strongly calcareous, cool subhumid	Carbonated Rego Humic Gleysol
Chortitz	Loamy, mixed, strongly calcareous, cool subhumid	Gleyed Cumulic Regosol
Deadhorse	Clayey, montmorillonitic, strongly calcareous, cool subhumid	Gleyed Carbonated Rego Black
Dugas	Clayey over loamy, montmorillonitic, strongly calcareous, cool subhumid	Gleyed Carbonated Rego Black
Eigenhof	Fine loamy, mixed, strongly calcareous, cool subhumid	Orthic Black
Edenburg	Fine loamy over sandy, mixed, strongly calcareous, cool subhumid	Orthic Black
Elias	Fine, montmorillonitic, strongly calcareous, cool subhumid	Gleyed Cumulic Regosol
Gnadenthal	Fine loamy, mixed, strongly calcareous, cool subhumid	Gleyed Carbonated Rego Black
Graysville	Fine loamy over clayey, mixed, strongly calcareous, cool subhumid	Gleyed Carbonated Rego Black
Glencross	Fine loamy, mixed, strongly calcareous, cool subhumid	Gleyed Carbonated Rego Black
Hochfeld	Coarse loamy, mixed, strongly calcareous, cool subhumid	Orthic Black
Horndean	Clayey over loamy, montmorillonitic, strongly calcareous, cool subhumid	Gleyed Orthic Black
Hobson	Coarse loamy over clayey, mixed, strongly calcareous, cool subhumid	Orthic Black
Huddlestone	Sandy over loamy-skeletal, mixed, strongly calcareous cool subhumid	Orthic Black
Jordan	Clayey over loamy, montmorillonitic, strongly calcareous, cool subhumid	Orthic Black
Morris	Clayey, montmorillonitic, strongly calcareous, cool subhumid	Gleyed Solonetzic Black
Neuenberg	Coarse loamy, mixed, strongly calcareous, cool subhumid	Gleyed Carbonated Rego Black
Neuhorst	Fine loamy, mixed, strongly calcareous, cool subhumid	Gleyed Carbonated Rego Black
Newton Siding	Fine loamy over sandy, mixed, strongly calcareous, cool subhumid	Gleyed Carbonated Rego Black
Osterwick	Sandy, mixed, strongly calcareous, cool subhumid	Carbonated Rego Humic Gleysol
Osborne	Clayey, montmorillonitic, strongly calcareous, cool subhumid	Carbonated Rego Humic Gleysol
Plum Coulee	Clayey, montmorillonitic, strongly calcareous, cool subhumid	Gleyed Orthic Black
Reinland	Coarse loamy, mixed, strongly calcareous, cool subhumid	Gleyed Carbonated Rego Black
Reinfeld	Fine loamy, mixed, strongly calcareous, cool subhumid	Orthic Black
Rignold	Fine loamy, mixed, strongly calcareous, cool subhumid	Gleyed Orthic Black
Roseisle	Fine loamy, mixed, strongly calcareous, cool subhumid	Orthic Black
Rosebank	Coarse loamy over clayey, mixed, strongly celcareous, cool subhumid	Gleyed Carbonated Rego Black
Rosengart	Fine loamy, mixed, strongly calcareous, cool subhumid	Orthic Black
Red River	Clayey, montmorillonitic, strongly calcareous, cool subhumid	Gleyed Carbonated Rego Black
Winkler	Clayey, montmorillonitic, strongly calcareous, cool subhumid	Orthic Black

*Soil families is a taxonomic unit in the Canadian Soil Classification System that aims at grouping soils within the Subgroup on the basis of properties important to plant growth and engineering properties. This arrangement provides information on profile type and parent material facilitating general comparison of soil series established.

**Cool subhumid refers to the climatic zone in Manitoba where the mean annual soil temperature is 5–8°C, where the growing season (greater than 5°C) ranges from 170–220 days, degree days (greater than 41°F) are 2250–3100, mean summer soil temperature is 15–18°C, soils having water deficits for a significant period during the growing season.

DESCRIPTION OF SOIL SERIES AND MAPPING UNITS

The soil series are described in alphabetical order and include a general description of the profile type, their textural variation, parent material composition and mode of deposition, local relief characteristics, drainage and a detailed tabular description of a representative profile of the series. Information on their suitability for various uses is given in other sections of the report.

BIRKENHEAD SERIES (Ba)

These well drained Calcareous Black soils were formed on moderately to strongly calcareous, stratified sandy and gravelly deposits. They most often occur on very gently sloping, stone-free, northwest-southwest trending sandy and gravelly beach ridges that are found along the western margin of the map area. The native prairie grass species usually found associated with these soils have largely been replaced by cultivated grasses and legumes such as brome-grass and alfalfa.

These rapidly permeable soils are characterized by very dark grey, fine sand textured surface Ah horizons that vary in thickness from 6 inches to approximately 15 inches; a weakly calcareous brownish colored, stratified fine sand to gravelly textured Bm horizon about 4 to 8 inches thick and a pale brown, moderately to strongly calcareous C horizon of stratified sand and gravel. Surface textures vary from fine sandy loam to loamy sand. They are very similar to the Hochfeld series differing from them in having coarser textures, a slightly deeper solum and having a calcareous Bm horizon.

A representative profile of Birkenhead Series in an alfalfa and brome pasture is described as follows:

Ap —0 to 6 inches, very dark grey (10YR 3/1 dry) fine sand; single grained; loose; pH 7.6; abrupt, smooth lower boundary.

Ah —6 to 15 inches, black to very dark grey (10YR 2/1 to 10YR 3/1, dry) fine sand; single grained; loose; pH 7.7; clear, smooth lower boundary.

Bmk —15 to 24 inches, dark brown to brown (10YR 3/3 to 10YR 4/3, dry) medium and fine sand; single grained; loose; pH 7.8; usually weakly calcareous, effervescing with dilute HCl; a gradual, smooth lower boundary.

BCk —24 to 28 inches, brown to pale brown (10YR 5/3 to 10YR 6/3) fine sand; single grained; loose; pH 7.9; weakly calcareous, effervescing slightly with dilute HCl; clear, smooth lower boundary.

Ck1 —28 to 34 inches, pale brown to very pale brown (10YR 6.5/3, dry) loamy medium sand; single grained; loose; pH 7.9; weakly calcareous, effervesces with dilute HCl; clear, smooth lower boundary.

Ck2 34 inches plus, pale brown to very pale brown (10YR 6.5/3 dry) fine sand; single grained; loose; pH 7.9; weakly to moderately calcareous; stratified sand and fine gravel, effervesces with dilute HCl.

BLUMENFELD SERIES (Bb)

These poorly drained Carbonated Rego Humic Gleysol soils have formed on medium grading to stratified medium to moderately fine textured, moderately to strongly calcareous deltaic and lacustrine sediments.

They occupy only a minor part of the map area, being confined to sloughs occurring westward from the Emerado Beach. Where uncultivated, the profile consists of a thin, very dark gray Ah horizon, a thick light grayish brown Ahg horizon, a dark gray to dark grayish brown ACg, a thick light gray Cca horizon over a similarly colored C horizon.

A profile description of a representative soil profile is as follows:

L-H —2 to 0 inches, very dark gray (10YR 3/1, dry) organic; mildly alkaline; pH 7.8; weakly calcareous; clear, smooth lower boundary.

Ahkg —0 to 17 inches, dark gray to dark grayish brown (2.5Y 4/1, dry) loam; moderate, medium, granular to moderate, fine, granular; friable when moist, slightly hard when dry; mildly alkaline, pH 8.1; weakly calcareous; gradual, wavy lower boundary.

Ckg1 —17 to 32 inches, light gray (2.5Y 7/2, dry) very fine sandy loam; weak, fine granular to weak, medium granular; very friable when moist, slightly hard when dry; mildly alkaline, pH 8.0 and strongly calcareous. Contains mottles of iron (10YR 6/6, moist); clear, wavy lower boundary.

Ckg2 —32 inches plus, light gray (2.5Y 7/2, dry) very fine sandy loam; structureless; very friable when moist, soft when dry; mildly alkaline and weakly calcareous. Iron mottled (7.5YR 5/8, moist).

TABLE 9

Analyses of Birkenhead Fine Sand

Hor.	Depth (inches)	Textural Class	Mech. Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	C.E.C. m.e./ 100 gms.	NH_4 Acetate Extractable Cations Ca	Mg	K	Na
Ap	0- 6	FS	93	—	7	7.6	0.4	—	2.7	17.7	15.7	2.9	0.7	0.1
Ah	6-15	FS	89	4	7	7.7	0.4	—	2.2	16.7	13.7	3.0	0.3	0.2
Bmk	15-24	MS	97	—	3	7.8	0.3	2.0	0.6	9.3	8.4	1.7	0.3	0.1
BCk	24-28	FS-MS	91	1	8	7.9	0.3	3.0	0.4	—	—	—	—	—
Ck1	28-34	LS	83	6	11	7.9	0.3	5.5	0.3	6.7	4.3*	2.0	0.3	0.1
Ck2	34+	FS-MS	94	6	—	7.9	0.3	7.9	0.2	5.3	3.8*	1.0	0.3	0.2

* By difference.

TABLE 10

Analyses of Blumenfeld Loam

Hor.	Depth (inches)	Textural Class	Mech. Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	C.E.C. m.e./ 100 gms.	NH_4 Acetate Extractable Cations Ca	Mg	K	Na
L-H	2- 0	–	–	–	–	7.8	2.3	–	6.7	–	–	–	–	–
Ahkg	0-17	L	45	32	23	8.1	0.7	14.3	1.3	15.7	18.5	12.8	0.8	0.8
Ckg1	17-32	VFSL	–	–	–	8.1	0.6	–	–	–	–	–	–	–
Ckg2	32+	VFSL	51	38	11	8.1	0.5	–	–	10.5	10.2	6.2	0.8	0.4

Blumengart Series (Bd)

These imperfectly drained Gleyed Cumulic Regosol soils have developed on weakly to moderately calcareous, dominantly fine textured, recently deposited shaly alluvium. They occur near stream channels that issue from the Manitoba Escarpment just west of the map area. Flakes of soft, dark grey shale are common in these sediments, but the amount decreases with distance from the stream.

In cultivated fields, the soils are characterized by a dark grey Ap horizon underlain hy dark grey to grey stratified clay and clay with very thin layers of sandy sediments often containing buried former Ah horizons. They are usually calcareous to the surface and usually stained with iron mottles, the stains becoming more numerous and distinct with depth. They differ from the very similar Elias soils in having more friable, darker colored surface horizons.

A representative profile of Blumenfeld Clay in a cultivated field is given below:

Apk 0 to 6 inches, dark greyish brown to very dark grey (10YR 4/2 to 10YR 3/1, dry) clay, moderate. fine, granular; firm when moist, hard when dry; mildly alkaline and weakly calcareous; abrupt smooth lower boundary.

Ckgj1 – 6 to 11 inches, greyish brown (2.5Y 5/2, dry) clay; weak, fine granular; firm when moist, hard when dry; mildly alkaline and weakly calcareous; common, fine to medium sized, distinct, dark yellowish brown (10YR 4/4, moist) iron mottles; abrupt, smooth lower boundary.

Ckgj2 11 to 16 inches, grey (2.5Y 5/0, dry) clay; massive breaking to weak, medium, granular; firm when moist, hard when dry; mildly alkaline, weakly calcareous; common, fine to medium sized, distinct, yellowish brown (10YR 5/4, moist) mottles; abrupt, smooth lower boundary.

Ckgj3 – 16 to 26 inches, dark grey (2.5Y 4/0, dry) clay; massive, breaking to moderate, medium, granular; firm when moist, hard when dry; mildly alkaline and weakly calcareous; contains pockets of very pale brown (10YR 7/3, moist) gypsum crystals and light grey (10YR 7/1, moist) dense carbonate concretions, as well as many, fine, faint brown mottles; clear, smooth lower boundary.

Ckgj4 – at 26 inches, a thin grey (2.5Y 5/0, dry) very fine sandy clay loam; massive breaking to moderate, medium, granular; firm when moist, hard when dry; mildly alkaline and weakly to moderately calcareous; contains pockets of gypsum crystals, lime carbonate concretions and mottles as in above horizon.

The runoff and permeability of these stone-free soils are slow because they occur on level terrain and have fine textures.

Blumenort Series (Be)

Soils of the Blumenort Series are poorly drained Carbonated Rego Humic Gleysols developed on stratified fine textured recently deposited alluvium. They occur in a few, small, scattered pockets adjacent to intermittent streams and creeks in areas too wet to cultivate. Slough grasses and weeds such as wild barley and sow thistle are commonly found on these soils.

Their profiles are characterized by very dark grey, mucky surface Ahg horizons that are mildly alkaline in reaction and weakly calcareous. Subsurface horizons are dark olive grey in color, mildly alkaline in reaction, calcareous and often contains light grey gypsum crystals and numerous, fine, distinct, brown mottles. Textures throughout the profile are dominantly clay; thin layers of sandy material are often found at varying depths. They are found in association with, and are very similar to Blumengart soils differing from them in having duller colors and a greater abundance of mottling in the upper part of the profile.

Chortitz Series (Cal)

The Chortitz Series is a somewhat poorly drained or imperfectly drained Gleyed Cumulic Regosol developed on weakly to moderately calcareous, moderately fine to moderately coarse textured recently deposited alluvium. The sediments are stratified with variable textured material occurring in thin layers throughout the profile. The surface texture of these productive soils is usually loam. These soils occur mainly in Twp. 3, Rge. 4W east of the Emerado Beach and are subject to frequent flooding from the Deadhorse Creek. They occupy very gently sloping terrain where runoff is slow to moderate and permeability or internal drainage is also moderately slow. These stone-free soils are cultivated and are suitable for all regionally adopted crops.

Their profiles are characterized by thin, dark grey surface horizons that are granular, firm to

TABLE 11

Analyses of Chortitz Clay Loam

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	C.E.C. m.e./ 100 gm.	Water Soluble Salts m.e./100 gm. Ca	Mg	Na	Total Cations	C1	SO_4	Total Anions
Apk	0- 8	CL	39	29	32	7.6	3.1	9.0	29.5	21.8	16.1	8.2	46.1	0.6	37.6	38.2
Ckgj1	8-32	VFSL	61	22	17	7.8	4.6	11.3	16.5	17.9	24.4	24.3	66.6	1.8	61.9	63.7
Ckgj2	32-40	C	13	33	54	7.4	4.2	1.5	–	25.3	25.0	15.7	66.0	0.7	62.6	63.3

friable when moist, mildly alkaline in reaction and moderately calcareous. Surface horizons are underlain by dark greyish brown to pale brown subsurface layers that vary considerably in texture and are friable, granular, mildly alkaline and moderately calcareous. Numerous, fine to medium, distinct brown mottles and white gypsum crystals also occur in the upper portion of their profiles.

These soils are coarser textured, more friable, permeable and slightly more saline than the very similar Blumengart and Elias soils.

A representative profile of Chortitz clay loam in a cultivated field is described below:

Apk – 0 to 8 inches, dark grey (10YR 4.5/1, dry) clay loam; moderate medium granular; firm when moist, slightly hard when dry; mildly alkaline, pH 7.6, moderately calcareous; slightly saline; clear, smooth lower boundary.

Ckgj1 – 8 to 32 inches, dark greyish brown to pale brown (10YR 6/3, moist to 10YR 3.5/2, moist) very fine sandy loam to clay loam; structureless to weak fine granular; mildly alkaline, pH 7.8, moderately calcareous; many, fine to medium sized, distinct brown (7.5YR 5/6, moist) mottles; slightly saline; clear, smooth lower boundary.

Ckgj2 – 32 to 40 inches, black (10YR 2/1, moist) clay; a buried former Ah horizon; massive; firm when moist, hard when dry; mildly alkaline, pH 7.4 and weakly calcareous; many, fine, faint, white (10YR 8/1) gypsum crystals, slightly saline.

FIGURE 8

Intermittent stream, where Chortitz soils are commonly found, running full during spring runoff.

Ckgj3 – 40 to 72 inches, stratified loam and clay; dark greyish brown to olive grey.

Chortitz Loam, Gently Undulating Phase (Ca2)

This soil has the same profile characteristics as the normal Chortitz series. This soil is confined largely to the numerous intermittent streams and creeks where terrain is irregular gently sloping.

Deadhorse Series (Da)

These are somewhat poorly or imperfectly drained Gleyed Carbonated Rego Black soils developed on fine textured, somewhat stratified, moderately to strongly calcareous deltaic and lacustrine sediments. They are found on level to very gently sloping terrain where runoff is very slow and where groundwater levels fluctuate between four and twelve feet below the surface. These stone-free soils are all under cultivation.

Their profiles are characterized by very dark grey to black, moderately thick to thick (about 15 to 20 inches) Ah horizons that often tongue into the Cg horizon to a depth of two or three feet. These Ah horizons usually have moderate, fine subangular blocky to medium granular structures; firm consistence when moist, are plastic and very sticky when wet and are calcareous to the surface. These Ah horizons grade through a 6 to 8 inch transitional AC horizon into greyish brown, iron stained, somewhat saline and gypsiferous Cg horizons. Buried former Ah horizons often occur at varying depths as well. Surface textures vary from loam to clay. Textures also vary from loam to clay due to stratification in the subsoils which is the key difference between this soil and the similar Red River Series. These soils also differ from the very similar Dugas Series in that the latter soils are underlain by coarse to medium textured sediments within three to four feet of the surface.

A representative profile of Deadhorse clay in a cultivated field is given below:

Ap – 0 to 6 inches, black to very dark grey (10YR 2/1 to 10YR 3/1, dry) clay; strong, fine, granular; very firm when moist and very hard when dry; mildly alkaline, pH 7.8 and weakly calcareous; abrupt, smooth lower boundary.

Ahk —6 to 14 inches, black to very dark grey (10YR 2/1 to 10YR 3/1, dry) clay; strong, medium, granular; very firm when moist, very hard when dry, moderately alkaline, pH 8.0, and moderately calcareous; gradual, wavy lower boundary.

ACk —14 to 20 inches, very dark greyish brown to dark greyish brown (10YR 3/2 to 10YR 4/2, dry) clay; strong, fine, subangular blocky to coarse granular; firm when moist and very hard when dry; moderately alkaline, pH 7.9; moderately calcareous; clear, wavy lower boundary.

Ckgj1 —20 to 32 inches, very dark greyish brown to greyish brown (2.5Y 3/2 to 2.5Y 5/2, dry) clay; moderate, medium, granular; firm when moist and hard when dry; mildly alkaline, pH 7.6; moderately calcareous; weakly saline and gypsiferous; gradual, irregular lower boundary.

Ckgj2 —32 to 52 inches, dark greyish brown to light brownish grey (2.5Y 4/2 to 2.5Y 6/2, dry) clay; moderate, medium, granular; firm when moist, very hard when dry; mildly alkaline, pH 7.8; moderately calcareous; weakly saline and gypsiferous; abrupt, smooth lower boundary.

IICkgj1 —52 to 60 inches, very dark greyish brown to dark greyish brown (10YR 3/2 to 10YR 4/2, dry) loamy fine sand; a buried former Ah horizon; structureless; friable when moist and soft when dry; mildly alkaline, pH 7.7 and moderately calcareous; weakly saline; a few fine, faint brown mottles; gradual, irregular lower boundary.

IICkgj2 —at 60 inches, dark greyish brown to greyish brown (2.5Y 4/2 to 2.5Y 5/2, dry) loamy fine sand; structureless; friable when moist and soft when dry; mildly alkaline, pH 7.7; moderately calcareous; weakly saline; many, fine, faint brown mottles.

Deadhorse Clay, Weakly Saline Phase (Db)

These soils differ from the normal Deadhorse clay soils in having an accumulation of salts within the rooting zone of plants in sufficient quantity to affect crop growth. The presence of salts can be detected in the field by erratic crop growth patterns because salts are not uniformly distributed in these soils. Significant amounts of normal Deadhorse clay soils are found in areas mapped as Deadhorse clay, slightly saline phase.

Deadhorse Clay Loam (Dc)

These are Deadhorse soils with clay loam surface textures. The subsurface horizons are fine textured

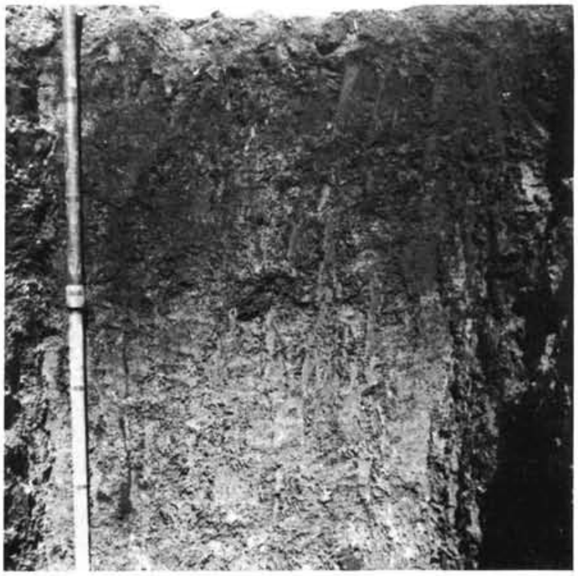


FIGURE 9

Soil profile of Deadhorse clay. A Gleyed Rego Black on stratified lacustrine clay sediments.

like the normal type. The surface horizons of these soils are more friable and usually remain in a more favorable state of tilth than the clay textured surface soil type. Permeability of the surface layer is moderately slow and in the subsurface horizons is very slow. Minor amounts of the normal clay type are found in areas mapped as Deadhorse clay loam.

Deadhorse Clay Loam, Weakly Saline Phase (Dd)

These are Deadhorse clay loam soils with a sufficient accumulation of soluble salts in the rooting zone of plants to affect crop growth. Like the slightly saline clay type, salts are not uniformly distributed in these soils. Areas of these soils can be detected in the field by erratic crop growth patterns. Areas of these soils contain significant amounts of non-saline Deadhorse clay loam soils.

TABLE 12

Analyses of Deadhorse Clay

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/cm^3	% $CaCO_3$ Equiv.	% Org. C	% Total N	C.E.C. m.e./100 gm	NH_4 Acetate Extractable Cations Ca	Mg	K	Na
Ap	0- 6	C	10	35	55	7.8	0.7	2.5	2.4	0.2	31.4	25.6	4.6	0.5	0.7
Ahk	6-14	C	5	32	63	8.0	0.5	11.5	0.8	0.1	29.1	22.3	5.4	0.8	0.6
ACk	14-20	C	13	33	54	7.9	0.6	11.0	0.3	0.1	—	—	—	—	—
Ckgj1	20-32		—	—	—	7.8	3.8	10.8	—	—	25.2	8.7	16.3	0.1	0.2
Ckgj2	32-52		—	—	—	7.8	3.2	10.8	0.2	—	—	—	—	—	—
IICkgj1	52-60	LFS	77	10	13	7.7	3.6	6.3	0.3	—	10.2	9.1	1.0	0.0	0.1
IICkgj2	60+	LFS	87	8	5	7.7	3.9	8.2	0.3	—	—	—	—	—	—

Exchangeable calcium determined by difference. NH_4 Acetate extractable calcium values exceeded C.E.C. values by 1 to 3 orders of magnitude.

Deadhorse Loam (De)

These are Deadhorse soils with loam textured surface horizons. Like the clay loam type the surface horizons of these soils are more friable, more permeable and remain in a more favorable state of tilth than the normal clay type. Minor amounts of the normal clay type are found in areas mapped as Deadhorse loam.

Dugas Series (Df)

These are somewhat poorly or imperfectly drained, Gleyed Carbonated Rego Black soils that have formed on thin moderately to strongly calcareous, fine textured lacustrine sediments overlying moderately to strongly calcareous, coarse to medium textured deposits. The clay layer usually ranges in depth from 18 inches to 2 or 3 feet. The underlying sediments range in texture from fine sand to loam and are usually stratified. They are found in level areas where runoff is slow. Permeability in the surface layers is very slow and moderate in the underlying coarser textured sediments.

Like the very similar Deadhorse series these soils have moderately thick to thick black to very dark grey Ah horizons that are neutral to mildly alkaline in reaction, weakly calcareous and granular. Consistence of these surface horizons varies from plastic to very sticky when wet, to firm when moist and very hard and brittle when dry. The lower boundary of the Ah horizon is very irregular and it is not unusual to find it tonguing down into the C horizon to depths of 2 or 3 feet. These surface horizons grade through a thin transition horizon into greyish brown clayey C horizons that are calcareous, weakly saline, gypsiferous and iron stained. The change from clay to the underlying stratified sandy material is abrupt and smooth. These sediments are also greyish brown in color, calcareous, moderately alkaline, weakly saline, gypsiferous and iron stained.

A representative profile of Dugas clay in a cultivated field is described below:

Ap – 0 to 8 inches, very dark gray (10YR 3/1, dry) clay; moderate, fine, blocky; firm when moist, very hard when dry; neutral, pH 6.8; clear, smooth lower boundary.

Ah – 8 to 12 inches, very dark gray (10YR 3/1, dry) clay; moderate, medium, granular; firm when moist, very hard when dry; neutral, pH 6.8; clear, irregullar lower boundary.

ACk – 12 to 18 inches, dark gray (10YR 4/1, dry) clay; moderate, fine, blocky; firm when moist, very hard when dry; mildly alkaline, pH 7.4 and weakly calcareous; clear, irregular lower boundary.

Ckgj1 – 18 to 30 inches, dark grayish brown (2.5Y 4/2, dry) clay; moderate, fine, granular; firm when moist, very hard when dry; mildly alkaline, pH 7.8; weakly calcareous; few, fine, faint brown mottles; gradual, irregular lower boundary.

Ckgj2 – 30 to 36 inches, grayish brown (2.5Y 5/2, dry) clay; moderate, fine, granular; firm when moist, very hard when dry; moderately alkaline, pH 8.0; weakly saline; strongly calcareous containing white (2.5Y 8/2, dry) lime concretions; few, fine to medium faint brown mottles; abrupt, smooth lower boundary.

IICksgj1 – 36 to 38 inches, dark gray (10YR 4/1, dry) clay loam; a buried former Ah horizon; moderate, fine, granular; friable when moist, hard when dry; moderately alkaline, pH 7.8; moderately calcareous, many fine to medium, faint, brown mottles; weakly saline and gypsiferous; clear, smooth, lower boundary.

IICksgj2 – 38 to 48 inches, grayish brown (2.5Y 5/2, dry) fine sandy loam; weak, fine, granular; friable when moist, slightly hard when dry; moderately alkaline, pH 8.2; moderately calcareous; many, fine to medium, distinct brown mottles; weakly saline and gypsiferous; contains white (2.5Y 8/2, dry) lime concretions; clear, smooth lower boundary.

IICksgj3 – 48 to 60 inches, light yellowish brown (2.5Y 6/4, dry) fine sand; structureless; loose when moist, loose when dry; moderately alkaline, pH 8.2; moderately calcareous; many, fine to medium, distinct brown mottles; weakly saline and gypsiferous.

Dugas Clay, Weakly Saline Phase (Dg)

These soils differ from the normal Dugas soils in having an accumulation of salts within the rooting zone of plants in sufficient quantity to affect crop growth. These salts, largely magnesium sulphate, are not uniformly distributed in these soils, accounting for the erratic crop growth in areas mapped as Dugas weakly saline phase. Significant areas of normal Dugas clay soils are also included.

TABLE 13

Analyses of Dugas Clay

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	% Total N	C.E.C. m.e./ 100 gm	NH_4 Acetate Extractable Cations Ca	Mg	K	Na
Ap	0- 8	C	27	27	46	6.6	1.13	–	3.3	0.3	35.4	25.7	8.0	1.5	0.6
Ah	8-12	C	21	24	55	6.8	0.5	–	2.4	0.2	34.3	24.2	9.2	0.3	0.6
ACk	12-18	C	19	24	57	7.4	0.6	1.7	1.9	0.1	31.9	27.2	10.0	0.4	0.7
Ckgj1	18-30	C	10	28	62	7.8	2.4	16.6	0.0	·	26.5	*14.0	11.8	0.3	0.4
Ckgj2	30-36	C	12	25	63	8.0	4.6	15.9	–	–	–	–	–	–	–
IICksgj1	36-38	CL	32	22	46	7.8	6.0	7.3	1.0	–	–	–	–	–	–
IICksgj2	38-48	FSL	62	12	26	8.2	6.4	10.4	0.3	–	–	–	–	–	–
IICksgj3	48-60	FS	74	11	15	8.2	7.2	7.6	–	–	–	–	–	–	–

*Determined by difference (C.E.C. – Exchangeable Mg, K and Na). NH_4 Acetate extractable calcium exceeded C.E.C. value by approximately 25 percent.

Dugas Clay Loam (Dh)

These are Dugas soils with clay loam textured surface horizons. The surface horizons of these soils are more permeable and have a softer more friable consistence than the normal clay type. Apart from these surface differences, the characteristics of these soils in the remainder of the profile are the same as those of the normal clay type. Included with this soil are small areas of the normal type as well.

Dugas Loam (Dk)

These are Dugas soils with loam textured surface horizons rather than Dugas soils with clay textured surface horizons. The surface horizons of the loam type soils are more permeable and have a softer, more friable consistence than either the clay type or the clay loam type. Included with this soil are small areas of the normal clay type and the clay loam type.

Dugas Loam, Weakly Saline Phase (Dl)

These are Dugas loam soils with sufficient salts in them to affect crop growth. Like the weakly saline clay loam type, the dominant salt in these soils is magnesium sulphate, erratically distributed. Small areas of non-saline Dugas clay loam and loam types are found in areas of these soils.

Eigenhof Series (Ec)

These are moderately well drained Orthic Black soils developed on moderately to strongly calcareous, moderately fine textured, deltaic and lacustrine sediments. These sediments are usually stratified below three to five feet of the surface varying from medium to fine in texture. They occupy smooth level to very gently sloping terrain where runoff is slow. Permeability of these soils is moderately slow. High groundwater levels affect these soils for a short period during the early spring runoff period.

These soils are characterized by moderately thick, black to very dark Ah horizons that are granular, neutral in reaction and having hard consistence when dry. Their dark greyish brown, clayey Bm horizons are neutral to mildly alkaline in reaction, granular and hard when dry. Their light brownish grey C horizons are usually mildly alkaline in reaction and iron stained.

FIGURE 10

Sunflowers growing on Eigenhof soils, located on Morden Experimental Farm.

Eigenhof soils differ from the very similar Edenburg clay loam soils in having more uniform textures in the C horizon. They are separated from similar, fine textured Winkler clay soils by having somewhat coarser textures, more rapid internal drainage and more desirable tilth characteristics.

A representative profile of Eigenhof clay loam in a cultivated field is given below:

Ap — 0 to 6 inches, very dark gray (10YR 3/1, dry) clay loam; moderate, fine, granular; firm when moist, hard when dry; neutral to slightly acid, pH 6.5; abrupt, smooth lower boundary.

TABLE 14

Analyses of Eigenhof Clay Loam

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	% Total N	C.E.C. m.e./ 100 gm	NH_4 Acetate Extractable Cations Ca	Mg	K	Na
Ap	0- 6	CL	22	39	39	6.5	0.8	–	4.3	0.4	32.8	27.6	2.6	1.2	0.6
Ah	6-10	CL	21	39	40	6.6	0.4	–	4.5	1.4	35.0	28.8	5.6	1.4	0.4
BA	10-13	VFSCL	20	40	40	6.8	0.3	–	3.4	0.3	–	–	–	–	–
Bm	13-18	VFSC	18	39	43	7.3	0.5	0.3	1.8	0.2	33.7	25.3	7.6	0.8	0.3
BCk	18-26	VFSCL	11	45	44	7.6	2.2	17.0	1.1	0.1	–	–	–	–	–
Ck1	26-34	CL	21	39	40	7.9	5.7	13.6	1.6	–	21.6	–*	16.8	0.3	5.2
Ck2	34+	CL	33	36	31	7.7	3.0	8.3	1.5	–	–	–	–	–	–

*NH_4 Acetate extractable Ca 37.0 m.e./gms.

Ah –6 to 10 inches, very dark gray (10YR 3/1, dry) clay loam; moderate, fine, granular; firm when moist, hard when dry; neutral to slightly acid, pH 6.6; clear, wavy lower boundary.

BA –10 to 13 inches, very dark grayish brown (10YR 3/2, dry) very fine sandy clay loam; moderate, medium, granular; firm when moist, hard when dry; neutral, pH 6.8; clear, wavy lower boundary.

Bm –13 to 18 inches, dark grayish brown (10YR 4/2, dry) very fine sandy clay; strong, coarse, granular; very firm when moist, very hard when dry; mildly alkaline, pH 7.3; clear, wavy lower boundary.

BCk –18 to 26 inches, grayish brown (10YR 5/2, dry) very fine sandy clay loam; strong, medium, granular; very firm when moist, very hard when dry; mildly alkaline, pH 7.6, and moderately calcareous; gradual, irregular lower boundary.

Ck1 –26 to 34 inches, pale brown (10YR 6/3, dry) clay loam; moderate fine, granular; firm when moist, hard when dry; moderately alkaline, pH 7.9, and strongly calcareous; a few, fine, faint brown mottles; gypsiferous; numerous white carbonate concretions; gradual, irregular lower boundary.

Ck2 –34 inches plus, light brownish gray (2.5Y 6/2, dry) clay loam; moderate, fine, granular; firm when moist, hard when dry; moderately alkaline, pH 7.7, strongly calcareous; many, fine, faint brown mottles; gypsiferous; numerous white calcium carbonate concretions.

Edenburg Clay Loam (Ed)

These are moderately well drained Orthic Black soils developed on three to four feet of moderately to strongly calcareous, moderately fine textured sediments overlying coarse to moderately coarse textured sediments. The change from firm clayey material to loose, very permeable sandy material is abrupt. They occupy smooth level terrain where surface runoff is moderately slow. They are affected by high groundwater levels for a short period during the spring runoff.

These soils, like the very similar Eigenhof soils, have moderately thick, black to very dark grey Ah horizons that are granular, neutral in reaction and hard in consistence; dark greyish brown Bm horizons neutral to mildly alkaline in reaction, granular, and hard in consistence; and a pale brown to brown, calcareous C horizon. The unconforming light yellowish hrown sandy material is usually calcareous, moderately alkaline and stained with numerous brown colored mottles.

A representative profile of Edenburg clay loam in a cultivated field is described below:

Ap –0 to 6 inches, black to very dark grey (10YR 2/1 to 10YR 3/1, dry) clay loam; strong, fine, granular; firm when moist, hard when dry; neutral in reaction, pH 6.8; abrupt, smooth lower boundary.

Ah –6 to 12 inches, black to very dark grey (10YR 2/1 to 10YR 3/1, dry) very fine sandy clay, strong, fine, granular; firm when moist, hard when dry; neutral in reaction, pH 6.9; clear, wavy lower boundary.

BA –12 to 17 inches, very dark brown to very dark greyish brown (10YR 2/2 to 10YR 3/2, dry) very fine sandy clay loam; strong, medium, granular; firm when moist, hard when dry; mildly alkaline, pH 7.3; clear, wavy lower boundary.

Bm –17 to 23 inches, very dark greyish brown (10YR 3/2 to 10YR 4/2, dry) very fine sandy clay loam; strong, medium, granular; firm when moist, very hard when dry; mildly alkaline, pH 7.4; gradual, wavy lower boundary.

BC –23 to 27 inches, dark greyish brown to greyish brown (10YR 4/2 to 10YR 5/2, dry) very fine sandy clay loam; strong medium granular; firm when moist, hard when dry; mildly alkaline, pH 7.7; weakly calcareous; a few, fine, faint brown mottles in lower portion of the horizon; clear, irregular, lower boundary.

Ck –27 to 34 inches, pale brown to very pale brown (10YR 6/3 to 10YR 7/3, dry) very fine sandy clay loam; moderate, medium, granular; firm when moist, hard when dry; moderately alkaline, pH 8.0; strongly calcareous; wavy, fine, faint to distinct, brown mottles; abrupt, smooth lower boundary.

IICkgj1 –34 to 44 inches, olive brown to light yellowish brown (2.5Y 4/4 to 2.5Y 6/4, dry) very fine sandy loam; weak, fine granular; friable when moist, soft when dry; moderately alkaline; pH 8.2; strongly calcareous; wavy, fine, faint to distinct brown mottles; gradual, irregular lower boundary.

IICkgj2 –44 inches plus, olive brown, light greyish brown (2.5Y 4/4 to 2.5Y 6/4, dry) very fine sandy loam; weak, fine granular; very friable when moist, soft when dry; moderately alkaline, pH 8.0; strongly calcareous; many, fine, faint to distinct brown mottles.

TABLE 15

Analyses of Edenburg Clay Loam

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/cm^3	% $CaCO_3$ Equiv.	% Org. C	% Total N	C.E.C. m.e./100 gm.	NH_4 Acetate Extractable Cations Ca	Mg	K	Na
Ap	0-6	CL	43	21	36	6.8	1.4	0.0	3.9	0.3	36.8	28.6	7.7	0.4	0.1
Ah	6-12	CL	47	17	36	6.9	0.3	0.0	3.4	0.3	32.6	24.2	7.7	0.4	0.3
BA	12-17	CL	52	14	34	7.3	0.3	0.0	1.8	0.2	–	–	–	–	–
Bm	17-23	CL	51	14	35	7.4	0.3	0.0	1.2	0.1	25.5	17.3	7.3	0.3	0.6
BC	23-27	CL	45	27	28	7.7	0.4	1.2	0.9	–	–	–	–	–	–
Ck	27-34	CL	45	19	36	8.0	0.7	29.8	0.8	0.1	24.6	17.1	6.9	0.2	0.4
IICkgj1	34-44	VFSL	65	18	17	8.2	0.5	16.6	–	–	–	–	–	–	–
IICkgj2	44+	VFSL	71	22	7	8.0	1.6	17.0	–	–	15.0	11.1	2.9	0.2	0.8

ELIAS SERIES (Ef)

These are somewhat poorly or imperfectly drained Gleyed Cumulic Regosol soils formed on moderately calcareous, dominantly fine textured, recently deposited shaly alluvium. They occur on level terrain adjacent to stream channels that issue from the Manitoba Escarpment just west of the map area. Flakes of dark grey shale are common in these stratified sediments that vary from sandy material to clayey material. These changes in texture are abrupt. Runoff is slow and permeability is also slow. They are affected by high groundwater levels for a significant period in the spring.

These soils have little or no horizon development but in cultivated fields may have slightly darkened Ap horizons that overlie dark greyish brown (10YR 4/2) to light brownish grey (10YR 6/2) iron stained material. Organic matter content usually decreases irregularly with depth. Erratic changes in organic matter content are associated with buried former Ah horizons. These soils lack the Ah horizon development that characterize the Blumengart soils found on the same parent material.

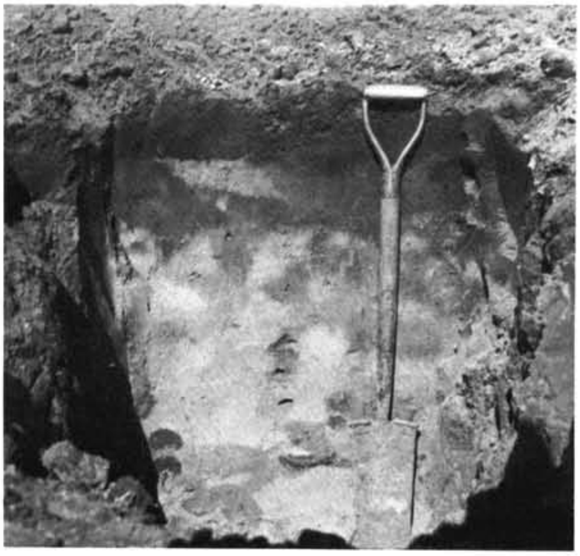


FIGURE 11

Soil profile of Gnadenthal loam. A Gleyed Carbonated Rego Black on calcareous loamy sediments.

GNADENTHAL SERIES (Ga)

These are somewhat poorly or imperfectly drained Gleyed Carbonated Rego Black soils formed on medium grading to stratified medium and moderately fine textured, moderately to strongly calcareous, deltaic and lacustrine sediments. They occupy extensive, smooth, level to very gently sloping areas east of the Emerado Beach where runoff is slow. They are also affected by high groundwater levels during the spring runoff period.

These soils have thick black to very dark grey Ah horizons that are granular, mildly alkaline in reaction and weakly calcareous; transitional brownish grey AC horizons and light yellowish brown to light olive brown C horizons that are moderately alkaline, moderately to strongly calcareous, often gypsiferous and mottled with iron stains. They differ from the very similar Neuenberg soils in having finer textures in the subsurface horizons. They are more friable and permeable than the moderately fine textured Neuhorst soils.

A representative Gnadenthal loam in a cultivated field is described below:

Apk —0 to 6 inches, black to very dark grey (10YR 2/1 to 3/1, dry) very fine sandy loam; weak, fine, granular; friable when moist, slightly hard to soft when dry; mildly alkaline, pH 7.4; weakly calcareous; clear, smooth lower boundary.

Ahk1 —6 to 9 inches, black to very dark grey (10YR 2/1 to 3/1, dry) very fine sandy loam; moderate, fine, granular; friable when moist, slightly hard to soft when dry; mildly alkaline, pH 7.6; weakly calcareous; clear, wavy lower boundary.

Ahk2 —9 to 14 inches, very dark grey to dark grey (10YR 3/1 to 4/1, dry) very fine sandy clay loam; moderate, fine, granular; firm when moist, slightly hard when dry; moderately alkaline, pH 8.3; moderately calcareous; clear, wavy lower boundary.

ACk —14 to 24 inches, dark greyish brown to light greyish brown (2.5Y 4/2 to 6/2, dry) very fine sandy clay loam; moderate, fine, granular, firm when moist, hard when dry; strongly alkaline, ph 8.7; strongly calcareous; gradual, irregular lower boundary.

Ckgj1 —24 to 30 inches, grayish brown to light grey (2.5Y 5/2 to 7/2, dry) very fine sandy loam; weak, fine, granular; friable when moist; hard when dry;

TABLE 16

Analyses of Gnadenthal Loam

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	% Total N	C.E.C. m.e./ 100 gm.	NH_4 Acetate Extractable Cations Ca	Mg	K	Na
Apk	0- 6	VFSL	66	15	19	7.4	1.2	2.1	3.4	0.3	21.2	13.4*	6.9	0.5	0.4
Ahk1	6- 9	VFSL	64	15	21	7.6	1.0	3.6	2.9	0.3	20.9	12.9*	7.7	0.1	0.2
Ahk2	9-14	VFSCL	55	19	26	8.3	0.5	15.8	1.8	0.2	—	—	—	—	—
ACk	14-24	VFSCL	57	20	23	8.7	0.7	18.7	0.7	0.1	10.4	—	—	—	—
Ckgj1	24-30	VFSL	63	19	18	8.5	0.7	16.6	0.4	<0.1	—	—	—	—	—
Ckgj2	30+	VFSL	75	15	10	8.2	2.7	17.3	0.1	<0.1	—	—	—	—	—

*Exchangeable Calcium determined by difference.

moderately alkaline, pH 8.5; moderately to strongly calcareous; a few, fine, faint brown mottles; clear, irregular lower boundary.

Ckgj2 — 30 inches plus, light olive brown to light yellowish brown (2.5Y 5/4 to 6/4, dry) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; moderately alkaline, pH 8.2; strongly calcareous; many, fine, faint brown mottles.

Gnadenthal Loam, Weakly Saline Phase (Gb)

These soils differ from normal Gnadenthal loam soils in having soluble salts within the rooting zone of plants in sufficient quantity to affect crop growth. The salts, largely magnesium sulphates, are not uniformly distributed in these soils, accounting for the erratic crop growth in areas mapped as Gnadenthal weakly saline phase. Significant areas of normal Gnadenthal loam soils are also included.

Gnadenthal Clay Loam (Gc)

These are Gnadenthal soils with clay loam textured surface horizons. Surface horizons of these soils are less permeable and have a harder consistence than the normal loam type. Apart from these differences the characteristics in the remainder of the solum are the same as those of the normal loam type. Small areas of the loam type are also included in areas of these soils.

Gnadenthal Clay (Gd)

These soils, like the Gnadenthal clay loam type are Gnadenthal soils with finer textured surface horizons making them less permeable, less friable and somewhat more difficult to till than the normal loam type. Included with these soils are small areas of the clay loam type.

FIGURE 12

Landscape of Gnadenthal soils showing limey surface horizons and flat topography.

FIGURE 13

Irregular pattern of wheat growth on weakly saline Gnadenthal soils. Note isolated areas of greater salt concentration where crop has been severely damaged.

GRAYSVILLE SERIES (Gf)

These are somewhat poorly or imperfectly drained Gleyed Carbonated Rego Black soils. They formed in thin, medium grading to moderately fine textured, moderately to strongly calcareous sediments overlying calcareous lacustrine clay. The change from loamy sediments to clayey sediments, usually within 2 to 4 feet of the surface, is abrupt. They occupy level land where runoff is slow. Internal drainage is impeded by fine textures in the subsoil and by high groundwater conditions for a significant period during the spring runoff.

These soils, like the very similar Gnadenthal soils, have moderately thick, black to very dark grey Ah horizons that are granular, friable, neutral to mildly alkaline in reaction and usually calcareous; a transitional dark greyish brown, strongly calcareous, granular, AC horizon and a light grey to greyish brown C horizon that is granular, moderately to strongly calcareous, somewhat saline, and mottled. Greyish brown, massive clay underlying these sediments are moderately to strongly calcareous, moderately alkaline and stained with numerous, distinct, fine to medium brown mottles.

The Graysville soils, like the productive Gnadenthal soils, are all cultivated and are well suited for cereals, sugar beets, sunflowers, buckwheat, peas, forage crops and corn.

GLENCROSS SERIES (Gg)

These are somewhat poorly or imperfectly drained Gleyed Carbonated Rego Black soils developed in thin, medium grading to moderately fine textured, moderately to strongly calcareous sediments that overlie strongly calcareous, stony, water-worked glacial till. The change from loamy sediments to stony, loamy textured till is abrupt and usually occurs at 1 to 4 feet below the surface. A gravelly or cobbly lense usually occurs at the contact of the unconforming layers. They occur in a few scattered small areas on level terrain where runoff is slow and in association with the well drained Roseisle soils.

These slightly to moderately stony soils have thin black to very dark grey Ah horizons that are granular, friable, mildly alkaline in reaction and calcareous; thin transitional, greyish brown, strongly calcareous, moderately alkaline, granular AC horizons and light grey to light brownish grey, strongly calcareous C horizons having a granular-like structure, friable to slightly hard consistence and numerous faint to distinct, medium to fine sized, brown mottles. Flakes of dark grey shale with white calcium carbonate coatings occur near the contact of the underlying till. The greyish brown to light brownish grey, loamy textured till is granular, moderately alkaline, moderately to strongly calcareous, gypsiferous and stained with brown mottles.

Hochfeld Series (Hb)

These are well drained Orthic Black soils developed in moderately coarse to coarse textured, moderately calcareous, sandy deltaic and lacustrine sediments. The deposits are stratified and become somewhat coarser with depth. They occupy smooth, level to very gently sloping terrain where there is very little runoff and internal drainage or permeability is moderately rapid. Internal drainage is influenced by high groundwater levels for a short period during spring runoff.

Hochfeld soils have moderately thick, very dark grey to dark grey, sandy Ah horizons that are weakly granular, loose in consistence and neutral in reaction; sandy, greyish brown Bm horizons that have weak granular structure, loose consistence and neutral reaction. These horizons are underlain by light yellowish brown, fine sandy C horizons that are loose, moderately alkaline in reaction, moderately calcareous and faintly stained with brown mottles.

These soils are very susceptible to wind erosion because of their sandy textures and loose consistence. It is not unusual in cultivated fields of Hochfeld soils to find Bm horizons being mixed with Ah horizons and imparting greyish brown color and more alkaline reactions to surface layers than normal.

Hochfeld soils differ from the similar but imperfectly drained, Reinland soils with which they are associated in having a distinct brown colored Bm horizon and in not having many brown mottles in the C horizon. They differ from the very similar, moderately well drained, somewhat finer textured, Rosengart soils in having looser consistence, greater permeability and more distinct Bm horizons.

A representative Hochfeld loamy fine sand in a cultivated field is given below:

Ap – 0 to 5 inches, very dark grey to dark grey (10YR 3/1 to 4/1, dry) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; neutral, pH 6.8; abrupt, smooth lower boundary.

Ah – 5 to 10 inches, very dark grey to dark grey (10YR 3/1 to 4/1, dry) very fine sandy loam; weak, fine granular; very friable when moist, soft when dry; neutral, pH 6.8; clear, wavy lower boundary.

Bm – 10 to 20 inches, dark greyish brown to light greyish brown (10YR 4/2 to 6/2, dry) loamy very fine sand; weak, fine granular; very friable when moist, soft when dry; mildly alkaline, pH 7.5; gradual, wavy lower boundary.

Ck1 – 20 to 34 inches, greyish brown to light brownish grey (10YR 5/2 to 6/2, dry) loamy fine sand; single grained; loose; moderately alkaline, pH 8.0; weakly calcareous; a few, fine, faint brown mottles; gradual, irregular lower boundary.

Ck2 – 34 inches plus; greyish brown to light brownish grey (2.5Y 5/2 to 6/2, dry) fine sand; single grained; loose; moderately alkaline, pH 8.3; moderately calcareous; numerous, fine to medium, faint to distinct brown mottles.

Hochfeld Fine Sandy Loam, Moderately Eroded Phase (Hc)

These are Hochfeld soils that have had a significant amount of their Ah horizons removed from them. Consequently, ordinary tillage has brought up and mixed the Bm horizon and in some cases the lower lying calcareous Ck horizons with surface soil in the plow layer. Generally, about 25 to 75 percent of the original A horizons have been re-

TABLE 17

Analyses of Hochfeld Very Fine Sandy Loam

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	% Total N	C.E.C. m.e./ 100 gm.	NH_4 Acetate Extractable Cations Ca	Mg	K	Na
Ap	0-5	VFSL	80	7	13	6.8	0.3	0.0	1.9	0.2	16.0	12.6	3.0	0.3	0.3
Ah	5-10	VFSL	80	7	13	6.8	0.4	0.0	2.0	0.2	16.7	13.6	2.6	0.4	0.2
Bm	10-20	LVFS	85	5	10	7.5	0.2	0.0	1.1	0.1	13.1	10.5	2.7	0.2	0.2
Ck1	20-34	LFS	87	4	9	8.0	0.2	3.2	0.3	<0.1	–	–	–	–	–
Ck2	34+	FS	91	3	6	8.3	0.2	9.5	0.2	<0.1	17.0	14.7	2.4	0.1	0.1

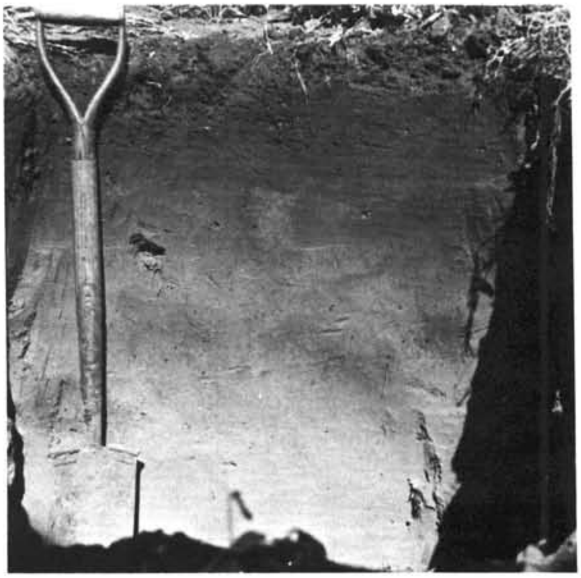


FIGURE 14

Soil profile of Hochfeld Series. An Orthic Black soil developed on moderately coarse, calcareous, sandy sediments.

moved. Rarely is this condition uniform throughout mappable areas.

These soils occur in small scattered areas in association with normal slightly eroded Hochfeld soils and with Hochfeld overblown phase.

Hochfeld Fine Sandy Loam, Overblown Phase (Hd)

These are Hochfeld soils that have an accumulation of dark greyish brown to greyish brown, thinly layered loamy fine sand deposits, about 6 to 12 inches thick, overlying normal Hochfeld soils.

They occur in small scattered areas along fence lines, field borders and old nucleated Mennonite villages.

HORNDEAN SERIES (He)

These are imperfectly drained Gleyed Orthic Black soils. They are formed in thin, fine textured, moderately to strongly calcareous lacustrine clay sediments overlying coarse to medium textured deposits. The change from massive clayey material to the underlying stratified sandy sediments is abrupt and usually occurs at 2 to 3 feet below the surface. They occur in level areas where runoff is slow and internal drainage or permeability is also slow because of fine surface soil textures. High ground-water levels affect these soils for significant periods during the spring runoff.

Horndean soils have moderately thick black to very dark grey Ah horizons that are granular, plastic and sticky when wet, very firm when moist and very hard when dry and neutral to mildly alkaline in reaction. These surface horizons grade into very dark brown to very dark greyish brown Bm horizons having blocky structure, plastic and sticky consistence when wet, very hard consistence when dry, numerous faint brown mottles and mildly alkaline reactions. These horizons grade in turn to greyish brown C horizons that are granular-like, firm when moist and hard when dry, mildly to moderately alkaline in reaction, stained with many, distinct, brown mottles and are gypsiferous, particularly near the contact of the clayey material and sandy material. The underlying light olive brown sandy sediments are stratified, loose, rapidly permeable, stained with many brown mottles, usually saline and moderately to strongly alkaline in reaction.

These soils differ from the moderately well drained very similar Jordan soils with which they are associated, in having darker grey or more neutral colors in the solum and a greater quantity of brown mottles higher in the profile. The imperfectly drained related Dugas soils do not have B horizons. The clayey Plum Coulee soils, like Horndean soils, are imperfectly drained, have iron stained B horizons, but are more uniformly fine textured in the subsoils.

A representative profile of Horndean clay in a cultivated field is described below:

Ap —0 to 6 inches, black to very dark grey (10YR 2/1 to 3/1, dry) clay; strong, fine, granular; firm when moist, very hard when dry; mildly alkaline, pH 7.6; weakly calcareous; abrupt, smooth lower boundary.

TABLE 18

Analyses of Horndean Clay

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	% Total N	C.E.C. m.e./ 100 gm.	NH_4 Acetate Extractable Cations Ca	Mg	K	Na
Ap	0- 6	C	16	33	51	7.6	0.7	2.9	2.9	—	42.2	33.6	10.0	0.9	0.4
Ah	6-11	C	16	26	58	7.5	0.5	0.0	3.6	0.3	41.8	33.4	9.8	0.6	0.7
Bmgj	11-18	C	10	21	69	7.4	0.4	0.2	1.4	0.1	39.7	32.3	9.5	0.7	0.9
BCkgj	18-26	C	8	21	71	7.9	0.5	8.4	0.8	0.1	—	—	—	—	—
Ckgj	26-34	C	10	24	66	7.8	3.3	17.1	0.0	—	30.3	12.7*	16.9	0.2	0.5
IICkgj1	34-44	CL	34	40	26	7.8	3.3	18.6	—	—	—	—	—	—	—
IICkgj2	44-50	VFS	87	10	3	8.1	5.9	11.7	—	—	—	—	—	—	—

*Exchangeable calcium determined by difference. NH_4 Acetate extractable calcium was 35.4 m.e./100gm.

Ah –6 to 11 inches, black to very dark grey (10YR 2/1 to 3/1, dry) clay; strong, medium, granular; firm when moist, very hard when dry; mildly alkaline, pH 7.5; clear, wavy lower boundary.

Bmgj –11 to 18 inches, very dark brown to very dark greyish brown (10YR 2.5/2 to 3/2, dry) clay; strong, fine, subangular blocky; very firm when moist, very hard when dry; mildly alkaline, pH 7.4; few, fine, faint brown mottles; clear, irregular lower boundary.

BCkgj –18 to 26 inches, dark greyish brown (10YR 4/2, dry) clay; strong, coarse, granular; very firm when moist, very hard when dry; moderately alkaline, pH 7.9; moderately calcareous; many, fine to medium, faint brown mottles; clear, irregular lower boundary.

Ckgj –26 to 34 inches, dark greyish brown to greyish brown (2.5Y 4/2 to 5/2, dry) clay; strong, granular; very firm when moist, very hard when dry; moderately alkaline, pH 7.8; moderately to strongly calcareous; many, fine to medium, faint brown mottles; numerous, small clusters of white gypsum crystals; clear, wavy lower boundary.

IICkgj1 –34 to 44 inches; dark greyish brown to greyish brown (2.5Y 4/2 to 5/2, dry) loam; moderate, granular-like structure; firm when moist, hard when dry; moderately alkaline, pH 7.8; strongly calcareous; many, fine to medium faint brown mottles; many small clusters of white gypsum crystals and calcium carbonate concretions; abrupt, wavy lower boundary.

IICksgj2 –44 to about 50 inches, olive brown to light olive brown (2.5Y 4/4 to 5/4, dry) very fine sand; single grained; loose; moderately alkaline, pH 8.1; weakly saline; moderately calcareous; many, fine to medium distinct brown mottles.

Horndean Clay Loam (Hf)

These are Horndean soils with clay loam textured surface horizons. As a consequence, the surface layers of these soils are somewhat more friable, offer less resistance to tillage and have a less firm consistence than the clay type. Small areas of the normal type are included in these soil areas.

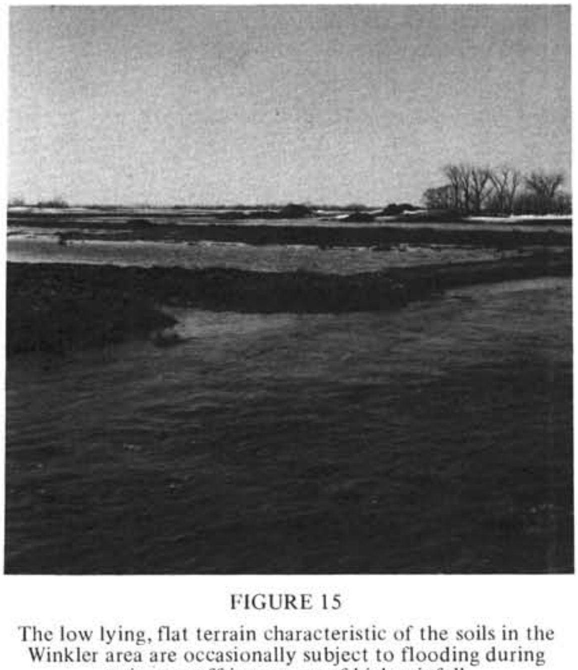


FIGURE 15

The low lying, flat terrain characteristic of the soils in the Winkler area are occasionally subject to flooding during spring runoff in seasons of high rainfall, as in April, 1962.

FIGURE 16

Soil profile of Horndean clay. A Gleyed Orthic Black developed on shallow clayey sediments overlying layered medium to coarse textured sediments.

Horndean Loam (Hh)

These are Horndean soils with loam textured surface horizons. They differ from the clay and clay loam types in having more friable, more permeable, and softer surface horizons. They are more suited to root crops than either of the other types.

HOBSON SERIES (Hj)

These are well drained Orthic Black soils formed in thin, moderately coarse to coarse textured, sandy sediments overlying calcareous lacustrine clay sediments. The change from the permeable sandy material to the massive slowly permeable clay is abrupt and usually occurs between 1 to 4 feet below the surface. They occupy smooth very gently sloping terrain where runoff is slow. Internal drainage is impeded due to fine textured subsurface soils.

They have, like the very similar Hochfeld soils, moderately thick, very dark grey Ah horizons that are weakly granular, soft in consistence and neutral in reaction; distinct greyish brown Bm horizons that are weakly granular, very soft and neutral in reaction. These horizons are in turn underlain by light yellowish brown to very pale brown, mildly alkaline, C horizons that are loose and weakly calcareous. They are often stained with medium, distinct brown mottles at the contact of the underlying light olive brown to light brownish grey clayey material. The clayey material is usually moderately calcareous and moderately alkaline and faintly stained with brown mottles. It is the occurrence of this clayey material within 1 to 4 feet of the surface that differentiates these soils from the Hochfeld soils.

The similar Rosengart soils have stronger granular structures in the solum and are uniformly medium textured throughout the profile.

Huddlestone soils are also very similar in profile characteristics to Hobson soils differing from them in having stony, loamy textured, strongly calcareous substrata.

HUDDLESTONE SERIES (Hk)

Huddlestone soils are well drained Orthic Black developed in thin, moderately coarse to coarse, moderatively calcareous deltaic and lacustrine sandy sediments that overlie strongly calcareous, stony, water-worked till. The change from sandy to clayey materials is abrupt occurring between 1 to 4 feet of the surface. They occupy a few small areas that are smooth, level to gently sloping and slightly to moderately stony.

Their profile characteristics are similar to those of Hobson and Hochfeld soils in having moderately deep, very dark grey Ah horizons that are weakly granular, soft and neutral in reaction. They also have distinct greyish brown Bm horizons that are weakly granular to single grained, soft to loose in consistence and neutral in reaction. These horizons are underlain by pale brown to light brownish grey sandy C horizons that are calcareous, mildly alkaline and faintly stained with iron mottles near the contact of the underlying loamy textured till. As well, a stony gravelly lag often occurs at the contact of the stony, light brownish grey to pale yellow till that is strongly calcareous, moderately alkaline and mottled.

Huddlestones series differ from the very similar Hobson soils in the nature of their subsoil properties. Hobson soils are underlain by slowly permeable, massive lacustrine clay, while Huddlestone soils are underlain by stony loamy till as described above.

The similar Hochfeld soils are uniformly sandy throughout their profiles.

Rosengart soils which are also well drained Orthic Black soils differ from Huddlestone in having uniform medium to moderately coarse textures throughout their profiles.

JORDAN SERIES (Ja)

These are moderately well drained Orthic Black soils developed in thin, moderately to strongly calcareous, fine clay that overlies calcareous, coarse to medium textured sediments. The surface texture of this series ranges from loam to clay. The change from clay to the coarser textured subsoil is abrupt and usually occurs within 2 to 4 feet of the surface. These coarser subsurface sediments are stratified and it is not unusual to find thin layers of fine to very fine sand alternating with layers of silty clay. They occupy level to very gently sloping land where runoff is moderately slow to slow. Internal drainage in these soils is also slow.

These soils which have developed under a lush growth of tall prairie grasses have thick, black to very dark grey, granular horizons. These horizons are plastic when moist and very hard when dry, and are usually neutral to slightly acid in reaction. A dark greyish brown, neutral to slightly alkaline B horizon having subangular blocky structure and plastic to very hard consistence underlies the A horizon. This B horizon often extends to the contact of the coarse textured, frequently slightly to moderately saline IIC horizon. The stratified IIC horizon is usually yellowish brown to very pale brown, moderately to strongly calcareous, mildly alkaline in reaction and stained with brown colored mottles.

These soils differ from the very similar Winkler series in having an unconforming stratified, coarser textured IIC horizon.

They differ significantly in texture from the moderately fine to medium textured Eigenhof and Reinfeld series; the somewhat stony, medium textured Roseisle series; the moderately coarse Rosengart series; the moderately coarse textured, sandy Hochfeld and Hobson series; the somewhat stony Huddlestone series and from the Edenburg series whose moderately fine textured surface layers overlay coarse sediments.

A description of a representative Jordan soil profile is given below:

Ap —0 to 6 inches, very dark grey to black (10YR 3/1 dry, to 10YR 2/1, moist) clay; strong, medium, granular structure; very firm when moist, very hard when dry; mildly alkaline in reaction, pH 7.5, abrupt, smooth lower boundary.

Ah —6 to 13 inches, very dark grey to black (10YR 3/1 dry to 10YR 2/1, moist) clay; strong, fine, granular structure; very firm when moist, very hard when dry; mildly alkaline in reaction, pH 7.5; clear, wavy lower boundary.

IIBA —13 to 18 inches, very dark greyish brown to very dark brown (10YR 3/2 dry to 10YR 2/2, moist) clay loam; strong, coarse granular; firm when moist, hard when dry; mildly alkaline in reaction, pH 7.5; clear, wavy lower boundary.

IIBm —18 to 24 inches, very dark greyish brown to very dark brown (10YR 3/2, dry to 10YR 2/2, moist) clay loam; strong, fine to medium, subangular blocky; firm when moist, hard when dry; mildly alkaline; pH 7.6; clear, wavy lower boundary.

IIBC —24 to 28 inches, dark greyish brown to very dark greyish brown (10YR 4/2, dry to 10YR 3/2, moist) clay loam; strong, coarse, granular; firm when moist, hard when dry; slightly calcareous and moderately alkaline in reaction, pH 7.8; clear, wavy lower boundary.

IICk —28 to 36 inches, light grey to greyish brown (10YR 7/2, dry to 10YR 5/2, moist) clay loam with fine layers of silt loam and sand; moderate, fine, granular structure; firm when moist, hard when dry; strongly calcareous and moderately alkaline in reaction, pH 8.1; clear, wavy lower boundary.

IICk2 —36 to 46 inches, yellowish brown to very pale brown (10YR 5/4 to 10YR 7/4, dry) clay loam with fine layers of very fine sandy loam and sand; weak, fine, granular; friable when moist, slightly hard when dry; strongly calcareous and moderately

TABLE 19

Analyses of Jordan Clay

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	% Total N	C.E.C. m.e./ 100 gm.	NH_4 Acetate Extractable Cations Ca	Mg	K	Na
Ap	0- 6	C	23	29	48	7.5	0.8	0.8	3.2	0.3	40.7	29.2	10.5	1.2	0.3
Ah	6-13	C	31	26	43	7.5	0.4	–	1.2	0.3	36.7	28.0	8.0	0.6	0.4
IIBA	13-18	CL	45	20	35	7.5	0.3	–	2.3	0.2	29.8	21.7	7.3	0.4	0.4
IIBm	18-24	CL	43	22	35	7.6	1.3	–	1.4	0.1	23.0	18.8	8.8	0.3	0.2
IIBCk	24-28	CL	40	23	37	7.8	4.6	1.8	1.3	0.1	–	–	–	–	–
IICk	28-36	CL	45	17	38	8.1	7.7	21.8	0.6	0.1	15.9	–	–	–	–
IICk2	36-46	L	39	38	23	8.0	6.7	22.9	–	–	–	–	–	–	–
IICk3	46+	SiCL	10	52	38	7.6	3.1	7.5	–	–	–	–	–	–	–

alkaline in reaction, pH 8.0; stained with numerous medium sized, yellowish brown to brown iron mottles.

IICk3 – This horizon is the same as the IICk2 horizon, differing from it in being less calcareous and only mildly alkaline in reaction, pH 7.6.

Jordan Clay Loam (Jb)

These are Jordan soils having a clay loam textured surface horizon. The surface horizons of these soils, therefore, are more friable and usually remain in a more favorable state of tilth than the clay type. Permeability of the surface horizons is moderately slow and very slow in the clay textured layers. Minor amounts of normal clay type Jordan soils are found in mapped areas of Jordan clay loam.

MORRIS CLAY (Mo)

The Morris Series consists of imperfectly drained Gleyed Solonetzic Black soils developed on weakly to moderately calcareous lacustrine clay deposits. These soils occur in the smooth level eastern section of the map area. Runoff is slow and permeability is very slow.

In their native state, these soils are characterized by a shallow dark grey, granular Ah or Ahej horizon, that is usually neutral to slightly acid in reaction and overlies a columnar very dark grey to dark grey Bnjgj1 horizon 4 to 5 inches thick. These columns often have a ⅛ inch thick grey to dark grey outer layer. This color distinction is not very evident in moist soil but is readily discernable in dry soils. This horizon grades into an amorphous dark grey to black Bnjgj2 that breaks readily into coarse subangular blocky aggregates when moist. When dry, this horizon becomes very hard and massive and breaks with difficulty into very coarse clods. Gypsum crystals are usually very prominent in the dull colored, amorphous, moderately alkaline C horizon.

Under cultivation, most of the Bnjgj1 horizon is incorporated into the Ap horizon. When moist, the Ap horizon is cloddy and breaks under pressure into weak, medium to fine granular peds; when dry, it becomes cloddy and very hard.

A description of a representative Morris clay soil in its natural state is given below:

Ahej – 0 to 2 inches, grey to black (10YR 5/1 dry, 10YR 2/1 moist) clay; moderate, fine, granular; friable when moist, hard when dry; slightly acid; abrupt, smooth boundary.

BA 2 to 3 inches, grey to black (10YR 5/1 dry, 10YR 2/1 moist) clay; moderate, medium, granular; friable when moist, hard when dry; slightly acid; abrupt, smooth boundary.

Bnjgj1 – 3 to 9 inches, dark grey to black (10YR 4/1 dry, 10YR 2/1 moist) clay; strong, coarse, columnar breaking to strong, coarse, blocky; very firm when moist, extremely hard when dry; slightly acid; clear, smooth boundary.

TABLE 20

Analyses of Morris Clay

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	% Moist 1/3 Atm.	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	% Total N	CEC m.e./ 100 gm.	NH_4 Ac Extractable Cations Ca	Mg	K	Na	H	Soluble Cations on saturated extract m.e./1 Ca	Mg	Na
Ahej	0- 2	C	12	33	55	32.8	6.2	0.2	0	3.6	0.3	39.7	16.4	14.9	1.8	0.6	6.0			
Bnjgj1	3- 9	C	5	24	71	41.5	6.2	0.2	0	2.3	0.2	47.6	18.5	22.4	1.1	1.6	4.0			
Bnjgj2	9-13	C	3	14	83	49.8	7.1	1.0	0.1	1.5	0.1	53.6	17.5	25.8	1.1	3.0	5.2			
BCkgj	13-17	C	3	19	78	45.6	7.8	2.5	4.1	1.1	0.1							6.0	8.8	12.5
Cksg1	17-24	C	3	28	69	41.9	8.0	6.4	12.5									22.8	42.0	36.5
Cksg2	24-36	C	2	24	74	29.8	8.1	6.8	13.9									23.8	48.0	34.5

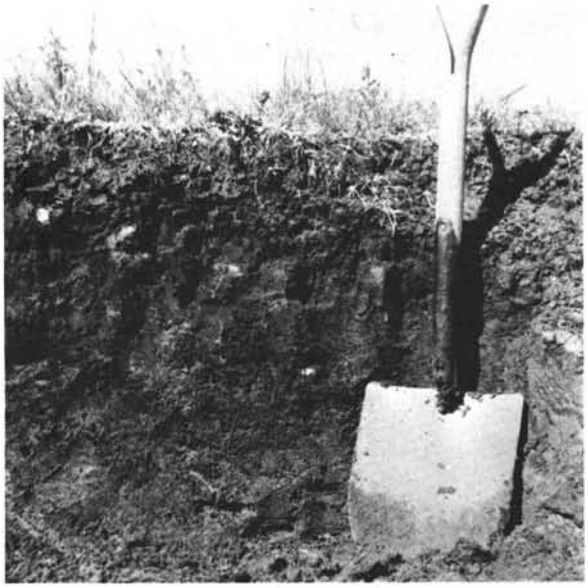


FIGURE 17

Soil profile of Morris clay. A Gleyed Solonetzic Black soil developed on deep lacustrine clay. They are usually associated with Red River series.

Bnjgj2 – 9 to 13 inches, dark grey to black (10YR 4/1 dry, 10YR 2/1 moist) clay; massive breaking to moderate, very coarse subangular blocky; very plastic when wet, very firm when moist, extremely hard when dry; neutral; gradual, wavy boundary.

BCkg – 13 to 17 inches, greyish brown to very dark greyish brown (2.5Y 5/2 dry, 2.5Y 3/2 moist) clay; few, fine, prominent yellowish brown (10YR 5/6 moist) mottles; amorphous breaking to moderate, very coarse, subangular, blocky; very plastic, very firm, very hard; moderately alkaline; moderately calcareous; gradual, wavy lower boundary.

Cksg1 – 17 to 24 inches, greyish brown to dark greyish brown (2.5Y 5/2 dry, 2.5Y 4/2 moist) clay; common, fine to medium, prominent yellowish brown (10YR 5/6 moist) iron mottles and gypsum crystals; amorphous breaking to weak, fine to medium, granular; very firm when moist, very hard when dry; moderately alkaline; moderately calcareous.

Cksg2 – 24 to 36 inches, greyish brown to dark greyish brown (2.5Y 5/2 dry, 2.5Y 4/2 moist) clay; common, fine to medium, prominent yellowish brown (10YR 5/6 moist) iron mottles and gypsum crystals; amorphous breaking to weak, fine to medium, granular; very firm when moist, very hard when dry; moderately alkaline; moderately calcareous.

NEUENBERG SERIES (Na)

The Neuenberg series consists of imperfectly to moderately well drained Gleyed Carbonated Rego Black soils developed on moderately to strongly calcareous, medium grading to moderately coarse textured deltaic and lacustrine sediments. These soils are common in occurrence, particularly west of the Emerado Beach where they are found in association with the Gnadenthal series. The deposits are usually stratified and underlain by lacustrine clay at 10 to 12 feet from the surface. The profile consists of a dark gray Ah horizon over a light brownish grey C horizon. Iron staining is variable. There is usually a carbonate concentration in the upper C horizon. The thickness of the Ah horizon is usually within the range of 5 to 12 inches. Cultivated soils effervesce with dilute HCl to the surface.

The topography is smooth, level to gently sloping. Runoff is slow and permeability moderate.

Drainage may be affected by a water table that is near the surface in the spring, but decreases 9 to 10 feet from the surface by late fall. A frozen layer keeps surface horizons near field capacity for the spring months, and is probably an influencing factor in surface lime accumulation and degree of iron mottling in the profile. There are no stones nor native vegetation left in areas of these soils.

These soils are being used for the production of grain, sugar beets, potatoes, onions, sunflowers, buckwheat, canning peas, corn, forage, and pasture.

A representative profile description of Neuenberg very fine sandy loam is described below:

Apk – 0 to 6 inches, very dark grey (10YR 3/1, dry) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; mildly to moderately alkaline, pH 8.3 and weakly calcareous; abrupt, smooth lower boundary.

Ahk – 6 to 12 inches, very dark grey (10YR 3/1, dry) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; mildly to moderately alkaline, pH 8.4 and weakly calcareous; clear, smooth lower boundary.

ACk – 12 to 24 inches, grey (10YR 5/1, dry) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; mildly to moderately alkaline, pH 8.3 and moderately calcareous; weakly iron stained; clear, smooth lower boundary.

TABLE 21

Analyses of Neuenberg Very Fine Sandy Loam

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm	$CaCO_3$ Equiv. %	Org. C %	Total N %	Exch. Cap. m.e./ 100 gm. soil	Exchangeable Cations Ca	Mg	K	Na	H
Apk	0- 6	VFSL	63	28	9	8.3	0.6	2.1	1.7	0.2	12.5	14.6	8.1	0.1	0.4	
Ahk	6-12	VFSL	81	6	13	8.4	1.1	2.7	1.7	0.2	15.1	–	–	–	–	
ACk	12-24	VFSL	77	8	15	8.3	0.5	8.1	1.0	0.1	–	–	–	–	–	
Ckgj1	24-30	VFSL	79	7	14	8.3	0.3	12.9	0.4	<0.1	18.9	13.6	6.9	0.1	0.3	
Ckgj2	30+	VFSL	85	8	7	8.2	0.3	15.9	0.1	–	–	–	–	–	–	

Ckgj1 — 24 to 30 inches, pale brown (10YR 6/3, dry) very fine sandy loam; structureless; loose when moist, soft when dry; moderately alkaline, pH 8.3 and moderately calcareous; iron stained; clear, wavy lower boundary.

Ckgj2 — 30+ inches, light yellowish brown (2.5Y 6/4, dry) very fine sand, structureless; loose when moist, loose when dry; moderately alkaline, pH 8.3, moderately calcareous; iron stained.

These soils are very similar in profile characteristics to the Gnadenthal Series differing from them in having somewhat coarser, sandier textures, thus making them significantly more friable and permeable. Both characteristics are important for the culture of such root crops as onions.

Neuenberg soils are distinctively coarser textured, more friable and permeable than the similar fine textured Red River, Deadhorse and Dugas Series; the moderately fine textured Neuhorst and Newton Siding Series; the medium textured, stony Glencross Series and the medium textured Graysville series that is underlain by impermeable clay.

They are not as droughty as the similar moderately coarse textured Reinland and Hochfeld series; nor the coarse textured Birkenhead series.

Neuenberg Very Fine Sandy Loam, Imperfectly Drained Phase (Nb)

These are Neuenberg soils that are located east of the Emerado Beach. They differ from the normal Neuenberg soils only in having a high water table for a significant period during spring runoff and after heavy summer rain storms. While not a serious limitation to dry land farming, this high water table condition can be a distinct problem under irrigation.

FIGURE 18

Soil profile of Neuenberg very fine sandy loam. A gleyed Carbonated Rego Black on medium to moderately coarse textured sediments.

FIGURE 19

Onions growing on Neuenberg soils. The permeable sandy textures of these fertile soils makes them well suited for such root crops.

Neuenberg Loam (Nc)

These are moderately well drained Neuenberg soils that differ from the normal very fine sandy loam type in having a loam to silt loam textured surface horizon. This surface horizon is therefore a little more plastic and sticky when moist than the very fine sandy loam type. The surface horizon is also somewhat less permeable. They are excellent soils both for dryland and irrigation culture.

NEUHORST SERIES (Ne)

The Neuhorst Series consist of imperfectly drained Gleyed Carbonated Rego Black soils developed on moderately to strongly calcareous, moderately fine textured deltaic and lacustrine sediments. These soils occupy only a small portion of the Morden-Winkler map area. Neuhorst clay loam is the most common type mapped. The profile consists of a moderately thick very dark grey Ah horizon over a grayish brown to light brownish gray, iron stained C horizon. Cultivated fields are calcareous to the surface and usually show some calcium carbonate accumulation in the upper C horizon.

The thickness of the Ah horizon is usually within the range of six to twelve inches. The C horizon is often stratified with loam and very fine sandy clay loam bands. Lacustrine clay is commonly encountered at five to six feet from the surface, with a range of about three to eight feet. Strong accumulations of gypsum are common in the C horizon. The degree of iron staining is variable in the upper C horizon, however, in the lower C horizon it is strong.

The topography of these soil areas is smooth level to gently sloping. Runoff is slow and permeability moderate to moderately slow. Permeability of the underlying clay is very slow, thus resulting in a water table that ranges from about four to seven feet of the surface.

These stone-free soils have developed under a lush growth of tall prairie grasses that have long since been replaced by cereals, flax, corn, sugar beets, potatoes, and some grasses for pasture and hay.

A representative description of a Neuhorst clay loam profile is given below:

Ap – 0 to 5 inches, very dark grey (10YR 3/1, dry) clay loam; moderate fine, granular; firm when moist, hard when dry; mildly alkaline, pH 7.7, and slightly saline; abrupt, smooth lower boundary.

Ah – 5 to 12 inches, very dark grey (10YR 3/1, dry) clay loam; strong, medium, granular; firm when moist, hard when dry; mildly alkaline, pH 7.8, and slightly saline; numerous rodent burrows; clear, irregular lower boundary.

ACk – 12 to 23 inches, greyish brown (10YR 5/2, dry) clay loam; moderate, fine, granular; firm when moist, hard when dry; moderately alkaline, pH 8.4, and moderately calcareous; numerous rodent burrows; clear, irregular lower boundary.

Ckgj1 – 23 to 36 inches, pale brown (10YR 6/3, dry) clay loam; moderate, fine, granular; firm when moist, hard when dry; moderately alkaline, pH 8.2, and strongly calcareous; iron stained; clear, irregular lower boundary.

Ckgj2 – 36 to 50 inches, light brownish grey (2.5Y 6/2, dry) clay loam; moderate, fine, granular; firm when moist, hard when dry; moderately alkaline. pH 7.9, strongly calcareous; iron stained.

Neuhorst soils are similar in profile characteristics to the clay textured Deadhorse, Dugas and Red River series, differing from them in being coarser textured, more friable and more permeable to water.

They are not as friable and permeable to water as the coarser textured Glencross, Gnadenthal, Graysville, Neuenberg, Newton Siding and Reinland Series.

Neuhorst soils are excellent for dryland farming but do have a drainage limitation under irrigation. High water table conditions, particularly after heavy rain storms, pose a flooding hazard if irrigation water is applied just prior to rain storms.

Neuhorst Clay Loam, Slightly Saline Phase (Nf)

These are normal Neuhorst soils that contain soluble salts within and below the rooting zone of plants in sufficient quantities to adversely affect growth. The distribution of soluble salts in these soils is variable and the presence of salt affected soils can be detected in the field by irregular growth patterns. A significant but minor amount of normal Neuhorst soils are usually found in these soil areas.

Neuhorst Loam (Ng)

These are normal Neuhorst soils with a thin loam textured surface layer approximately 6 to 8 inches thick. The plow layer of these soils are not as sticky and plastic as the normal clay loam type.

Neuhorst Clay (Nh)

These are areas of Neuhorst soils with a very thin clay textured surface horizon approximately 6 to 8 inches thick. These finer textures cause the surface plow layer to be less permeable to water and more plastic and sticky than the surface of the clay loam and loam types.

Newton Siding Series (Nj)

The Newton Siding Series consists of imperfectly drained Gleyed Carbonated Rego Black soils developed on thin, moderately fine textured, moderately to strongly calcareous sediments overlying sandy, coarse to moderately coarse textured sediments.

The topography is level to very gently sloping. Runoff is slow, and permeability is moderately slow to slow. The native vegetation consists of dominantly tall prairie and prairie-meadow grasses.

The soil is characterized by a weakly calcareous, very dark gray Ah horizon 10 to 16 inches thick; a gray AC horizon 3 to 8 inches thick; and a light gray to light brownish gray C horizon. A lime accumulation zone of 4 to 6 inches thick may be present below the AC horizon. These soils have a similar solum as the Neuhorst Series, but differ

TABLE 22

Analyses of Neuhorst Clay Loam

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm	$CaCO_3$ Equiv. %	Org. C %	Total N %	Exch. Cap. m.e./ 100 gm. soil	Exchangeable Cations Ca	Mg	K	Na	H
Ap	0- 5	VFSCL	58	18	24	7.7	3.1	–	5.4	0.5	32.1	22.6	9.4	0.9	0.4	
Ah	5-12	VFSCL	57	17	26	7.8	6.8	–	3.5	0.3	31.1	17.0	15.1	0.9	9.7	
ACk	12-23	VFSCL	56	18	26	8.4	1.0	9.3	1.2	0.1	–	–	–	–	–	
Ckgj1	23-36	VFSCL	54	20	26	8.2	0.7	17.1	0.6	<0.1	31.8	17.4	13.6	0.4	1.6	
Ckgj2	36-50	CL	39	31	30	7.9	0.6	19.5	0.5	<0.1	23.9	–	–	–	–	

from them in the texture of the underlying sediments; the Neuhorst soils have dominantly stratified medium- to moderately fine-textured sediments with thin strata of coarser sediments while the Newton Siding soils have dominantly stratified fine sand to loamy fine sand sediments with thin strata of fine sandy loam.

A description of a representative Newton Siding clay loam profile is given below:

Ap — 0 to 5 inches, very dark grey (10YR 3/1 dry) silty clay loam; moderate, fine, granular; friable when moist, slightly hard when dry; mildly alkaline; noncalcareous; clear, smooth boundary.

Ahk — 5 to 15 inches, very dark grey (10YR 3/1 dry) silty clay loam; moderate, fine, granular; friable when moist, slightly hard when dry; mildly alkaline; weakly calcareous; gradual, wavy boundary.

ACk — 15 to 20 inches, gray to light grey (10YR 6/1 dry) silt loam; weak, fine, granular; friable when moist, slightly hard when dry; moderately alkaline; strongly calcareous; gradual, wavy boundary.

Ckgj — 20 to 38 inches, light grey (10YR 7/2 dry) silty clay loam; weak, fine pseudo granular; friable when moist, slightly hard when dry; moderately alkaline; strongly calcareous; clear, smooth boundary.

IICkgj1 — 38 to 48 inches, light brownish grey (10YR 6/2 dry) stratified, dominantly fine sand with fine sandy loam strata; few, fine, faint mottles; single grain; loose; moderately alkaline; moderately to strongly calcareous.

Newton Siding, Clay Loam Slightly Saline Phase (Nk)

These are normal Newton Siding clay loam soils that contain soluble salts within and below the rooting zone of plants in sufficient quantities to adversely affect growth. The distribution of salts in these soils is variable both in a vertical and horizontal direction. The presence of these salt affected soils can be detected in the field by irregular plant growth patterns. The presence of salts in the profiles of these soils when in a moist condition are often very difficult to detect. However, numerous glistening, white colored crystals of gypsum often indicate their presence in significant amounts. It is not unusual to find normal Newton Siding soils in significant quantities in areas mapped as the slightly saline phase.

Newton Siding Clay (Nl)

These are Newton Siding soils with a very thin clay textured surface horizon approximately 6 to 8 inches thick. The fine clay texture imparts to the plow layer a more plastic, sticky and less friable condition than the normal Newton Siding soils. It also causes the surface layer to be less permeable to water.

Newton Siding Clay, Slightly Saline Phase (Nm)

These are clay type Newton Siding soils which contain sufficient amounts of soluble salts in the rooting zone to adversely affect plant growth. Like the slightly saline clay loam type, the presence of salts is very difficult to detect in their profiles, particularly when they are moist. They are often detected in the field by the presence of irregular plant growth patterns.

OSTERWICK SERIES (Oa)

The Osterwick series are poorly drained Carbonated Rego Humic Gleysols developed on weakly to moderately calcareous, moderately coarse to medium textured deposits. They are found only in some sloughs west of the Emerado Beach and constitute only a very small acreage. The profile consists of a thin L-H where the soils are uncultivated, a thick very dark grey to black Ah horizon high in organic matter, a dark grey to grey transition horizon, a light grey horizon of lime accumulation, over a light grey to grey iron stained C horizon.

The topography is depressional, the runoff nil and the permeability moderate to moderately rapid. The water table is near the surface, consequently most of these soils are left to slough grasses and weeds which may or may not be cut for hay. There are no stones in areas of these soils.

A description of a representative Osterwick profile is given below:

L-H — 2 to 0 inches, very dark grey to dark grey (2.5Y 3.5/0, dry) loamy muck; moderately alkaline, pH 8.2, and weakly calcareous; abrupt, smooth lower boundary.

TABLE 23

Analysis of Newton Siding Clay Loam

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	% Moist 1/3 Atm.	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	C.E.C. m.e./ 100 gm.	NH_4 Ac Extractable Cations Ca	Mg	K	Na
Ap	0- 5	SiCL	14	47	39	37	7.6	0.9	0.0	4.1	35.9	21.8	12.7	2.5	0.2
Ahk	5-15	SiCL	18	44	38	30	7.5	0.5	1.3	3.2	34.8	24.1	12.0	0.8	0.2
ACk	15-20	SiL	7	67	26	31	8.3	1.0	19.9	0.5					
Ckgj	20-38	SiCL	9	56	35	30	8.4	0.3	23.8	0.6	19.2				
IICkgj1	38-48	FSL	51	36	13	17	8.2	0.4	15.0	0.3					

TABLE 24

Analyses of Osterwick Very Fine Sandy Loam

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/ cm	$CaCO_3$ Equiv. %	Org. C %
L-H	2- 0					8.2	0.9	3.4	5.2
Ahkg	0-12	VFSL	71	13	16	8.1	0.6	4.5	4.0
ACkg	12-14	VFS	88	8	4	8.4	0.5	8.5	1.2
Ckg1	14-19	LVFS	83	5	12	8.7	0.6	15.6	–
Ckg2	19+	LVFS	81	12	7	8.8	0.6	13.8	–

Ahkg – 0 to 12 inches, very dark grey to dark grey (2.5Y 3.5/0) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; moderately alkaline, pH 8.1, and weakly calcareous; clear, smooth lower boundary.

ACkg – 12 to 14 inches, dark grey to grey (2.5Y 4.5/0, dry) very fine sand; weak, fine, platy to weak, fine granular; very friable when moist, soft when dry; moderately alkaline, pH 8.4, and weakly calcareous; clear, smooth lower boundary.

Ckg1 – 14 to 19 inches, light grey (2.5Y 7/2, dry) loamy very fine sand; moderate medium platy; very friable when moist, slightly hard when dry; moderately alkaline, moderately calcareous; stained with yellowish brown mottles (2.5Y 5/6 moist and 10YR 5/8, moist); clear, smooth lower boundary.

Ckg2 – 19 inches plus, grey to light grey (5Y 6.5/1, dry) loamy very fine sand; structureless, moderately alkaline; weakly calcareous and stained with yellowish brown mottles (2.5Y 6/6, moist).

FIGURE 20

Soil profile of Osterwick soils. A poorly drained Carbonated Rego Humic Gleysol on sandy sediments.

Osborne Series (Oc)

The Osborne series is a poorly drained Rego Humic Gleysol developed on weakly to strongly calcareous, fine textured lacustrine clay deposits. In the Winkler area, they occupy only a minor area being confined to sloughs in areas of fine textured deposits. The topography is level to depressional. There is no runoff and permeability is slow. Surface drains are usually quite effective in removing excess moisture that accumulates in the spring or in periods after heavy rains.

The profile consists of a very dark grey Ah horizon which frequently tongues into an olive grey, gleyed C horizon. Under wet and moist conditions, these clays appear massive, but separate into well formed granules on drying. The surface horizons are generally quite high in organic matter.

These soils are used for cereal production or pasture or, if the area is small, commonly left to native slough grasses and weeds.

A description of a representative Osborne soil profile is given below:

Apk – 0 to 5 inches, dark grey to black (10YR 4/1 dry, 10YR 2/1 moist) clay; weak, fine, granular; plastic when wet, firm when moist, hard when dry; moderately alkaline; weakly calcareous; abrupt, smooth boundary.

Ckg1 – 5 to 11 inches, light grey to dark grey (10YR 7/1 dry, 5Y 4/1 moist) clay; amorphous breaking to weak, fine, granular; firm when moist, very hard when dry; moderately alkaline; moderately calcareous; clear, wavy boundary.

Ckg2 – 11 to 17 inches, white to light grey to grey (10YR 7/1-8/1 dry, 5Y 5/1 moist) silty clay; white lime concretions (10YR 8/1 moist); fine, granular; very plastic when wet, firm when moist, hard when dry; moderately alkaline; strongly calcareous; clear, smooth boundary.

Ckg3 – 17 to 23 inches, white to olive grey (10YR 8/1 dry, 5Y 5/2 moist) silty clay; white lime concretions (10YR 8/1 moist) and common, fine to medium, prominent yellowish red (5YR 5/6 moist) mottles; amorphous to weak, fine, granular; very plastic when wet, firm when moist, hard when dry; moderately alkaline, strongly calcareous; clear, smooth boundary.

Ckg4 – 23 to 35 inches, white to olive grey (10YR 8/2 dry, 5Y 5/2 moist) silty clay; light grey (10YR 7/1 moist) carbonate concretions; common, fine to

TABLE 25

Analyses of Osborne Clay

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	% Moist 1/3 Atm.	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	% Total N	C.E.C. m.e./ 100 gm	NH_4 Ac Extractable Cations Ca	Mg	K	Na
Apk	0- 5	C	4	35	61	47	7.8	0.4	3.8	2.7	0.3	51.1	23.5	21.1	0.5	0.4
Ckg1	5-11	C	2	40	58	44	8.2	0.3	15.1	0.6	0.1	33.7	15.6	21.9	0.6	0.5
Ckg2	11-17	SiC	1	45	54		8.0	0.4	20.4	0.5	<0.1					
Ckg3	17-23	SiC	1	42	56	43	8.0	0.5	19.4	0.5	<0.1	28.6	13.5	17.7	0.6	0.8
Ckg4	23-35	SiC	2	55	43		7.9	0.8	20.4	0.6	<0.1					
Ckg5	35-48	C	2	40	58	46	7.8	1.0	9.5	0.7	<0.1					

medium, prominent reddish brown (5YR 4/4 moist) mottles; massive breaking to fine, granular; very plastic when wet, firm when moist, hard when dry; moderately alkaline; strongly calcareous; abrupt, clear boundary.

Ckg5 — 35 to 48 inches, white to olive grey (10YR 8/2 dry, 5Y 4/2 moist) clay; common, fine to medium, prominent reddish brown (5YR 4/4 moist) mottles; fine, granular to massive; firm when moist, hard when dry; mildly alkaline; moderately calcareous; few, fine, faint mottles; clear, irregular boundary.

Osborne soils are similar to but differ from Red River Series in being more poorly drained. Consequently, they are from the point of view of tilth, workability, timeliness of operations such as planting and harvesting, more difficult to manage than the Red River soils.

They differ from the medium textured Blumenfeld and moderately coarse textured Osterwick soils in being much less friable and workable and very much less permeable to water. Blumenort soils differ from Osborne soils in having more variable textures both in a vertical and horizontal direction. All of these poorly drained soils, however, have a high water table condition for significant periods after spring runoff and after heavy summer rain storms in wet years. High water tables, particularly those within the rooting zone of plants, adversely affect plant growth for lack of adequate aeration.

FIGURE 21

Soil profile of Osborne clay. A poorly drained Rego Humic Gleysol developed on deep lacustrine clay sediments.

PLUM COULEE SERIES (Pa)

The Plum Coulee series are imperfectly drained Gleyed Orthic Black soils developed on weakly to strongly calcareous fine textured deposits. Plum Coulee clay is the most common type. A Plum Coulee clay loam type and a Plum Coulee loam type also occur within the map area. The parent material of these soils often have thin, stratified, alternating layers of clay and very fine sand to fine sand within four feet of the surface. The sola usually ranges from twenty to thirty inches in thickness. The profile has a moderately thick, very, dark grey Ah horizon, a very dark greyish brown Bmg horizon over a greyish brown Cg horizon. Iron staining occurs in the lower B and in the C horizon. The C horizon is usually gypsiferous and may be slightly saline.

The Plum Coulee series has a variable thickness of Ah horizon, usually between six and twelve inches. The upper profile is lime free, but below the B horizon an increase in the concentration of lime carbonate occurs sharply with depth. Iron staining follows a similar pattern, being weak in the B horizon and increasing with depth. Accumulations of soluble salts and gypsum in the lower profile are commonly observed in these soils.

The topography is smooth level to gently sloping. Runoff and permeability is slow. The internal drainage in these stone-free soils may be impeded somewhat by a high water table and a subsurface frozen layer during the spring months.

The soils are used primarily for cereal production with smaller acreages in field peas and corn.

A profile description of a representative Plum Coulee series is given below:

Ap — 0 to 5 inches, very dark grey (10YR 3/1, dry) clay loam; moderate, fine to moderate, medium, granular; firm when moist, very hard when dry, slightly acid, pH 6.7, and non-calcareous; abrupt, smooth lower boundary.

TABLE 26

Analyses of Plum Coulee Clay Loam

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/cm	$CaCO_3$ Equiv. %	% Org. C	% Total N	Exch. Cap. m.e./100 gm. soil	Exchangeable Cations Ca	Mg	K	Na	H
Ap	0- 5	CL	33	32	35	6.7	1.0	–	3.4	0.3	32.7	16.1	9.1	0.6	0.2	
Ah	5-10	CL	33	30	37	7.2	0.6	0.1	3.2	0.3	29.7	20.8	9.8	0.9	0.5	
Bmgj	10-17	C	21	33	46	7.4	0.9	0.2	1.5	0.2	33.0	14.9	15.8	0.6	1.3	
BCkgj	17-23	C	18	39	43	8.0	1.1	1.1	0.8	0.1	–	–	–	–	–	
Ckgj1	23-35	C	17	25	58	7.8	3.2	1.0	0.9	<0.1	23.4	–	–			
Ckgj2	35-48	C	–	–	–	7.9	2.7	5.3	0.5	<0.1	–	–	–	–	–	

Ah –5 to 10 inches, very dark grey (10YR 3/1, dry) clay loam; moderate, fine, subangular blocky, firm when moist, very hard when dry; neutral to mildly alkaline, pH 7.2, and non-calcareous; clear, smooth lower boundary.

Bmgj 10 to 17 inches, very dark greyish brown (10YR 3/2, dry) clay; weak, coarse, prismatic breaking to moderate, medium, subangular blocky; firm when moist, very hard to extremely hard when dry; neutral to mildly alkaline, pH 7.4, non-calcareous, and slightly mottled; clear, smooth lower boundary.

BCkgj –17 to 23 inches, dark greyish brown (10YR 4/2, dry) clay; moderate, medium, granular; firm when moist, very hard when dry; mildly to moderately alkaline, pH 8.0, weakly calcareous and iron stained; clear, smooth lower boundary.

Ckgj1 –23 to 35 inches, greyish brown (2.5Y 5/2, dry) clay; strong, fine, granular, very firm when moist, very hard when dry; mildly to moderately alkaline, pH 7.8, moderately calcareous, and iron stained (10YR 6/4, moist); gradual, irregular lower boundary.

Ckgj2 –35 to 48 inches, greyish brown (2.5Y 5/2, dry) clay; weak, fine, granular; very firm when moist, very hard when dry; mildly to moderately alkaline, pH 7.9; moderately calcareous, containing pockets of light grey (10YR 7/2, moist) lime, gypsum and stained with yellowish brown (10YR 5/6, moist) mottles.

These soils differ from the very similar Horndean Series in having more uniform textures in their C horizons. Horndean soils have stratified coarse to moderately coarse textured sandy layers alternating with very thin bands of silt loam to silty clay within 2 to 4 feet of the surface.

Plum Coulee series are not as friable and permeable as the similar medium textured Rignold series.

Plum Coulee Clay Loam (Pb)

These are normal Plum Coulee soils having a clay loam textured surface horizon 8 to 10 inches thick (see profile description and table of analysis). These clay loam textured types of Plum Coulee have a more friable and permeable plow layer than normal clay type Plum Coulee soils.

These are very good soils under dryland culture. However, they have a drainage and a high water table condition that imposes a moderately severe limitation for use under irrigation.

Plum Coulee Loam (Pc)

These are Plum Coulee soils having loam textured surface horizons. The loam texture has the effect of making the plow layer much more friable, less sticky and plastic and more permeable than either the clay or clay loam types.

Reinland Series (Ra)

The Reinland series consist of imperfectly to moderately well drained Gleyed Carbonated Rego Black soils developed on moderately to strongly calcareous, moderately coarse to coarse textured sandy deltaic and lacustrine deposits. These deposits are usually stratified and underlain by lacustrine clay at depths of about 15 feet. The topography is smooth level to gently sloping. There is little runoff and permeability of the soil parent material is moderate to moderately rapid. In the spring, the water table is near the surface, but recedes 10 to 12 feet from the surface by later winter. The water table recedes much more rapidly in Reinland soils that occur to the west of the Emerado Beach than in those which occur east of the beach. This difference in behavior of groundwater fluctuations imparts a significant drainage limitation when Reinland soils that occur east of the beach are irrigated.

The profile consists of a moderately thick dark grey Ah horizon, over a light brownish grey iron stained C horizon. The iron staining is light in the upper C horizon, but increases with depth. The depth of the Ah horizon is about 16 inches with a range from 12 to 20 inches.

A description of a representative Reinland soil profile is given below:

Ah –0 to 20 inches, very dark grey to dark grey (10YR 3/1, moist, 10YR 4/1, dry) loamy very fine sand; weak, fine, granular; very friable when moist, soft to loose when dry; mildly alkaline in reaction, pH 7.7, and slightly calcareous; numerous rodent burrows; clear, wavy lower boundary.

ACgj –20 to 26 inches, very dark greyish brown to dark greyish brown (10YR 3/2 moist, 10YR 4/2 dry) loamy very fine sand; weak, fine, granular, very friable when moist, soft to loose when dry;

moderately alkaline, pH 7.9, and weakly calcareous; numerous rodent burrows; numerous fine to medium sized iron mottles; clear, wavy lower boundary.

Ckgj1 – 26 to 38 inches, dark greyish brown to light brownish grey (10YR 4/2 moist, 10YR 6/2 dry) loamy very fine sand; weak, fine, granular; very friable when moist, soft to loose when dry; moderately alkaline, pH 8.0, and moderately calcareous; numerous rodent and small animal burrows; iron stained; gradual, wavy lower boundary.

Ckgj2 – 38 inches plus, yellowish brown to very pale brown (10YR 5/4 moist, 10YR 7/4 dry) loamy very fine sand; weak, fine, granular; very friable when moist, soft to loose when dry; moderately alkaline, pH 8.3, moderately calcareous, iron stained.

These moderately coarse textured sandy soils are considerably more friable and permeable to water than the similar medium textured Neuenberg.

Reinland, Moderately Eroded Phase (Rb)

Minor areas of Reinland soils occur in the map area that have had removed from them by wind, a sufficient amount of the A horizon so that ordinary tillage will bring up and mix the lower lying horizons with surface soil in the plow layer. However, this eroded condition is not uniform throughout a mappable area. In most sites, the plow layer consists mainly of the original A horizon mixed with underlying horizons, whereas in others the original A horizon has been completely removed and the plow layer in such cases consists of calcareous C horizon material.

Reinland Overblown Phase (Rc)

These are minor areas of Reinland soils that have had deposited on them a significant amount of wind blown material. This wind deposited material is usually very fine sand in texture and

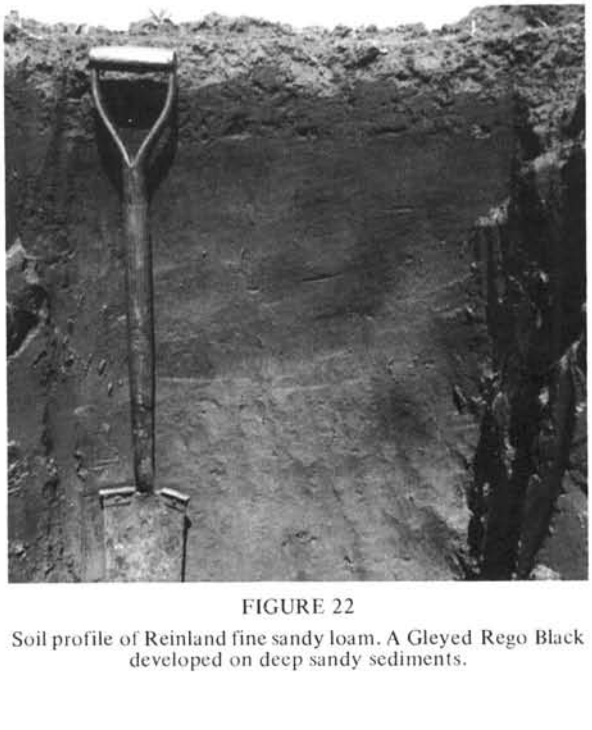


FIGURE 22

Soil profile of Reinland fine sandy loam. A Gleyed Rego Black developed on deep sandy sediments.

is usually several inches to several feet in thickness. The deeper overburden occurs along old fence lines and field borders where more material has been trapped. This material usually contains much less organic matter than the original A horizon and as a result imparts a much lighter color to the surface layer of these soils.

Reinland Imperfectly Drained Phase (Rd)

Significant areas of normal Reinland soils occur east of the Emerado Beach in the Winkler area. Because of their location they have much higher groundwater levels during the spring runoff and after heavy rain storms in wet years than do Reinland soils located west of the beach. This groundwater condition imparts little difference to the profile characteristics of these soils except for increased amounts of iron staining in the subsurface horizons. However, it does impose on them a moderately severe drainage limitation when they are irrigated.

REINFELD SERIES (Re)

The Reinfeld series are moderately well drained Orthic Black soils developed on moderately to strongly calcareous, medium grading to stratified, medium to moderately fine textured lacustrine sediments. These soils are usually found in association with Gnadenthal soils or with Plum Coulee loam where they occupy slightly better drained positions. Topography is smooth level to very gently sloping. Runoff is slow and permeability moderate. Drainage is influenced by a water table that appears to fluctuate between 4 and 12 feet from the surface. There are no stones and native vegetation left. These soils are being used for the production of cereals, sugar beets, potatoes, peas, sunflowers, onions, and some forages.

The profile consists of a very dark grey Ah horizon, a greyish brown to dark greyish brown Bm over a light brownish grey to pale brown C horizon. The thickness of the Ah varies within the range of 6 to 9 inches. The thickness of the sola is usually about 18 inches with a range of 14 to 24 inches.

A description of a representative Reinfeld soil profile is given below:

Ap – 0 to 6 inches, very dark grey (10YR 3/1, dry) very fine sandy clay loam; weak, fine, granular; friable when moist, slightly hard when dry; neutral to mildly alkaline, pH 7.1, and non-calcareous; abrupt, smooth lower boundary.

Ah – 6 to 9 inches, very dark grey (10YR 3/1, dry) very fine sandy clay loam; weak, fine granular; friable when moist, slightly hard when dry; neutral to mildly alkaline, pH 7.2, and non-calcareous; clear, wavy lower boundary.

AB – 9 to 12 inches, very dark greyish brown (10YR 3/2, dry) very fine sandy clay loam; weak, fine, granular; friable when moist, slightly hard when dry; mildly alkaline, pH 7.6, and non-calcareous; clear, wavy lower boundary.

Bm – 12 to 17 inches, dark greyish brown (10YR 4/2, dry) very fine sandy clay loam; weak, fine granular; friable when moist, slightly hard when dry; mildly alkaline, pH 7.6, and non-calcareous; clear, wavy lower boundary.

BCk – 17 to 20 inches, greyish brown (10YR 5/2, dry) loam; medium, fine, granular; friable when moist, slightly hard when dry; moderately alkaline, pH 8.2 and weakly calcareous; clear, wavy lower boundary.

Ckgj1 – 20 to 35 inches, light brownish grey (10YR 6/2, dry) loamy very fine sand; medium, fine, granular; friable when moist, slightly hard when dry; moderately alkaline, pH 8.6, and moderately calcareous; iron stained; numerous calcium carbonate concretions; abrupt, smooth lower boundary.

Ckgj2 – 35 to 48 inches, very pale brown (10YR 7/4, dry) very fine sandy loam; weak fine granular; very friable when moist, soft when dry; mildly to moderately alkaline, pH 8.3 and moderately calcareous; iron stained; numerous calcium carbonate concretions; clear, wavy lower boundary.

Ckgj3 – 48 inches plus, light brownish grey (2.5Y 6/2, dry) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; mildly to moderately alkaline, pH 8.1 and moderately calcareous, strongly iron stained and contains calcium carbonate concretions.

These soils differ from very similar, moderately fine textured Eigenhof and Edenburg soils in being somewhat coarser textured. They are, as a consequence, more friable and permeable to water. Reinfeld series are somewhat less well drained than either the Eigenhof or Edenburg and have as a result, duller colored and more iron stained profiles.

Reinfeld soils are considerably more friable and permeable to water than the fine textured, clayey Winkler and Jordan soils. They are more plastic, sticky and less permeable than the medium textured, somewhat stony Roseisle soils; the medium textured Rosengart soils; and the moderately coarse textured Hochfeld and Hobson soils.

Rignold Series (Rg)

The Rignold Series consists of imperfectly drained Gleyed Orthic Black soils developed on thin, medium grading to moderately fine textured, moderately to strongly calcareous deltaic and lacustrine sediments overlying calcareous lacustrine clay. Topography is very gently sloping to level. Permeability in the medium textured sediments is moderately slow and slow to very slow in the fine textured clay sediments. Runoff is slow. These soils which have developed under a lush growth of tall prairie grasses are characterized by a very dark grey, granular Ah horizon 7 to 10 inches thick; a light brownish grey, granular Bm horizon 8 to 12 inches thick; an iron stained, calcareous and mildly alkaline BC horizon and a light olive brown, granular C horizon that is mottled with iron stains and strongly calcareous. The subsoil may be slightly saline. These soils differ from the very similar fine to moderately fine textured clayey Horndean and Plum Coulee soils in being more friable, more permeable to water and in being less plastic and sticky as well.

Roseisle Series (Rh)

Roseisle Series are well drained, Orthic Black soils that have developed on thin medium grading to moderately fine textured deltaic and lacustrine sediments overlying stony, moderately to strongly calcareous, medium textured water-worked glacial till. Depth of the lacustrine mantle over the till is variable ranging from 6 inches to several feet in thickness; a thin gravelly or cobbly lense usually occurs at this contact. Texture of the surface sediments are variable, ranging from fine sandy loam to clay loam. Topography is smooth, gently sloping, dipping very gently eastward in a series of wave-washed terraces formed during the recession of glacial Lake Agassiz. Runoff is moderate; internal drainage is moderately rapid to the contact of the medium textured compacted till where it is moderately slow.

Roseisle soil profiles are characterized by very dark grey to black, granular Ah horizons that are friable and neutral in reaction overlying a dark greyish brown, granular Bm horizon that is also friable and neutral to mildly alkaline in reaction. The B horizon often terminates at the gravelly to stony contact of the underlying glacial till. The pale brown granular-like C horizon usually occurs in the till deposit below the sandy mantle and occasionally occurs within the sandy layer where the deposits exceed several feet in thickness.

These soils are similar in profile characteristics to the medium textured Rosengart and Reinfeld soils and the moderately fine textured Eigenhof and Edenburg soils, differing from them in being somewhat better drained and in being slightly to moderately stony.

They are much more friable and permeable to water than the fine textured Winkler and Jordan soils.

Roseisle, Stony Phase (Ri)

These are normal Roseisle soils that are moderately to very stony. The sandy lacustrine mantle overlying water-worked till is usually much thinner than that of normal Roseisle soils. Stoniness in these soils are of sufficient quantity to significantly interfere with cultivation.

Rosebank Series (Rj)

Rosebank Series consists of imperfectly drained Gleyed Carbonated Rego Black soils developed in thin, moderately coarse to coarse textured, moderately calcareous, sandy deltaic and lacustrine sediments that overlie calcareous lacustrine clay. The layer of sandy sediments overlying the clay is variable ranging from less than one foot to three or four feet in thickness. Topography is smooth, very gently sloping to level. Runoff is slow. Internal drainage is rapid in the sandy sediments and slow in the underlying clay.

Rosebank soil profiles are characterized by a very dark grey to black, weakly granular Ah horizon about 6 to 13 inches thick that is very friable, often weakly calcareous and mildly alkaline in reaction. Below the Ah lies a dark grey to greyish brown transitional AC horizon, 3 to 12 inches thick, that is weakly granular, very friable to loose, calcareous and mildly to moderately alkaline in reaction. The calcareous, clay textured, massive C horizon is mottled with iron stains and very impermeable to water. Often, the C horizon occurs in the sandy mantle where the sediments are found to exceed more than several feet in thickness. In sandy sediments the pale brown very friable to loose C horizon is mildly alkaline, faintly mottled with iron stains and rapidly permeable to water. Very often calcium carbonate concretions and many fine to medium sized iron mottles concentrate at the sand-clay contact.

FIGURE 23
Beans growing on Rosengart loam.

ROSENGART SERIES (Rn)

The Rosengart Series consists of moderately well drained soils developed on medium grading to moderately coarse textured moderately to strongly calcareous deltaic and lacustrine sediments. These deposits are normally stratified and are underlain by lacustrine clay, commonly within 10 to 15 feet of the surface. Topography is smooth, level to very gently sloping. There is little or no runoff and permeability is rapid to moderately rapid down to the groundwater table resting above the very slowly permeable clay substrate. During the spring runoff the water table may be close to the surface and sometimes perched above a frozen subsurface layer. However, it gradually lowers as summer progresses and by fall it is down to 10 to 12 feet below surface.

The Rosengart soil profile consists of a moderately thick, very dark grey, granular Ah horizon that is usually very friable and neutral to mildly alkaline in reaction; a thin dark greyish brown, granular, friable Bm horizon that is mildly alkaline and non-calcareous; and a light brownish grey, iron stained C horizon that is moderately alkaline and strongly calcareous. Cultivated soils are usually non-calcareous in the Ap and Bm horizons. However, there often is a slight accumulation of calcium carbonate in the upper portion of the C horizon. Thickness of the Ah horizon is variable, being affected by wind erosion and by minor variations of the soil forming processes.

A description of a representative Rosengart soil profile is given below:

Ap — 0 to 6 inches, very dark grey (10YR 3/1) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; mildly alkaline to neutral, pH 7.6; non-calcareous; abrupt, smooth lower boundary.

Ah — 6 to 11 inches, very dark grey (10YR 3/1) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; mildly alkaline, pH 7.7, non-calcareous; clear, wavy lower boundary.

Bm — 11 to 15 inches, dark greyish brown (10YR 4/2) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; mildly alkaline, pH 7.7, non-calcareous; clear, irregular lower boundary.

TABLE 27

Analyses of Rosengart Series

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/cm	$CaCO_3$ Equiv. %	% Org. C	% Total N	Exch. Cap. m.e./100 gm. soil	Exchangeable Cations Ca	Mg	K	Na
Ap	0-6	VFSL	78	8	14	7.6	0.4	—	2.3	0.2	20.6	15.2	5.5	0.1	0.2
Ah	6-11	VFSL	76	9	15	7.7	0.3	—	1.8	0.1	20.1	16.1	4.3	0.2	0.2
Bm	11-15	VFSL	72	9	9	7.7	0.8	—	1.0	0.1	20.0	15.0	5.6	0.3	0.3
BCk	15-22	VFSL	74	10	15	7.8	1.8	1.8	0.5	<0.1	—	—	—	—	—
Ck1	22-30	VFSL	72	9	19	7.9	1.5	12.4	0.5	<0.1	—	—	—	—	—
Ck2	30+	LVFS	82	8	10	7.8	2.1	11.4	0.2	<0.1	9.9	11.1	3.5	0.1	0.2

BCk — 15 to 22 inches, greyish brown (10YR 5/2) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; moderately alkaline, pH 7.8, and calcareous; clear, irregular lower boundary.

Ck1 — 22 to 30 inches, light grey (10YR 7/2) very fine sandy loam; weak, fine, granular; very friable when moist, soft when dry; moderately alkaline, pH 7.9, and calcareous; iron stained; clear, irregular lower boundary.

Ck2 — 30 inches plus, light brownish grey (10YR 6/2,) loamy very fine sand; structureless; loose when moist, loose when dry; moderately alkaline, pH 7.8, and calcareous; iron stained.

Rosengart soils form a soil catena with Neuenberg soils (Gleyed Rego Blacks). They are very similar in profile features to the coarser textured Hochfeld, Hobson and Huddlestone soils and the finer textured Reinfeld, Roseisle, Edenburg, Eigenhof, and Winkler soils.

Rosengart Loam (Rm)

These are Rosengart soils that differ from normal Rosengart soils in having a loam textured surface horizon. Because of the slightly finer texture the plow layer of these soils are somewhat more plastic, sticky and less permeable than the normal soils.

FIGURE 24

Soil profile of Red River clay. A Gleyed Rego Black developed on deep lacustrine clay.

Red River Series (Rr)

The Red River Series consists of imperfectly drained Gleyed Rego Black soils developed on moderately calcareous, fine textured lacustrine deposits. These soils occur on level to very gently sloping terrain. Runoff is slow and permeability is very slow. Native vegetation consists of tall prairie and meadow-prairie grasses.

The soil is characterized by a very dark grey, weak, fine granular Ah horizon, 5 to 9 inches thick; a moderately calcareous grey AC horizon that is weak, fine granular to massive and a grey C horizon. The clay content of the parent material is normally greater than 60 percent.

The Red River soil has profile characteristics similar to the Deadhorse clay but is more uniformly clay textured throughout the profile and is not as stratified. The parent material of the Deadhorse soil contains about 40 to 60 percent clay and is usually stratified, whereas the parent material of the Red River soils in the Morden-Winkler area contains more clay and is usually more saline. These soils are associated with the Morris clay soils.

A representative profile of the Red River Clay is described below:

Ap — 0 to 5 inches, very dark grey to black (2.5Y 3.5/0 dry, 10YR 2/1 moist) silty clay to clay; weak, fine granular; firm when moist, hard when dry; neutral, pH 7.2, non-calcareous; abrupt, smooth boundary.

Ah — 5 to 9 inches, very dark grey to black (2.5Y 3.5/1 dry, 10YR 2/1 moist) clay; weak, fine, granular; firm when moist, hard when dry; mildly alkaline, pH 7.4; usually non-calcareous; clear, irregular boundary.

ACkgj — 9 to 12 inches, grey to dark greyish brown (2.5Y 6/1 dry, 2.5Y 4/2 moist) clay; weak, fine, granular to massive; firm when moist, hard when dry; mildly alkaline, pH 7.7, moderately calcareous; a few, fine, faint mottles; clear, irregular boundary.

Ckgj — 12 to 36 inches, grey to greyish brown (2.5Y 6/1 dry, 2.5Y 4.5/3 moist) clay; few, fine, distinct to prominent yellowish brown (10YR 5/6 moist) mottles; massive; very firm when moist, very hard when dry; moderately alkaline, pH 7.8, moderately calcareous.

TABLE 28

Analyses of Red River Clay

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	% Moist 1/3 Atm.	pH $CaCl_2$	Cond. mmhos/ cm^3	% $CaCO_3$ Equiv.	% Org. C	% Total N	C.E.C. m.e./ 100 gm.	NH_4 Ac Extractable Cations Ca	Mg	K	Na
Ap	0- 5	SiC	5	47	48	41	7.2	0.6	0.8	4.8	0.3	47.2	28.2	17.0	1.8	0.3
Ah	5- 9	C	5	37	58	43	7.4	0.4	1.3	3.6	0.3	46.9	26.7	18.5	1.3	0.4
ACkgj	9-12	C	8	28	64	41	7.7	0.4	14.8	1.2						
Ckgj	12-36	C	7	31	62	44	7.8	1.0	7.8							

WINKLER SERIES (Wa)

The Winkler Series consists of moderately well drained Orthic Black soils developed on fine textured, moderately to strongly calcareous, somewhat stratified clay sediments. These stratified clayey sediments are generally underlain by stratified sandy textured material at 4 to 6 feet from the surface. Topography is level to smooth, very gently sloping. Runoff is slow and permeability is moderately slow to slow. Drainage is also influenced by a groundwater table that fluctuates between 4 to 9 feet from the surface. A perched water table at or near the surface commonly occurs for a short period during early spring when subsurface soils are still frozen.

Winkler soil profiles are characterized by moderately thick, strongly granular, very dark grey to black Ah horizons that are very firm to hard and neutral in reaction. The strongly granular, dark greyish brown Bm horizons are also very firm to hard, and neutral in reaction. Their light brownish grey, granular-like C horizons are hard, moderately calcareous and mildly alkaline. The lower portion of the Bm and C horizons are faintly iron stained and usually contain crystals of gypsum. The sola have good structure and are quite permeable for fine textured soils.

A description of a representative Winkler Clay is given below:

Ap —0 to 6 inches, very dark grey (10YR 3/1 dry) clay; strong, medium, granular; very firm when moist, very hard when dry; neutral, pH 6.7, and non-calcareous; abrupt, smooth lower boundary.

Ah —6 to 12 inches, very dark grey (10YR 3/1 dry) clay; strong, medium, granular; very firm when moist, very hard when dry; neutral, pH 6.7, and non-calcareous; clear, wavy lower boundary.

BA —12 to 15 inches, very dark greyish brown (10YR 3/2 dry) clay; strong, coarse, granular; very firm when moist, very hard when dry; mildly alkaline, pH 6.6, and non-calcareous; clear, wavy lower boundary.

Bm —15 to 20 inches, dark greyish brown (10YR 4/2, dry) clay; strong, fine subangular blocky; very firm when moist, very hard when dry; mildly alkaline and non-calcareous; clear, wavy lower boundary.

BCk —20 to 34 inches, greyish brown (10YR 5/2, dry) clay; strong, coarse, granular; very firm when moist, very hard when dry; moderately alkaline, pH 7.6, and calcareous; lower portion of the horizon is iron stained; clear, wavy lower boundary.

Ck —34 to 44 inches, pale brown (10YR 6/3, dry) clay; strong, fine, granular; very firm when moist, very hard when dry; moderately alkaline, pH 7.5 and strongly calcareous; iron stained and gypsiferous; abrupt, wavy lower boundary.

IICkgj1 —44 to 54 inches, light brownish grey (10YR 6/2, dry) clay loam; medium, fine, granular; firm when moist, hard when dry; moderately alkaline, pH 7.5, and strongly calcareous; iron stained and gypsiferous; clear, wavy lower boundary.

IIC2 —54 inches plus, light grey (10YR 7/2, dry) clay loam; medium, very fine, granular; firm when moist, hard when dry; moderately alkaline and strongly calcareous; iron stained and gypsiferous.

Winkler Series forms a catenary group with Plum Coulee and Deadhorse Series. They are similar in profile features to Jordan Series, differing from them in being uniformly fine textured. Winkler soils are finer textured, are less permeable and less friable than the moderately fine textured Eigenhof and Edenburg soils.

They are considerably more plastic, sticky and less permeable to watery than the coarser textured Reinfeld, Roseisle, Rosengart, Hochfeld, Hobson, Huddlestone and Birkenhead Series.

Winkler Clay Loam (Wb)

These are normal Winkler soils having thin surface horizons, approximately 6 to 8 inches thick that are clay loam in texture rather than clay in texture. These soils as a consequence possess plow layers that are more friable, less sticky and plastic and more permeable to water than the normal Winkler clay type.

Winkler Loam (Wc)

These soils like the Winkler clay loam type are normal Winkler soils. They have thin surface horizons that are loam in texture and therefore, have plow layers that are much more friable, less sticky, less plastic and more permeable to water than the normal clay type or clay loam type of Winkler Series.

TABLE 29

Analyses of Winkler Clay

Horizon	Depth (inches)	Textural Class	Mechanical Analysis % Sand	% Silt	% Clay	pH $CaCl_2$	Cond. mmhos/cm	$CaCO_3$ Equiv. %	Org. C %	Total N %	Exch. Cap. m.e./100 gm. soil	Exchangeable Cations Ca	Mg	K	Na
Ap	0- 6	C	17	40	43	6.7	–	–	4.2	0.3	36.1	26.5	7.0	1.1	0.6
Ah	6-12	C	17	36	47	6.7	–	–	3.9	0.3	35.2	25.2	7.0	1.3	0.6
BA	12-15	C	14	38	48	6.6	–	–	3.0	0.2	–	–	–	-	-
Bm	15-20	C	14	38	48	6.7	–	–	1.4	0.2	29.7	23.7	4.6	0.7	0.6
BCk	20-34	C	12	45	43	7.6	0.3	9.7	1.5	0.1	–	-	–	–	–
Ck	34-44	C	11	43	46	7.5	2.9	11.1	0.8	<0.1	23.4	36.0	9.2	0.3	1.1
IICkgj1	44-54	CL	35	35	30	7.5	3.3	10.5	0.7	<0.1	–	–	–	–	–

AGRICULTURE

Agricultural interpretations of soil survey information contained in this section of the report are made to provide a better understanding of soils and their land use potential under dryland and irrigation farming systems. These interpretations are based mainly on extensive field observations, soil analyses, and to a limited extent on experimental data provided by research workers in soils and crops.

The climate in the Portage la Prairie area is suitable for a wide variety of cereal and horticultural crops. For dryland farming, the precipitation is satisfactory; temperatures during the growing season and frost-free season are favorable and pose no limitations (refer to climatic section). However, to maintain high yields and quality on special and horticultural crops, irrigation during dry periods is recommended. The soil capability for dryland farming and soil suitability for irrigation are described in the following sections.

SOIL CAPABILITY CLASSIFICATION FOR DRYLAND AGRICULTURE*

The capability classification is one of a number of interpretive groupings for agriculture that can be made from soil survey data. In this classification the mineral soils are grouped into seven classes on the basis of their limitations for dryland farming. The first three classes are considered capable of sustained production of common field crops, the fourth class is marginal for sustained arable agriculture, the fifth class is capable of use only for improved permanent pasture, the sixth class is capable of use only for wild pasture, while the seventh class is for soils and land types considered incapable of use for arable agriculture or permanent pasture. While the soil areas in classes one to four are capable of use for cultivated field crops they are also capable for use for permanent pasture. Soil areas in all classes may be suitable for forestry, wildlife and recreational uses. For purposes of this classification, trees, shrubs and ornamental plants that require little cultivation are not considered.

This soil capability classification is based on the assumption that:

1. It is an interpretive classification based on the effects of combinations of climate and soil characteristics and their general productive capacity for common field crops.

2. Soils will be well managed and cropped, using a largely mechanized system of culture.

3. Soils within a capability class are similar with respect to degree but not kind of limitation. Each class includes many different kinds of soils and many soils within any one class require unlike management.

4. Soils considered economically feasible for improvement by drainage, by irrigating, by removing stones, by altering soil structure, or by protecting from overflow are classified according to their continuing limitations or hazards after improvements have been made.

5. The capability classification of the soils in an area may be changed when major reclamation works are installed that permanently change the limitations in use for agriculture.

6. Distance to market, kind of roads, location, size of farms, characteristics of land-ownership, cultural patterns and the skill or resources of individual operators are not criteria for capability groupings.

7. Capability groupings are subject to change as new information about the behavior and responses of the soils become available.

The capability classification consists of three categories:

1. *The capability class*, the broadest category is a grouping of soils that have the same relative degree of limitation or hazard for agricultural use. The limitation becomes progressively greater from Class 1 to Class 7. The class indicates the general suitability of the soils for agricultural use.

2. *The capability subclass* is a grouping of soils with similar kinds of limitations and hazards. These limitations are: adverse climate for crop production (c); undesirable soil structure and/or low permeability (d); erosion damage (e); low fertility (f); inundation by streams or lakes (i); moisture limitation, soils affected by droughtiness owing to coarse soil texture (m); salinity (n); stoniness (p); consolidated rock near the surface (r); two or more adverse soil characteristics such as d, f, m and n (s); adverse topography, either steep slopes or frequency and pattern of slopes in different directions (t); excess water, other than that brought about by inundation (w); cumulative minor adverse characteristics (x).

3. *The unit* is a subdivision within the subclass category that groups together soils that will respond similarly to management.

Brief descriptions of the classes, subclasses and units, together with the soils contained in each unit are:

CLASS 1 - Soils in Class 1 have no significant limitations that restrict their use for crops. These soils have level or gently sloping topography, are deep, well to imperfectly drained and have moderate water holding capacity. They are naturally well supplied with plant nutrients; easily maintained

*The Canada Land Inventory Report No. 2, 1965. Soil Capability Classification for Agriculture. Canada Department of Forestry.

in good tilth and fertility, and moderately high to high in productivity for a wide range of field and vegetable crops. The soils in this class are:

Eigenhof Clay Loam	Ec
Edenburg Clay Loam	Ed
Gnadenthal Loam	Ga
Gnadenthal Clay Loam	Gc
Gnadenthal Clay	Gd
Glencross Loam	Gg
Graysville Loam	Gf
Jordan Clay	Ja
Jordan Clay Loam	Jb
Neuenberg Very Fine Sandy Loam	Na
Neuenberg Imperfectly Drained Phase	Nb
Neuenberg Loam	Nc
Neuhorst Clay Loam	Ne
Neuhorst Loam	Ng
Neuhorst Clay	Nh
Newton Siding Clay Loam	Nj
Newton Siding Clay	Nl
Reinfeld Loam	Re
Rosengart Very Fine Sandy Loam	Rn
Rosengart Loam	Rm
Winkler Clay	Wa
Winkler Clay Loam	Wb
Winkler Loam	Wc

CLASS 2 - Soils in this class have moderate limitations that reduce the choice of crops or require moderate conservation practices. These soils usually have a good waterholding capacity and are either naturally well supplied with plant nutrients or are highly responsive to inputs of fertilizer. They are moderately high to high in productivity for a fairly wide range of crops. Good soil management and cropping practices can be applied without difficulty.

2i These are imperfectly drained fine to moderately coarse textured soils that are found on recently deposited alluvium. They are stratified, variable in texture and found adjacent to stream channels where they are occasionally affected by wetness due to flooding. The soils in this subclass are:

Chortitz Series	Ca1
Elias Clay	Ef

2m – These are moderately well drained to imperfectly drained soils developed on nearly level to gently sloping sandy sediments. They are easily tilled and are readily permeable to roots, air and moisture. They have a low to moderate organic matter content, and moderately low moisture retention capacity. They are somewhat droughty, and if not protected, are susceptible to wind erosion. It is important to maintain organic matter in these soils through the addition of organic residues such as barnyard manure, straw, or green manure crops to prevent wind erosion, to increase water retention capacity and to build up fertility. These soils are very responsive to additions of nitrogen, phosphorus and in some cases, potassium fertilizers. The soils are:

Hobson, Fine Sandy Loam	Hj
Reinland, Fine Sandy Loam	Ra
Reinland, Moderately Eroded Phase	Rb
Reinland, Overblown Phase	Rc
Reinland, Imperfectly Drained Phase	Rd
Rosebank, Fine Sandy Loam	Rj

2p – The soils in this subclass are well to moderately well drained soils that have developed on a thin, medium textured sandy mantle that overlies stony, calcareous medium textured, water-worked till. These soils are somewhat stony and impose a slight limitation to cultivation. They are suitable for and produce excellent crops of wheat, oats, barley, flax, forages, as well as such special crops as corn, sunflowers, and other row crops. These are also responsive to additions of nitrogen and phosphorus fertilizers. The soils are:

Roseisle Loam	Rh

2w – The soils in this class are imperfectly drained fine-textured soils on level to very gently sloping topography. They have a moderately high content of organic matter. They have a slow to very slow permeability. The main soil management problems are maintenance of tilth and good aeration. If cultivated when they are too moist or dry, large massive lumps will result, forming a poor seed bed. The soils take longer to warm up in the spring than medium- to moderately fine-textured soils and usually take longer to dry out following rains. Incorporation of stubble or green manure crops is a good practice to maintain good surface structure and improve permeability. Shallow surface drains should be planned to remove any standing water. Drains and natural intermittent streams or creeks should be made saucer-shaped and seeded down to permanent grass to prevent siltation and to allow implement traffic. The soils in this subclass are:

Blumengart Clay	Bd
Deadhorse Clay	Da
Deadhorse Clay Loam	Dc
Deadhorse Loam	De
Dugas Clay	Df
Dugas Clay Loam	Dh
Dugas Loam	Dk
Horndean Clay	He
Horndean Clay Loam	Hf
Horndean Loam	Hh
Morris Clay	Mo
Plum Coulee Clay	Pa
Plum Coulee Clay Loam	Pb
Plum Coulee Loam	Pc
Rignold Loam	Rg
Red River Clay	Rr

CLASS 3 - Soils in this class have moderately severe limitations that reduce the choice of crops or require special management and conservation practices. Limitations include one or two of the following conditions: ponding for considerable periods of time, erosion, droughtiness, high water tables, flooding and salinity. The subclasses and units in this class are:

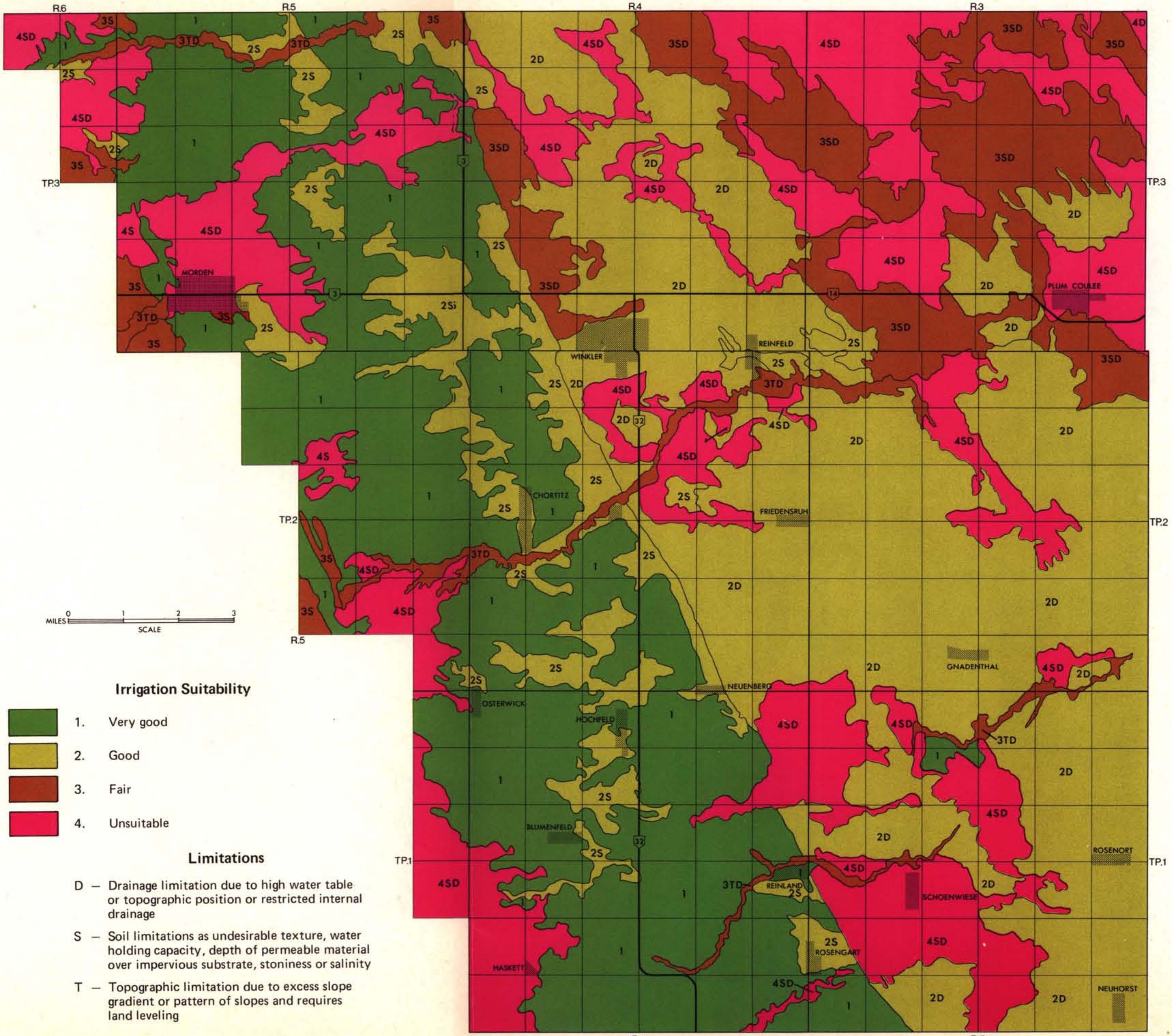
3m – These soils occur on level to very gently sloping, moderately coarse to coarse textured sandy deposits. They have rapid permeability, low water retention capacity, and low to moderate organic matter content. They are subject to droughtiness during the early summer if a dry period results. Wind erosion is a problem if the land remains bare. They are relatively low in natural fertility, but will respond well to additions of nitrogen, phosphorus and potash. Organic residues such as barnyard manure, stubble, straw or green manure crops should be incorporated into the soil regularly to improve or maintain the organic matter status, increase water retention capacity, prevent erosion and to build up the fertility. Under good management, these soils will produce good to excellent crops of cereals, forage and hay. The soils in this subclass are:

Hochfeld Fine Sandy Loam	Hb
Hochfeld Fine Sandy Loam, Moderately Eroded Phase	Hc
Hochfeld Fine Sandy Loam, Overblown Phase	Hd

3nw1 – These are imperfectly drained, slightly to moderately saline, fine-textured soils on level to very gently sloping topography. Crop growth is quite variable on these soils depending on the moisture conditions during the season and the amount of salts present. Degree of salinity is quite variable not only in a horizontal direction or at different sites within an area, but also in a vertical direction. Salts may also be translocated either during the year or over a period of years by capillary rise of saline water and

FIGURE 25

IRRIGATION LAND CLASSES OF MORDEN-WINKLER AREA



subsequent evaporation resulting in a concentration of salts. The usual method to decrease salinity in soils is to improve drainage, avoid the practice of summerfallow and grow crops that will help maintain soil permeability. These soils are able to produce good crops of cereals, forage and hay crops under good management. The soils in this unit are:

Deadhorse Clay, Slightly Saline Phase	Db
Deadhorse Clay Loam, Slightly Saline Phase	Dd
Dugas Clay, Slightly Saline Phase	Dg
Dugas Clay Loam, Slightly Saline Phase	Dl

3nw2 – These are imperfectly drained, slightly to moderately saline, medium- to moderately fine-textured soils on level to very gently sloping topography. Degree of salinity is quite variable throughout areas of these soils and the effect on crops is also very variable depending on the type of crop grown and moisture conditions throughout the growing season. These soils will produce good crops of cereals, forage and hay under good management and fertilizer practice. The soils are:

Gnadenthal Loam, Slightly Saline Phase	Gb
Neuhorst Clay Loam, Slightly Saline Phase	Nf
Newton Siding Clay Loam, Slightly Saline Phase	Nk
Newton Siding Clay, Slightly Saline Phase	Nm

3p – The soils in this class are moderately well drained, medium-textured soils developed on moderately to very stony, thin sandy sediments overlying calcareous glacial till. Agricultural utilization of these soils is hampered by stoniness; stone removal is required for continued cultivation. Good crops of wheat, oats, barley, flax, alfalfa, hay and grass seed can be produced with proper fertilization with nitrogen and phosphate. The soils in this subclass are:

Huddlestone Loamy Fine Sand	Hk
Roseisle Loam, Stony Phase	Ri

3wl – These soils are slowly to very slowly permeable and subject to ponding for considerable periods of time if artificial drainage is not provided. Grain and forage crops can be grown if adequate drainage and good management is provided. The soils in this group are:

Blumenort	Be
Osborne Clay	Oc

3w2 – These poorly drained soils developed on medium to moderately coarse textured sediments are found in level to depressional areas where they cannot be drained economically. While these soils are permeable to water they nevertheless remain saturated for considerable periods during the growing season due to high groundwater levels. Grain and forage crops can be grown if adequate drainage and good management is provided. The soils in this group are:

Blumenfeld Loam	Bb
Osterwick Fine Sandy Loam	Oa

CLASS 4 - The soils in this class have severe limitations that restrict the choice of crops or require special conservation practices or both. These soils have such limitations that they are only suited for a few crops, or the yield for a range of crops may be low or the risk of crop failure is high. The limitations may seriously affect such farming practices as the timing and ease of tillage, planting and harvesting, and the implementation and maintenance of conservation practices. These soils are low to medium in natural productivity for a narrow range of crops but may have higher productivity for a specially adapted crop.

4i – These are imperfectly to somewhat poorly drained soils developed on stratified, moderately fine to moderately coarse textured recent alluvium. They occur adjacent to stream channels and in some cases form the bed of intermittent streams. Topography is irregular, very gently sloping due to stream cutting and deposition. The risk of frequent flooding with severe effects on crops is high. The soils in this subclass are:

Chortitz, Gently Undulating Phase	Ca2

4m – These are sandy to gravelly coarse-textured well drained soils that are droughty. They are low in natural fertility and low in organic matter. Wind erosion is a hazard in cultivated areas. Organic residues such as barnyard manure, stubble and green manure crops should be returned to the soil to prevent erosion, build up nutrient levels, and increase water retention capacity. These soils are suitable for production of forage and cereal crops under good management. The soils in this subclass are:

Birkenhead Loamy Sand	Ba

IRRIGATION SUITABILITY OF SOILS

The appraisal of land for irrigation suitability involves an evaluation of physical, economic and sociological factors. Physical factors, such as soil, water and climate determine the capacity of an area to prduce crops. The economic and sociological factors determine the kind of crops grown and the monetary returns that might be expected. However, from the standpoint of determining the desirability of the land for irrigation, such economic and sociological questions do not concern this report.

Soil classification, as a systematic procedure for delineating land suitability for irrigation, provides a sound basis for fitting land resources into a plan of irrigation development. Land classification emphasizes the prediction of soil behavior for the permanence of crop production. This requires, for example, that drainage requirement be fully recognized because the water regime will be drastically changed and that soil salinity be appraised in terms of anticipated effects.

The soils in the Morden-Winkler area are dominantly moderately well drained to somewhat poorly drained Black soils. Approximately 50 percent of the soils are medium to moderately fine textured, 25 percent are moderately coarse textured and 23 percent are fine textured. Classification of these soils for irrigation suitability places approximately 26 percent as very good, 35 percent as good, 13 percent as fair and 25 percent as unsuitable.

A. *Criteria for the Determination of Irrigation Suitability of Soils.*

Criteria for determining irrigation suitability of land are summarized in Table 30*. They were selected to provide guidelines to assist in the design and management of an irrigation project. They key on such permanent and non-permanent features and properties of soil as:

*Standard employed in this study were adapted from "A Revised Method for Rating Irrigation Soils of Alberta and Saskatchewan", H. C. Moss and W. E. Bowser, University of Saskatchewan, 1961.

1. *Texture.*

A permanent property of soil that greatly affects its ability to retain and transmit water. Generally speaking, soils that range from moderately coarse to moderately fine in texture, are considered to be very good to good for irrigation. Approximately 75 percent of the soils in the map area fall into this category.

Coarse textured sandy soils tend to be deficient in water holding capacity and are excessively permeable resulting in very inefficient use of water applied. The Birkenhead soils that occur on minor beach ridges and terraces west of Morden fall in this category.

Fine textured, clay soils are very impervious and can become water logged when flood irrigated. Soils so affected are the Red River, Morris, Deadhorse, Dugas, Winkler, Plum Coulee, Horndean, Jordan, Blumengart and Elias Series. They comprise approximately 25 percent of the map area and occur mainly in township 3, range 3 and in smaller areas at the foot of the Manitoba Escarpment and the Emerado strandline.

Suitability of soils for irrigation based on texture, can be inferred from their effects on saturation percent and disturbed hydraulic conductivity. (see Table 31).

2. *Structure.*

A characteristic of soil affecting permeability and tilth. Coarse textured sandy soils usually have single grained structure that causes excessive permeability, poor tilth and is susceptible to erosion. Moderately coarse to moderately fine textured soils in the Morden-Winkler area have dominantly granular structures that permit good but not exces-

TABLE 30

Land Classification Standards for Irrigation Suitability — Pembina River Study — Manitoba

Land Characteristics	*Symbols* Subclass Defic.	Class 1 - Very Good	Class 2—Good	Class 3—Fair	Class 4—Unsuitable
SOILS	S				
Texture					
very coarse textured very fine textured	v h	Fine sandy loams to clay loams	Loamy fine sand to light clay	Sand to permeable clay	Gravel to clay
Water holding capacity low available moisture capacity	q	40 to 60 saturation % >6" storage in 4 feet <4"/hr. hydraulic cond.	35 to 65 sat. % >5" storage in 4 feet <5"/hr. hydraulic cond.	25 to 75 sat. % >3" storage in 4 feet <7"/hr. hydraulic cond.	<25 or >75 sat. % <3" storage in 4 feet >7"/hr. hydraulic cond.
Geological Deposit shallow deposit over sand or gravel	k	36" or more of fine sandy loam or heavier	24" or more of fine sandy loam or heavier, or 30" plus of loamy fine sand or sandy loam	18" or more of sandy loam or heavier, or 24" plus of loamy sand	<18" of sandy loam or heavier, or <24" of loamy sand or sand
shallow deposit over impervious substrata	b	>10' of permeable material	>6' of permeable material	>3' of permeable material	<3' of permeable material
Salinity and Alkalinity	a	<4 mmhos in 0-2' <8 mmhos below 2' <6 S.A.R.	<4 mmhos in 0-2' <12 mmhos below 2' <8 S.A.R.	<8 mmhos in 0-2' <15 mmhos below 2' <12 S.A.R.	>8 mmhos in 0-2' >15 mmhos below 2' >12 S.A.R.
EXTERNAL FEATURES	T				
Topography *Slope* excess gradient	g	<1% and 0.1% in general gradient	<3% in general gradient	<5% in general gradient	>5% in general gradient
Irrigation pattern deficient field size or shape	j	400' minimum run 10 acres minimum size if regular 20 acres minimum size if irregular	300' minimum run 5 acres minimum size if regular 8 acres minimum size if irregular	150' minimum run 5 acres minimum size	<150' run <5 acres size
Surface (levelling requirement)	u	Light—0 to 200 cubic yards excavation per acre	Medium—200 to 350 cubic yards excavation per acre	Heavy—350 to 500 cubic yards excavation per acre	Excessive more than 500 cu. yds. excavation per acre
Cover (vegetation) tree and brush clearing	c	None to light clearing	None to medium clearing	None to heavy clearing	Heavy bush
Stones — rock clearing	r	None to light clearing	None to medium clearing	None to heavy clearing	Excessively stony
DRAINAGE	D				
high water table restricted outlet		No problem anticipated	Moderate drainage problem anticipated but may be improved at relatively low cost	Moderate to severe drainage problem anticipated but may be improved by expensive but feasible measures	Drainage improvement not considered feasible

TABLE 31

Physical and Chemical Characteristics of Soils as Related to Irrigation for Morden-Winkler Map Area

Soil Type and Phase	Irrigation Class	Depth (feet)	Texture	Saturation Percentage	pH	Conductivity mmhos/cm	Soluble Salts m.e./1 Na	Soluble Salts m.e./1 Ca+Mg	S.A.R.	Disturbed Hydraulic Cond.	Groundwater Fluctuation
Birkenhead, loamy sand (Ba)	3Sq	0- 1	LMS-FS	22-30	7.3-7.6	0 -0.5				9.0-15.0	below 8 feet most of the year
		1-10	MS	18-25	7.6-8.1	0.3-0.5				10.0-25.0	
Blumenfeld, loam (Bb)	4D	0- 1	L	50-60	7.8-8.1	0.5-2.3				2.0- 4	at or near surface to 4 or 5 feet
		1-10	L-CL	50-60	7.8-8.1	0.5-2.5				0.5- 2.0	
Blumengart, clay (SW 18-1-4W) (Bd)	4Sh	0- 1	C	81	7.3	2.6	2.3	32.8	0.6	<0.1	2 to 8 feet
		1- 2	C	85	7.7	2.1	2.0	27.4	0.5	<0.1	
		2- 3	C	90	7.7	1.0	2.5	9.3	1.2	<0.1	
		3- 4	C	95	7.7	1.8	4.9	18.5	1.6	<0.1	
		4- 5	C	92	7.7	2.5	9.3	24.5	2.7	<0.1	
		5- 6	C	86	7.6	3.6	11.8	40.6	2.6	<0.1	
		6- 8	C	70	7.6	4.0	16.5	41.6	3.6	0.2	
		8-10	L-CL	62	7.9	2.5	11.5	22.2	3.5	0.6	
Blumenort, clay (Be)	4D	Similar to Blumengart clay except for fluctuation of ground water from near surface to 5 or 6 feet.									
Chortitz, loam (NE 16-3-4W) (Ca1)	2D	0- 1	FSL-CL	41	7.4	1.4	1.8	11.5	0.8	2.9	2 to 8 feet
		1- 2	VFSL	41	7.9	0.5	1.0	4.0	0.8	3.2	
		2- 3	FSL	35	8.1	0.5	0.8	4.2	0.6	3.8	
		3- 4	FSL	37	8.1	0.6	1.0	4.9	0.6	2.5	
		4- 6	SiC	106	8.0	1.0	4.3	7.4	2.2	<0.1	
		6- 8	C	115	7.9	1.1	4.7	8.5	2.1	neg	
Chortitz, loam Gently Undulating Phase (Ca2)	3TD	Same as Chortitz smooth phase except for more irregular topography.									
Deadhorse, clay (NW 31-1-3W) (Da)	4Sh	0- 1	C	72	7.9	0.9	2.2	6.9	1.2	0.15	5 to 10 feet below surface
		1- 2	C	87	8.1	0.7	4.2	4.3	2.9	0.3	
		2- 3	C	90	7.9	4.2	17.5	49.6	3.5	–	
		3- 4	C	95	8.2	8.1	51.0	75.4	8.3	0.07	
		4- 5	C	90	8.1	8.1	52.5	74.2	8.6	0.05	
		5- 7	VFSCL	45	8.3	12.6	96.0	112.9	12.8	0.33	
		7- 9	VFSCL	52	8.4	12.6	95.0	104.9	13.1	0.13	
Deadhorse, clay saline phase (NW 22-1-3W) (Db)	4Sha	0- 1	C	65	7.4	3.3	9.0	29.5	2.3	0.4	5 to 10 feet below surface
		1- 2	C	70	7.7	9.8	51.5	99.4	7.3	0.07	
		2- 3	C	72	7.5	12.2	72.0	124.7	9.1	0.05	
		3- 5	C	82	7.6	11.5	67.0	110.2	9.0	0.05	
		5- 7	C	81	7.9	11.5	65.0	107.3	8.9	0.07	
		7- 9	C	97	7.9	10.3	60.0	103.0	8.4	0.03	
		9-10	C	107	7.8	9.8	49.0	81.7	7.7	0.01	
Deadhorse, clay loam (Dc)	4Sh	Same as Deadhorse clay except for a more permeable surface layer.									
Deadhorse, clay loam saline phase (NE 9-1-3W) (Dd)	4Sha	0- 1	CL	56	8.0	8.0	51.0	91.7	7.5	1.3	5 to 10 feet below surface
		1- 3	C	96	7.7	18.8	130.0	253.0	11.6	0.05	
		3- 5	C	105	8.1	18.2	119.0	195.7	12.0	0.08	
		5- 7	C	108	8.0	18.2	118.0	193.5	12.0	0.04	
		7-10	C	110	8.1	16.1	104.0	173.7	11.1	0.04	
Deadhorse, loam (De)	4Sh	Same as Deadhorse clay and Deadhorse clay loam except for a more permeable surface layer.									
Dugas, clay (NW 32-1-3W) (Df)	4Sh	0- 2	CL-C	60	7.8	1.3	3.8	12.4	1.5	0.39	5 to 10 feet below surface
		2- 4	C	55	7.7	4.5	7.3	78.8	1.4	0.08	
		4-10	VFSCL	50	7.8	3.0	5.0	35.6	1.2	1.2	
Dugas, clay, saline phase (SE 18-1-4W) (Dg)	4Sha	0- 1	C	103	7.8	6.8	41.0	74.2	6.7	0.02	
		1- 2	C	97	7.7	6.5	37.0	74.2	6.1	0.04	
		2- 3	CL	86	7.6	4.6	20.5	54.1	3.9	0.25	
		4- 5	FSCL	67	7.7	3.8	15.0	40.1	3.3	0.54	
		5- 7	FSL	37	7.7	2.9	8.5	46.9	1.6	2.1	
		7-10	FSL-FS	36	7.7	3.0	7.3	32.0	1.8	2.2	
Dugas, clay loam (Dh)	4Sh	Same as Dugas clay except for a more permeable surface layer.									
Dugas, loam (Dk)	4Sh	Same as Dugas clay and Dugas clay loam except for a more permeable surface layer.									

TABLE 31 Cont'd.

Physical and Chemical Characteristics of Soils as Related to Irrigation for Morden-Winkler Map Area

Soil Type and Phase	Irrigation Class	Depth (feet)	Texture	Saturation Percentage	pH	Conductivity mmhos/cm	Soluble Salts me./1 Na	Soluble Salts me./1 Ca+Mg	S.A.R.	Disturbed Hydraulic Cond.	Groundwater Fluctuation
Dugas, loam, saline phase (Dl)	4Sha	Same as Dugas clay, saline phase except for a more permeable surface layer.									
Eigenhof, clay loam (NW 4-3-5) (Ec)	1	0- 1	CL	62	7.1	2.7	3.8	26.7	1.0	1.18	4 to 10 feet below surface
		1- 2	CL	62	7.1	2.6	1.5	32.5	0.4	0.32	
		2- 3	CL	66	7.6	1.5	1.1	16.0	0.4	0.19	
		3- 4	CL	68	7.7	2.2	2.0	26.0	0.5	0.13	
		4- 5	VFSCL	65	7.6	3.2	2.0	41.4	0.4	0.30	
		5- 7	VFSCL	67	7.6	3.3	2.3	43.8	0.5	0.22	
		7- 9	VFSCL	62	7.8	3.8	3.8	51.9	0.7	0.17	
		9-10	SiCL	65	7.8	3.8	4.3	53.9	0.8	0.18	
Edenburg, clay loam (SE 22-2-4) (Ed)	1	0- 1	VFSCL	60	7.4	1.0	2.0	11.0	0.9	1.0	3 to 8 feet below surface
		1- 2	VFSCL	50	8.1	2.0	6.8	21.7	2.1	0.79	
		2- 3	VFSCL	57	8.1	6.4	31.0	77.5	5.0	0.42	
		3- 4	FSCL	45	8.3	4.1	25.0	30.2	6.4	0.42	
		4- 5	VFSCL	58	8.2	4.1	24.5	30.2	6.3	0.35	
		5- 6	FSCL-FSL	42	8.2	5.0	30.0	40.3	6.7	0.49	
		6- 8	LFS-FSL	37	8.1	6.3	33.0	56.0	6.2	1.4	
		8- 9	C	82	8.0	6.7	28.0	78.1	4.5	0.17	
Elias, clay (Ef)	4Sh	Same as Blumengart except that surface layers do not contain as much organic matter.									
Gnadenthal, loam (NW 4-2-3W) (Ga)	2D	0- 1	L	47	8.0	1.8	3.2	20.3	1.0	2.0	6 to 9 feet below surface
		1- 2	VFSL	42	8.3	1.5	3.2	16.1	1.1	1.9	
		2- 3	VFSL	41	8.3	1.0	2.6	10.1	1.2	2.6	
		3- 4	VFSL	45	8.4	1.1	2.6	10.9	1.1	0.9	
		4- 6	VFSL-L	48	8.3	0.6	2.3	6.2	1.3	neg	
		6- 7	VFSCL	49	8.2	0.9	2.7	7.2	1.4	0.2	
		7- 9	VFSL	40	8.4	0.9	3.0	7.3	1.6	1.03	
Gnadenthal, loam saline phase (16-1-3W) (Gb)	4DSa	0- 2	VFSL	62	7.5	1.5	3.4	7.6	1.1	1.4	1 to 7 feet below surface
		2- 3	SiCL-L	57	7.7	9.8	55.5	100.0	7.8	0.5	
		3- 4	VFSL	42	7.7	13.1	88.0	130.7	10.9	1.6	
		4- 5	SiCL-L	47	8.0	14.0	88.0	136.4	10.7	0.2	
		5- 8	VFSCL	47	7.9	11.5	73.0	123.2	9.3	1.2	
		8-10	SiL	51	7.9	9.8	55.0	97.5	7.9	0.2	
Gnadenthal, clay loam (Gc)	2D	Same as Gnadenthal loam except for a less permeable surface layer.									
Gnadenthal, clay (Gd)	2D	Same as Gnadenthal loam and clay loam except for a less permeable surface layer.									
Graysville, loam (SW 1-3-3W) (Gf)	3SbD	0- 1	L-CL	51	7.7	0.7	1.2	6.6	0.7	2.6	6 to 10 feet below surface
		1- 2	L-CL	49	7.8	0.5	2.0	4.6	2.0	2.0	
		2- 3	L-CL	53	8.2	1.1	2.4	11.3	1.0	1.0	
		3- 4	L-CL	37	8.0	1.1	3.0	10.9	1.3	2.9	
		4- 5	C	94	7.9	1.0	2.8	9.5	1.3	0.03	
		5- 7	C	100	7.8	1.5	3.4	16.6	1.2	0.03	
		7-18	C	105	7.8	3.7	5.8	51.8	1.1	0.03	
Glencross, loam (Gc)	2D	Similar to Gnadenthal loam except for the occurrence of moderately stony, loam textured, glacial till at approximately 2 to 4 feet of the surface.									
Hochfeld, fine sandy loam (SW 9-2-4W) (Hb)	2Sq	0- 1	LVFS	42	7.4	0.6	0.8	6.2	0.5	2.7	rarely rises to 6 or 7 feet below surface
		1- 2	LVFS	38	8.0	0.4	1.2	2.9	1.0	6.4	
		2- 3	LVFS-FS	36	8.1	0.3	1.0	2.8	0.8	4.9	
		3- 4	LVFS-FS	37	8.1	0.3	0.6	2.7	0.5	3.0	
		4- 5	LVFS-FS	40	8.0	0.3	1.1	2.5	1.0	3.8	
		5- 7	VFSL	44	8.2	0.3	0.6	2.4	0.5	3.5	
		7- 9	VFSL	45	8.1	0.3	0.8	2.5	0.7	2.2	
Hochfeld, fine sandy loam Eroded Phase (Hc)		Same as Hochfeld fine sandy loam except for less organic matter content in the surface layer.									
Hochfeld, fine sandy loam Overblown Phase (Hd)		Same as Hochfeld fine sandy loam except for a thin surface layer of eroded material that is usually more permeable than normal Hochfeld soils.									
Horndean, clay (Sw 33-2-4W) (He)	4Sh	0- 1	C	69	7.7	1.0	3.6	6.6	2.0	1.4	4 to 8 feet below surface
		1- 2	C	75	7.7	1.4	6.4	10.9	2.7	0.5	
		2- 4	CL	40	8.2	1.2	5.8	9.5	15.9	3.6	
		4- 5	CL	67	8.1	2.1	9.5	15.9	3.4	2.3	

TABLE 31 Cont'd.

Physical and Chemical Characteristics of Soils as Related to Irrigation for Morden-Winkler Map Area

Soil Type and Phase	Irrigation Class	Depth (feet)	Texture	Saturation Percentage	pH	Conductivity mmhos/cm	Soluble Salts m.e./1 Na	Ca+Mg	S.A.R.	Disturbed Hydraulic Cond.	Groundwater Fluctuation
Horndean, clay loam	4Sh	0- 1	SiCL	62	7.4	1.3	2.9	12.2	1.2	1.5	4 to 8 feet
(14-2-3W)		1- 2	C	80	8.2	2.0	13.3	12.4	5.3	0.2	below surface
(Hf)		2- 3	CL	51	8.4	4.7	26.0	34.5	6.3	0.8	
		3- 4	VFSCL	48	8.4	5.8	34.5	45.8	7.2	0.3	
		4- 7	VFSL	40	8.1	10.6	68.0	94.8	9.9	0.8	
		7- 9	VFSL	41	8.1	8.8	51.0	80.1	8.1	0.8	
Horndean, loam .... (Hh)	4Sh	Same as Horndean, clay loam except for a more permeable surface layer.									
Hobson, fine sandy loam (Hj)	3Sb	Surface 2 to 4 feet is the same as Hochfeld fine sandy loam. These soils are underlain by impermeable lacustrine clay that impedes free drainage internally.									
Huddlestone, loamy .... fine sand .... (Hk)	3Sq	Surface 2 to 4 feet is very similar to Birkenhead loamy sand; i.e. are characterized by low moisture holding capacity and high or excessive water transmissibility. They are underlain by moderately to very stony glacial till that is permeable and nonsaline.									
Jordan, clay	3Sh	0- 1	C-CL	61	6.6	1.2	0.9	14.2	0.3	1.3	7 to 8 feet
(NE 32-2-4W)		1- 2	C	77	7.2	0.9	0.9	10.5	0.4	–	below surface
(Ja)		2- 3	C	73	7.5	0.5	1.1	4.5	0.7	<0.1	
		3- 4	Cl-C	69	7.6	1.2	3.4	9.9	1.5	<0.1	
		4- 5	C	84	7.4	3.9	7.5	47.3	1.5	<0.1	
		5- 7	FSL	35	7.5	4.4	13.5	58.4	2.5	1.1	
		7-10	SiL	44	7.5	5.1	14.0	60.2	2.6	0.6	
Jordan, clay loam .... (Jb)	3Sh	Same as Jordan clay except for a slightly more friable and permeable surface layer.									
Morris, clay	4Sh	0- 1	C	86	7.8	2.2	13.5	14.9	4.9	0.02	8 to 10 feet
(NW 21-2-2W)		1- 2	C	94	7.8	8.6	50.0	94.9	7.3	0.03	below surface
(Mo)		2- 3	C	100	7.9	9.3	53.0	97.3	7.6	0.03	
		3- 4	C	104	7.8	9.2	51.0	87.6	7.7	0.01	
		4- 6	C	105	7.8	8.6	49.5	87.0	7.5	neg	
		6- 8	C	130	7.7	8.3	44.5	79.8	7.0	neg	
Neuenberg, very fine	1	0- 1	VFSL	55	7.5	1.1	1.8	11.0	0.8	3.7	4 to 9 feet
sandy loam		1- 2	VFSL	44	7.9	0.6	1.4	4.9	0.9	1.2	below surface
(NE 1-1-4W)		2- 3	VFSL	37	7.8	0.5	1.4	4.1	1.0	3.5	
(Na)		3- 4	VFSL	37	7.8	0.5	2.0	3.3	1.6	4.0	
		4- 6	VFSL	44	8.0	0.8	4.5	3.8	3.4	1.3	
		6- 8	VFSCL	44	8.0	1.1	5.5	7.4	2.9	0.5	
		8-10	VFSCL	57	7.9	0.9	4.0	5.7	2.4	0.2	
Neuenberg, very fine	2D	0- 1	VFSL	61	7.6	1.9	1.7	17.1	0.6	2.9	4 to 8 feet
sandy loam, imperfectly..		1- 2	VFSL	45	8.4	1.4	5.5	12.4	2.2	2.0	below surface
drained phase		2- 3	VFSL	41	8.3	0.9	4.0	6.8	2.2	3.6	
(NW 9-2-3W)		3- 4	LVFS	37	8.2	0.9	3.2	6.8	1.7	1.1	
(Nb)		4- 5	LVFS	39	8.3	0.9	3.1	7.1	1.6	1.3	
		5- 6	LVFS	40	8.1	1.1	4.8	8.7	2.3	1.9	
		6- 7	VFSCL	65	8.2	0.8	2.5	5.8	1.5	0.2	
		7- 9	VFSCL	44	8.1	0.7	2.8	5.0	1.8	0.3	
Neuenberg, loam .... (Nc)	1	Same as Neuenberg very fine sandy loam except for a somewhat less permeable surface layer.									
Neuhorst, clay loam	2D	0- 1	CL	50	6.9	0.9	2.4	8.2	1.2	1.4	6 to 9 feet
(SE 7-3-3W)		1- 2	CL	51	7.5	0.5	1.9	3.7	1.4	–	below surface
(Ne)		2- 3	CL	68	7.9	0.4	1.9	2.8	1.6	0.1	
		3- 4	VFSCL	50	7.9	0.5	2.3	2.9	1.9	0.1	
		4- 5	VFSCL	47	7.8	1.8	8.3	12.6	3.3	0.2	
		5- 9	VFSL	42	7.9	6.8	51.0	37.4	11.8	0.5	
Neuhorst, clay loam	4SaD	0- 1	CL	53	7.6	0.9	1.3	8.8	0.6	1.4	4 to 8 feet
saline phase		1- 2	CL	61	8.1	1.1	7.8	8.9	3.7	0.4	below surface
(28-1-3W)		2- 3	CL	45	8.2	8.1	47.0	88.6	7.1	0.6	
(Nf)		3- 5	VFSL-CL	37	8.1	13.7	82.0	165.6	9.0	0.5	
		5- 7	SiCL-SiL	66	7.9	9.6	48.0	112.3	6.4	0.1	
		7-10	C	106	7.8	7.5	35.0	48.9	7.1	0.02	
Neuhorst, loam .... (Ng)	2D	Same as Neuhorst, clay loam except for a more friable and permeable surface layer.									
Neuhorst, clay .... (Nh)	2D	Same as Neuhorst, clay loam except that the surface is less friable and permeable.									

TABLE 31 Cont'd.

Physical and Chemical Characteristics of Soils as Related to Irrigation for Morden-Winkler Map Area

Soil Type and Phase	Irrigation Class	Depth (feet)	Texture	Saturation Percentage	pH	Conductivity mmhos/cm	Soluble Salts m.e./1 Na	Ca+Mg	S.A.R.	Disturbed Hydraulic Cond.	Groundwater Fluctuation
Newton Siding, clay loam	2D	0- 1	SiCL	76	7.3	0.9	3.2	6.5	1.8	0.1	4 to 9 feet
(SW 26-2-5W)		1- 2	SiCL	81	7.8	2.6	7.5	22.4	3.4	0.3	below surface
(Nj)		2- 3	SiCL	50	8.1	1.3	7.4	7.5	3.8	0.4	
		3- 4	VFSL	36	8.0	1.0	4.2	7.3	2.2	0.7	
		4- 6	LFS	37	8.2	0.9	4.1	6.1	2.3	1.8	
		6-10	LFS	40	8.1	0.7	2.4	4.6	1.6	2.1	
		10-12	LFS	41	8.2	0.8	2.7	5.2	1.7	1.9	
Newton Siding, clay loam, slightly saline phase (Nk)	4SaD	Same as Newton Siding clay loam except for significant amounts of soluble salts in the profile.									
Newton Siding, clay (Nl)	2D	Same as Newton Siding clay loam except for a thin clay textured surface layer that is somewhat less permeable.									
Newton Siding, clay, saline phase (Nm)	4SaD	Same as Newton Siding clay except for significant amounts of soluble salts in the profile.									
Osterwick, fine sandy loam (Oa)	4D	Very similar in texture, saturation percentage, soluble salt content, S.A.R. and hydraulic conductivity to Reinland Soils. However, these soils are subject to high groundwater table conditions.									1 to 5 or 6 ft. below surface
Osborne	4D	0- 1	C	72	7.6	0.9	1.8	8.5	0.9	0.6	near surface to
(15-2-2W)		1- 2	C	71	7.9	4.2	21.0	40.9	4.6	0.04	8 or 10 feet
(Oc)		2- 3	C	79	8.0	4.7	25.8	41.0	5.7	0.02	below surface
		3- 4	C	86	8.1	5.6	39.0	42.3	8.5	0.02	
		4- 6	C	100	8.0	6.2	43.6	42.9	9.4	0.01	
		6- 8	C	106	7.8	9.1	52.5	91.4	7.8	0.01	
Plum Coulee, clay	4Sh	0- 1	C-CL	60	7.4	0.8	0.8	8.6	0.4	1.7	7 to 10 or 12
(SE 1-3-3W)		1- 2	C	72	7.4	0.6	1.5	5.9	0.9	0.03	feet below
(Pa)		2- 3	SiCL	54	7.9	1.5	2.8	18.1	0.9	0.3	surface
		3- 4	SiCL	54	7.8	1.2	2.2	13.2	0.9	0.3	
		4- 8	SiL-LVFS	36	8.2	0.5	1.1	3.9	0.8	0.8	
		8-10	SiC	112	7.7	0.7	1.5	6.6	0.8	0.1	
Plum Coulee, clay loam (Pb)	4Sh	Same as Plum Coulee clay except for a somewhat more permeable surface layer.									
Plum Coulee, loam (Pc)	4Sh	Same as Plum Coulee clay and Plum Coulee clay loam except for a more permeable surface layer.									
Reinland, fine	1	0- 1	FSL	41	7.9	0.7	0.7	7.2	0.4	3.2	7 to 10 or 12
sandy loam		1- 2	FSL	39	8.2	0.4	1.0	3.8	0.7	3.3	feet below
(WC 10-1-4W)		2- 4	FSL	42	8.3	0.4	1.0	3.7	0.7	2.4	surface
(Ra)		4- 7	FSL	38	8.0	1.0	2.3	8.8	1.1	1.2	
		7-10	FSL	41	8.1	0.4	0.5	3.3	0.4	0.7	
		10-12	FSL	40	8.2	0.3	0.8	2.8	0.7	1.9	
Reinland, fine sandy loam, eroded phase (Rb)	1	Same as Reinland fine sandy loam except for a thin surface layer that contains less organic matter.									
Reinland, fine sandy loam, overblown phase (Rc)	1	Same as Reinland fine sandy loam except for a thin surface layer of fine sand to loamy fine sand that contains somewhat less organic matter.									
Reinland, fine sandy	2D	0- 1	FSL-VFSL	41	7.9	0.6	0.8	6.7	0.4	3.8	4 to 8 feet
loam, imperfectly		1- 2	FSL	36	8.4	0.5	2.1	6.1	1.2	1.9	below surface
drained phase		2- 3	FSL	36	8.3	0.6	1.8	6.0	1.0	3.8	
(NW 31-2-3W)		3- 5	LFS	36	8.2	0.4	1.2	4.5	0.8	3.1	
(Rd)		5- 6	VFSCL	46	8.2	0.5	1.3	4.2	0.9	0.5	
		6- 8	LFS	38	8.3	0.8	1.9	3.7	1.4	2.0	
		8-10	C	108	7.7	0.7	1.9	5.4	1.2	0.1	
Reinfeld, loam	1	0- 1	VFSL	46	7.0	0.7	1.2	6.4	0.7	4.1	6 to 9 feet
(34-2-4W)		1- 2	VFSL	51	7.6	0.7	0.8	7.2	0.4	2.9	below surface
(Re)		2- 3	VFSL	40	7.6	0.7	1.1	6.3	0.6	2.3	
		3- 4	VFS	37	8.2	0.6	1.4	4.8	0.9	2.8	
		4- 5	VFSL-VFSCL	48	7.8	0.5	1.1	4.8	0.7	0.1	
		5- 7	VFSL	48	7.6	0.5	1.2	3.7	0.9	0.3	
		7-10	VFSL	44	8.0	0.4	1.1	2.8	0.9	0.4	

TABLE 31 Cont'd.

Physical and Chemical Characteristics of Soils as Related to Irrigation for Morden-Winkler Map Area

Soil Type and Phase	Irrigation Class	Depth (feet)	Texture	Saturation Percentage	pH	Conductivity mmhos/cm	Soluble Salts m.e./1 Na	Ca+Mg	S.A.R.	Disturbed Hydraulic Cond.	Groundwater Fluctuation
Rignold, loam (NE 35-3-4W) (Rg)	3Sb	0- 1	FSL	36	7.7	1.2	1.8	10.1	0.8	2.6	8 to 10 feet below surface
		1- 2	FSL	38	7.9	0.7	1.3	5.5	0.8	3.3	
		2- 3	FSL	38	7.9	1.0	2.5	8.0	1.3	2.5	
		3- 4	FSCL	84	7.8	2.8	9.0	27.7	2.4	1.6	
		4- 6	C	94	7.7	4.4	12.5	57.1	2.3	<0.1	
		6- 7	C	102	7.7	4.4	13.0	57.3	2.4	<0.1	
Roseisle, loam (Rh)	2S	Similar to Reinfeld except for a moderately stony, loamy textured, water-worked till substrate at 2 to 4 feet below surface.									6 to 10 feet below surface
Roseisle, loam, moderately to very stony phase (Ri)	3Sr	Same as Roseisle loam except for more surface stone.									
Rosebank, fine sandy loam (Rj)	3SbD	Similar to Rignold loam except that seasonal water table fluctuation is greater.									4 to 10 feet below surface
Rosengart, loam (Rm)	1	Same as Rosengart very fine sandy loam except for a somewhat less friable and permeable surface layer.									
Rosengart, very fine sandy loam (SE 6-1-3W) (Rn)	1	0- 1	VFSL	36	7.2	0.6	0.7	6.2	0.4	2.6	5 to 10 feet below surface
		1- 2	VFSL	38	8.0	0.5	1.0	4.7	0.7	3.8	
		2- 3	VFSL	39	8.2	0.5	1.4	4.2	1.0	1.1	
		3- 4	VFSCL	49	8.2	0.4	1.2	4.1	0.8	0.3	
		4- 6	SiCL	41	8.2	0.4	1.1	3.9	0.8	0.3	
		6- 7	SiCL & C.S.	45	8.1	0.4	1.1	4.0	0.8	0.2	
		7- 9	SiC	80	7.9	0.3	0.8	3.6	0.6	0.04	
		9-11	SiC	75	7.7	0.9	1.0	7.8	0.5	0.05	
Red River, clay (Rr)	4Sh	Same as Morris clay except for a more friable surface layer.									
Winkler, clay (NW 8) (Wa)	3Sh	Same as Winkler clay loam except for a very thin surface that is somewhat less permeable and friable.									
Winkler, clay loam (NW 8-3-4W) (Wb)	3Sh	0- 1	CL	61	6.4	0.9	1.3	7.6	0.7	0.8	6 to 9 feet below surface
		1- 2	C	83	7.6	0.6	2.0	4.6	1.3	0.1	
		2- 3	C	80	8.0	0.5	2.5	2.7	2.2	0.1	
		3- 4	C	82	7.8	0.6	3.0	2.9	2.5	0.1	
		4- 6	C	105	7.9	1.1	7.0	4.9	4.5	<0.1	

sive transmission of water, have good tilth and resist erosion. The fine textured clay soils are usually granular in the plow layer due to high organic matter content but become very massive as organic matter content decreases with depth. Fine texture and massive structure combine to make subsurface layers of these clay soils virtually impervious to water.

3. *Uniformity and Depth of Geological Deposit*

Generally speaking a deep, uniform, permeable deposit is desirable. Depth to impervious material should be sufficient to allow free drainage and to avoid the build-up of a water table.

The moderately coarse to medium textured deposits that occur west of the Emerado beach are fairly uniform and deep, ranging from 20 to 30 feet in thickness. Textural change of one class in a vertical direction is common, since most of these off-shore lacustrine sediments are stratified. Pockets of fine textured alluvium occur around Morden and along the Manitoba Escarpment and often overly these permeable medium to moderately fine textured sediments.

The moderately coarse to moderately fine textured Reinland, Gnadenthal, Neuenberg and Neuhorst soils that occur east of the Emerado Beach are also fairly uniform and quite deep. However, they do tend to become thinner in the eastern section of the map area. Depth to impervious clay substrata in the Plum Coulee area ranges from several feet to about 6 feet and ranges from 6 to 10 feet in the vicinity of the Emerado Beach.

More information on the character of the geological deposits is given in Section 1.

4. *Drainage*

A non-permanent feature of soils that affects the economic soundness or irrigation development should soil be otherwise suitable for irrigation. Generally, moderately well drained to imperfectly drained, moderately coarse to moderately fine textured soils are considered to be suitable for irrigation. In general, most of the soils of the Winkler area fall in this category. Imperfectly drained, impermeable fine textured clay soils are not suitable for irrigation. Well drained granular structured, clay soils are only marginal for irrigation. Poorly drained soils are not suitable for irrigation regardless of texture, since drainage improvement is not considered to be feasible.

The drainage factor takes into account surface and subsurface drainage characteristics as well as groundwater flow.

(a) *Surface and Internal Drainage*

Surface runoff and internal drainage in terrain from the Manitoba Escarpment eastward to the Emerado Beach is good because of slope (see Figure 6) and the permeable nature of the surface deposits in this area. While numerous shallow depressions occur in this section of the map area, they hold water only for short periods after the spring runoff or after heavy summer storms. Numerous streams in well developed channels with banks that are 10 to 12 feet deep traverse terrain that falls 10 to 15 feet per mile.

Terrain from the Emerado Beach eastward falls very gradually at a rate of 3 to 5 feet per mile and streams that traverse this area lack well-developed channels and often flood their banks. Texture of the sediments are also not as permeable. Surface and internal drainage in this section of the map area is not as good as it is west of the beach.

(b) *Groundwater*

Natural groundwater flow in the surface deposits overlying bedrock in the Morden-Winkler map area is northeastward toward the Red River. Water table fluctuations are characterized by a sharp rise in spring and early summer due to recharge from snowmelt and spring precipitation followed by a sharp decline during the summer when evapotranspiration losses are high and then a more gradual decline in fall and winter reflecting outflow to streams. Recharge to aquifers (rise of groundwater) in the area are derived entirely from precipitation. Only rarely does recharge occur at anytime other than the spring period. Discharge from aquifers (lowering of water table) occurs through evaporation and transpiration and direct discharge to streams.

Groundwater hydrographs of the shallow observation well M in the Chortitz-Hochfeld area, well Q in the Plum Coulee area and well A in the Morden area show local variation in groundwater characteristics. Hydrographs do not show a sharp rise of groundwater in deep permeable sandy deposits in the Chortitz-Hochfeld area, well M, nor in well Q, located in very impermeable clay near Plum Coulee. Hydrographs in wells A (Morden) and G (Schoenwiese), on the other hand, show sharp rises of very saline water, indicating local areas where groundwater flow tends to move in an upward direction (see Figure 25).

A unique feature of the Morden-Winkler area is the occurrence of the "Winkler Aquifer" which consists of up to 200 feet of sand and gravel deposits (Figures 26 and 27)[1]. The highest part of the aquifer is at or near land surface north of Deadhorse Creek some 4 miles northwest of Winkler and is covered by 30 to 40 feet of stratified silty clay to clay and till deposits near Winkler. Transmissibility of the aquifer ranges from 80,000 to 700,000 gallons per day per foot. Quality varies considerably with depth. Concentrations of dissolved solids range from 450 to 700 milligrams per liter in the upper 180 feet of the aquifer and 4,000 milligrams per liter in its lower section. The source of the saline water appears to be sandstone beds of the Swan River Formation which occur below the aquifer and are known to contain extremely saline water. Data from observation wells show no appreciable water level decline in the aquifer at present rates of pumping. Indications are that with proper management and expansion of the well field the aquifer could meet by several times the present rate of water consumption. The aquifer, if necessary, could be artificially recharged by diverting water from the creeks that cross it into the aquifer.

Other sources of well water for domestic and farm use are shallow wells in sandy lake and beach deposits in the Morden-Chortitz area, scattered shallow lenses of sand and gravel in till deposits in the Osterwick, Neuenberg, Hasket, Rosengart areas and very scattered shallow wells in buried sandy beaches in the area that lies to the east of the Winkler Aquifer (Figure 26).

The quality of water from shallow wells is variable but in the main suitable for domestic use. Well water in the vicinity of Morden and again in the Schoenwiese and Plum Coulee areas appear to be more saline than in other sections of the map area. All deep wells, particularly those that capture water from the sandstone beds of the Swan River formation are very saline and are not suitable for domestic or irrigation use.

The amount of water available for irrigation from aquifers without producing undesirable effects, according to the groundwater hydrologists of the Water Resources branch, of the Provincial Department of Mines, Resources and Environmental Management[2], is very limited. Large scale mining of water would drastically affect present well systems, discharge to streams and the areal extent of present aquifers.

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[1] M. Rutulis, Ground Water Geologist, Water Resources Branch, Dept. of Mines, Resources and Environmental Management. Personal Communication.

[2] M. Rutulis. Personal Communication.

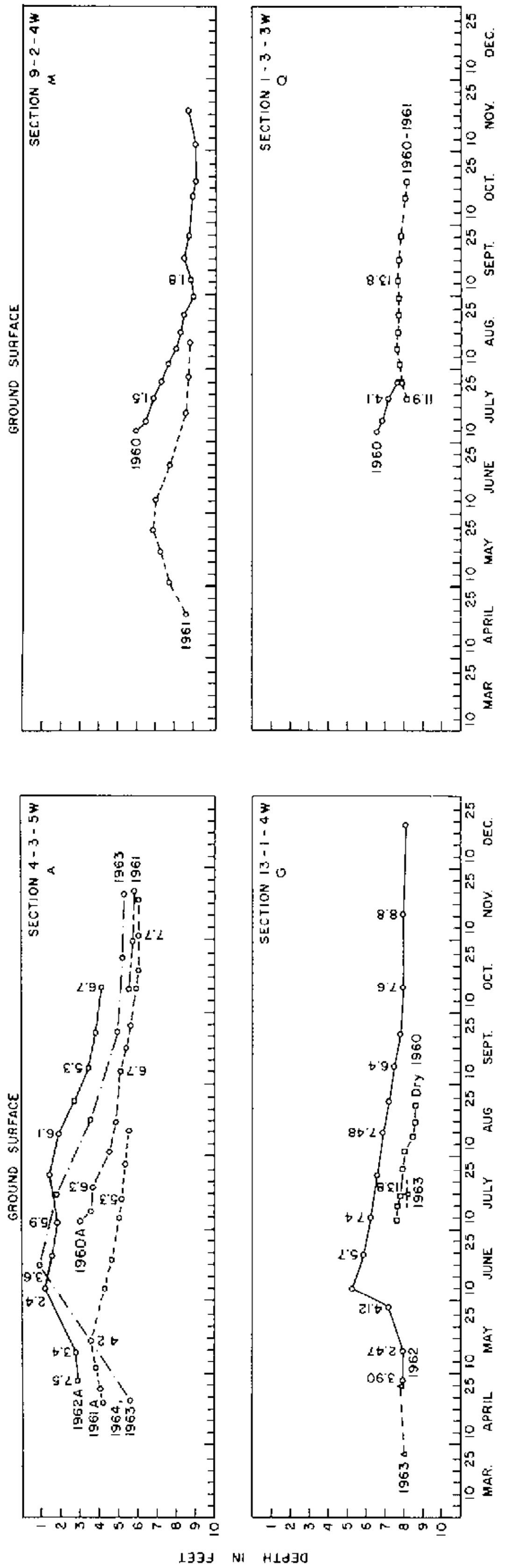
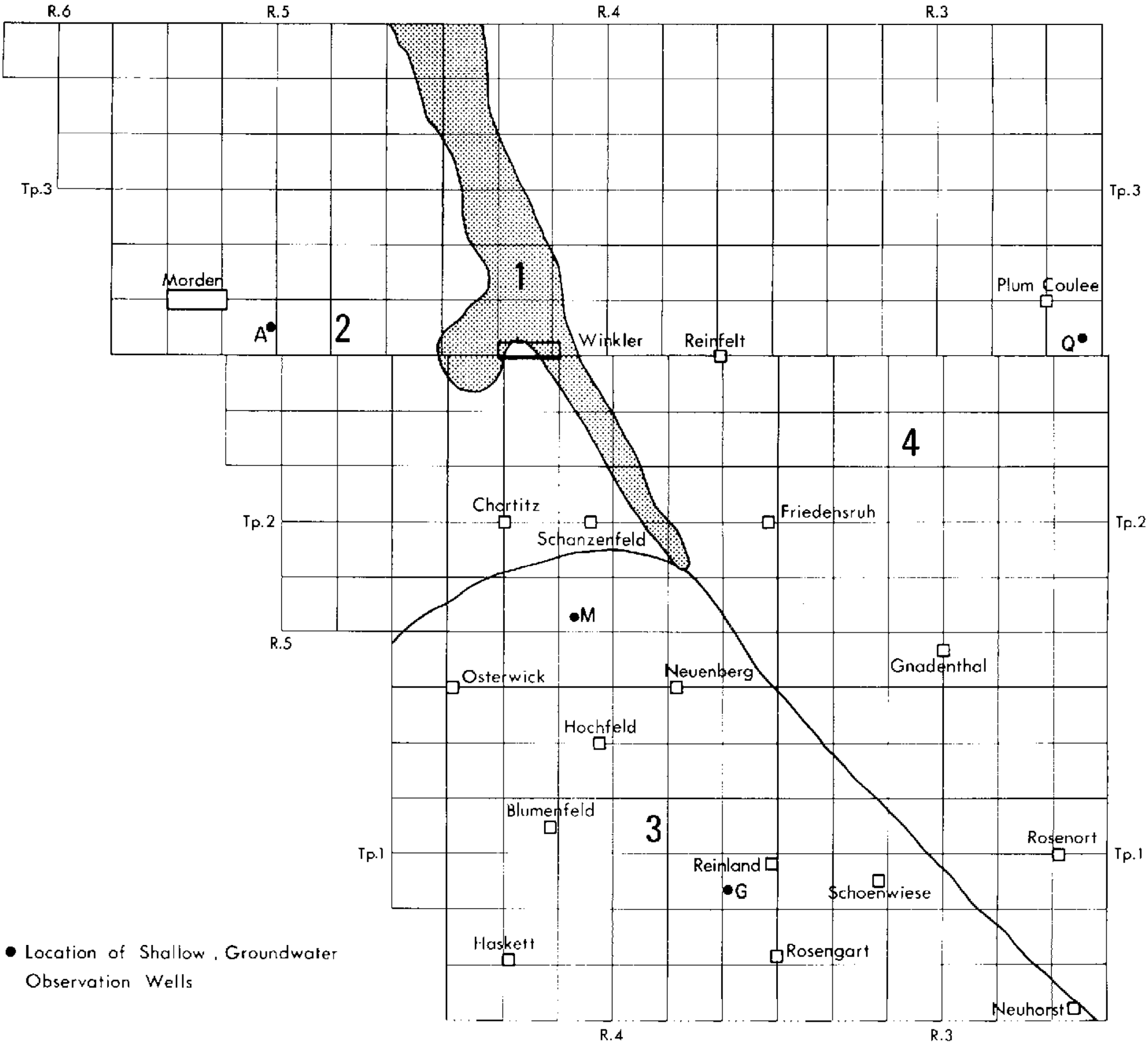


FIGURE 26

Hydrographs of a number of shallow observation wells indicating local variation in groundwater characteristics.

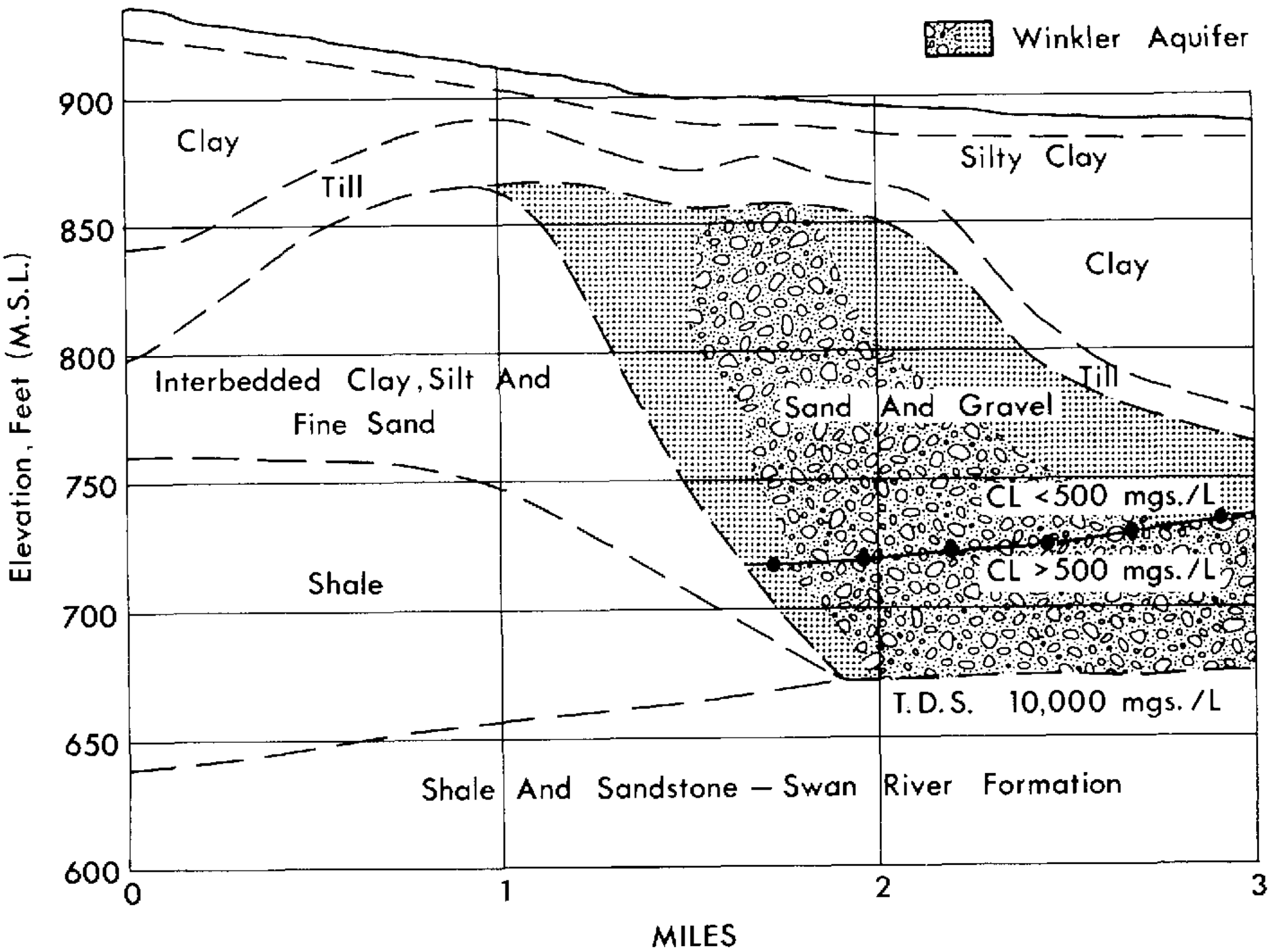


LEGEND

1. Winkler aquifer, up to 200 feet of sand and gravel deposits. Water of good quality and quantity.
2. Shallow sand, silt and clay deposits over till, underlain by deep shale beds of the Favel, Ashville and Riding Mountain Formation. Local water supply from shallow wells of good quality.
3. Shallow wells very similar to area 2, except that sand and gravel deposits in the till are more common. Surface sandy and silty deposits are thicker. Water is of good quality.
4. Shallow wells in shallow localized sand and silty deposits buried in thick impervious clay deposits. Water is of variable quality and limited quantity. Deep wells are artesian and very saline. Clay deposits prevent rapid transmission of upward movement of water.

FIGURE 27

Outline of the Winkler Aquifer and other Aquifers in the map area. Location of shallow groundwater observation well.



Reference:
M. RUTULIS, Water Resources Division
Manitoba Department of Mines, Resources and Environmental Management

FIGURE 28
Cross section of the Winkler Aquifer.

5. *Physical and Chemical Properties of Soils*

Non-permanent chemical properties of the soils such as fertility, reaction or degree of acidity or alkalinity, salinity, exchangeable sodium (or sodium absorption ratio - S.A.R.) and permanent physical properties such as hydraulic conductivity and water storage capacity are important parameters in evaluating land for irrigation. The analytical values of these parameters appear in Table 31.

In general, the application of nitrogen, phosphorus and in some cases potassium fertilizer to all crops grown under dryland culture has proven to be a most profitable management practice in the area. While this may indicate a problem of some measure it is not one that is considered to be important in evaluating soils for irrigation, since the problem can be readily and economically overcome.

Soil reaction or the degree of acidity or alkalinity in the soils of the map area range from neutral to moderately alkaline, a very acceptable range from the point of view of crop growth.

Soil salinity in the Morden-Winkler area is widespread and saline spots may occur in almost all soils. However, the degree of salinity is not severe. In general, the electrical conductivity (a measure of salt content in soils) in the surface horizons of soils is low and increases with depth. The coarse and moderately coarse textured soils are usually non-saline, medium and moderately fine textured soils, are variably saline and the fine textured soils are commonly saline. The degree of salinity in most cases ranges from slight to moderate. Soils of similar texture tend to be more saline in areas below the 900 A.S.L. contour than above. Calcium and magnesium are the dominant soluble salts, but as salinity increases the relative proportion of calcium decreases and the relative proportion of sodium increases. The amount of soluble potassium is relatively constant. Sulphates are the dominant anion in all soils. Chlorides are present in only minor amounts.

Exchangeable sodium of Sodium Absorption Ratio (S.A.R.) is low in almost all soils in the map area. Only a few of the very saline soils in the area have high and undesirable S.A.R. values. High S.A.R. values may be associated with low hydraulic conductivity. Good irrigation soils have S.A.R. values of less than 6, fair soils have values between 6 and 8, poorly suited soils have values that exceed 8.

Hydraulic conductivity is a measure of the transmissibility of water in soil and should be neither excessive nor too slow. Soils having disturbed hydraulic conductivities of that range from 0.8 to 3.0 inches per hour have satisfactory water transmissibility. In general, fine textured soils have hydraulic conductivities that are too low and coarse textured soils have conductivities that exceed 3 inches per hour.

Water holding capacity is another permanent physical feature of soils that is dependent upon the texture of the soil. Good irrigation soils generally are able to store more than 6 inches of water in 4 feet of soil, fair irrigation soils hold between 4 to 6 inches of water. Coarse textured soils generally hold less than 4 inches. Almost all soils except the coarse textured Birkenhead series have adequate moisture storage capacity.

6. *Topography*

In land classification the development requirements for gravity irrigation are governed by topographic features. These features determine the ease or difficulty of conveying water over the farm and of applying it to cropped land. Irrigation development includes clearing land, levelling, construction of permanent farm ditches and drains and water controls.

Land levelling requirements (see Figure 28) are based on the number of cubic yards of earthmoving per acre necessary for the system. They are determined by systematic field traversing and examination of the land features with reference to detailed topographic maps. In estimating land leveling requirements the following design standards are used in rating topography*:

(1) Downfield slope between adjacent 100 foot stations must be more than 0.2 percent but not greater than 1.0 percent.

(2) Transverse slope between adjacent 100 foot stations must be less than 0.3 percent.

(3) A minimum of 0.3 feet of topsoil is to be replaced on cut areas greater than 0.5 feet provided that fertility of the topsoil is better than the exposed horizon.

In general, the overall slope of the Morden-Winkler map area is level to smooth, very gently sloping (see Figure 6). Terrain from the Manitoba Escarpment to the Emerado Beach falls at the rate of 10 to 15 feet per mile; equivalent to about 0.2 percent between adjacent 100-foot stations. Except in areas adjacent to stream channels, land in this section requires little land leveling (see Figure 28).

Terrain eastward from the Emerado Beach (900 A.S.L. contour) is level to depressional falling at a rate of approximately 4 to 5 feet per mile which is equivalent to about 0.1 percent slope between 100 foot stations. More land leveling is required in this section of the map area to build sufficient grade to ensure water flowage by gravity.

7. *External Features*

Other external features of land of concern in land evaluation for irrigation suitability are vegetative cover and stones. Neither of these features of land are of importance in the Morden-Winkler area.

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*C.D.A. Handbook for the classification of irrigation land in the prairie provinces, P.F.R.A., Regina, Sask., 1964.

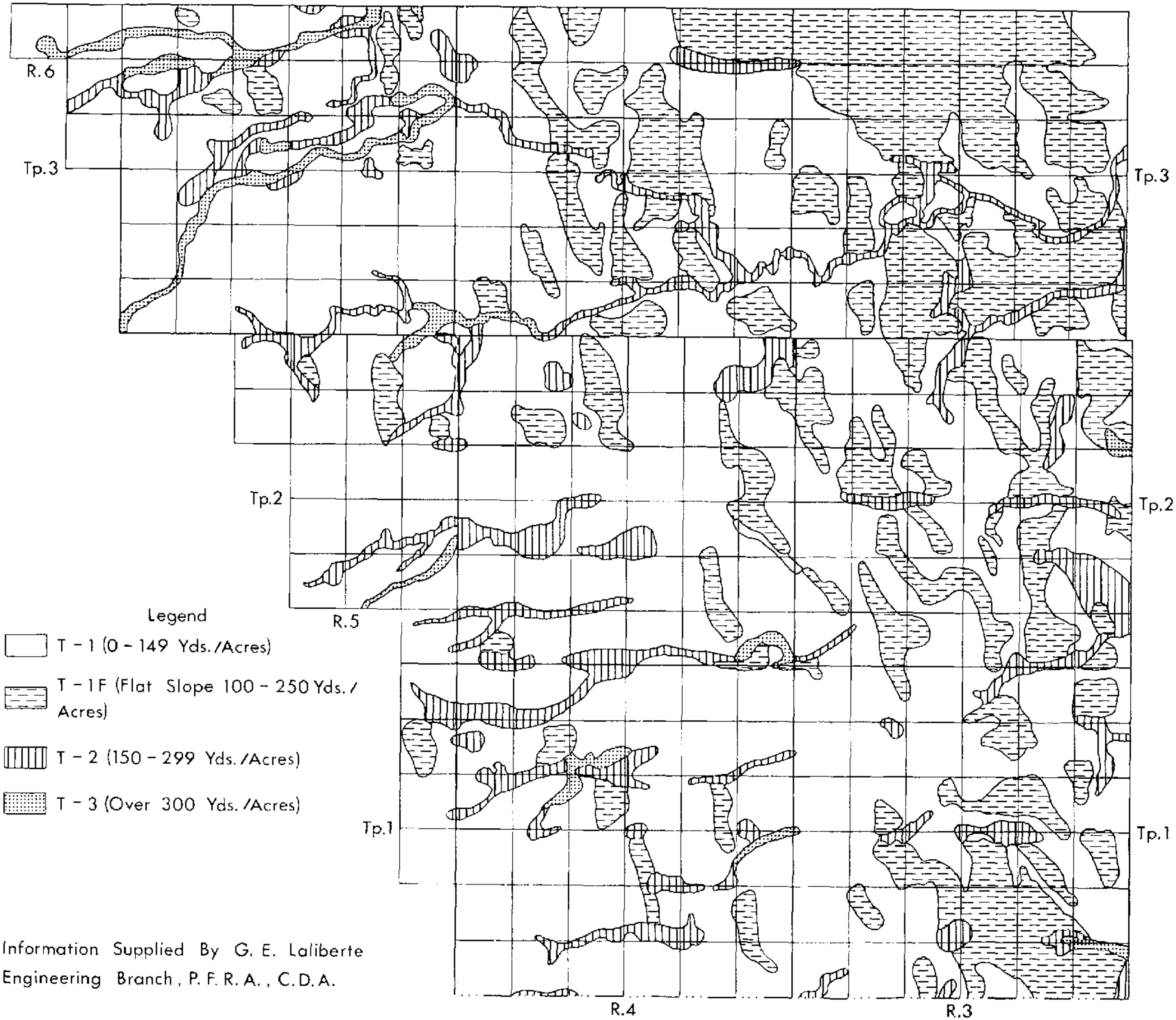


FIGURE 29
Land leveling requirement for flood irrigation development.

B. Irrigation Classification of Soils

Soils of the Morden-Winkler area have been classified into four irrigation suitability classes based on the criteria and guidelines outlined above. The distribution of these 4 classes in the map area are shown in Figure 33.

CLASS 1 - These are fine sandy loam to clay loam textured soils that are well suited for irrigation and have no significant limitations. They have good water holding capacity, good permeability, low salt content, good surface and internal drainage and satisfactory slope or topography. Drill logs to 10 feet of representative soil profiles in this group are shown in Figure 29. The soils in this group are:

Eigenhof, clay loam	Ec
Edenburg, clay loam	Ed
Neuenberg, very fine sandy loam, imperfectly to moderately well drained phase	Na
Neuenberg loam	Nc
Reinland fine sandy loam, imperfectly to moderately well drained phase	Ra
Reinland, slightly eroded phase	Rb
Reinland, overblown phase	Rc
Reinfeld, loam	Re
Rosengart, loam	Rm
Rosengart, very fine sandy loam	Rn

CLASS 2 - These are medium to moderately fine textured soils which have some limitation in use for irrigation. This class includes soils with moderate drainage problems that can be improved at relatively low cost, or soils with moderately low moisture holding capacity, or soils with a moderate stone clearing problem.

Drill logs to 10 feet of representative soil profiles in this class are shown in Figure 30.

The subclasses included in this class are:

2D – These are imperfectly drained soils that have a moderate drainage problem due to seasonal high groundwater levels. The soils are:

Chortitz, loam	Ca1
Gnadenthal loam	Ga
Gnadenthal clay	Gd
Glencross loam	Gg
Neuenberg very fine sandy loam, imperfectly drained phase	Nb
Neuhorst clay loam	Ne
Neuhorst loam	Ng
Neuhorst clay	Nh
Newton Siding, clay loam	Nj
Newton Siding, clay	Nl
Reinland, fine sandy loam, imperfectly drained phase	Rd

2Sq – These are moderately coarse, well drained soils that have moderately low water holding capacities. The soils are:

Hochfeld, fine sandy loam	Hb
Hochfeld, fine sandy loam, slightly eroded phase	Hc
Hochfeld, fine sandy loam, overblown phase	Hd

2Sr – These are well drained, medium textured soils that have a moderate stone clearing problem. The group includes:

Roseisle, loam	Rh

CLASS 3 - These are well drained, moderately coarse textured soils with low moisture holding capacity, or well drained medium to fine textured soils with restricted permeability or shallow soils overlying impermeable clay. The soils in this class are only marginally suitable for irrigation.

Drill logs to 10 feet of representative soil profiles in this class are shown in Figure 31.

The subclasses include:

3Sb – Moderately well drained, medium textured soils that usually have less than 3 feet of permeable material overlying impermeable, massive lacustrine clay. The soils are:

Hobson, fine sandy loam	Hj
Rignold, loam	Rg

3SbD – Imperfectly drained shallow, medium textured soils overlying impermeable clay. These imperfectly drained soils have restricted permeability and as a result a moderately severe drainage problem. The soils are:

Graysville, loam	Gf
Rosebank, fine sandy loam	Rj

3Sh – These are moderately well drained, permeable clay textured soils. Good drainage and high organic matter content in the surface horizon of these soils explains the improved permeability of these soils. Permeability decreases as organic matter content decreases downward in their profiles. These soils have very high saturation percentage and relatively low hydraulic conductivity or water transmissibility. The soils are:

Jordan, clay	Ja
Jordan, clay loam	Jb
Winkler, clay	Wa
Winkler, clay loam	Wb
Winkler, loam	Wc

3Sq – These are coarse textured, rapidly drained soils that are limited by low moisture holding capacity. The soils are:

Birkenhead, loamy sand	Ba

3Sr – These are well drained, moderately coarse to medium textured soils that overly glacial till and as a consequence are moderately to very stony, creating a moderately severe stone removal problem. The soils are:

Huddlestone, loamy fine sand, moderately to very stony phase	Hk
Roseisle, loam, moderately to very stony phase	Ri

3TD – These are imperfectly drained due to seasonal high water table conditions and uneven topography. These soils would require heavy excavation to prepare them for irrigation. The soils are:

Chortitz, loam, gently undulating phase	Ca2

CLASS 4 - The soils in this class are considered to be unsuitable for irrigation because of severe drainage problems, or impermeability of the geological material, or salinity or a combination of these problems.

Drill logs to 10 feet of representative soil profiles are shown in Figure 32.

Subclasses include:

4D – These are moderately coarse to fine textured soils that are poorly drained. Drainage improvement is considered to be not feasible. The soils are:

Blumenfeld, loam	Bb
Blumenort, clay	Be
Osterwick, fine sandy loam	Oa
Osborne, clay	Oc

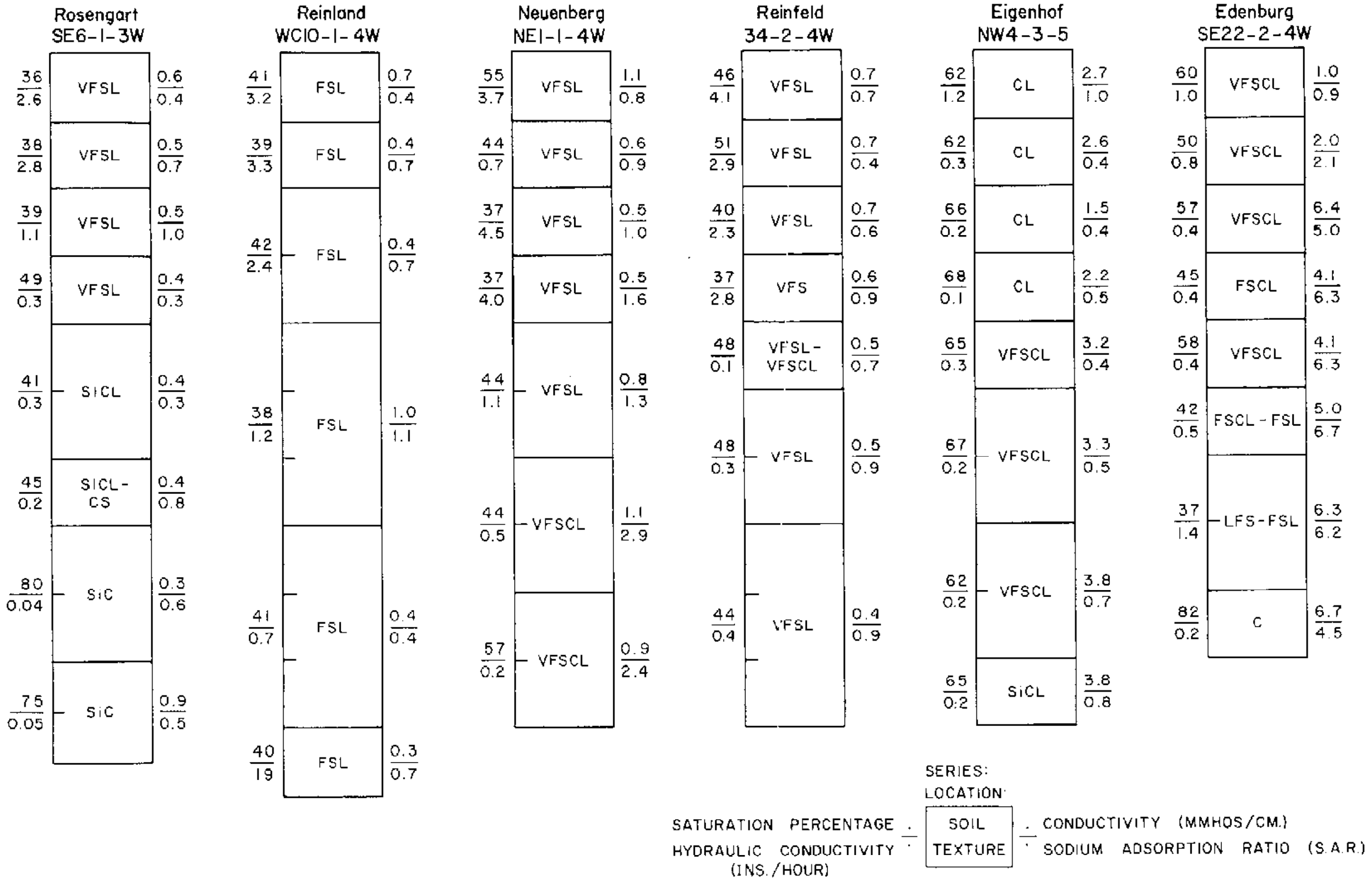


FIGURE 30
Drill logs of Class 1 irrigation soils showing texture, saturation percentage, hydraulic conductivity, electrical conductivity and sodium adsorption ratio at one foot intervals.

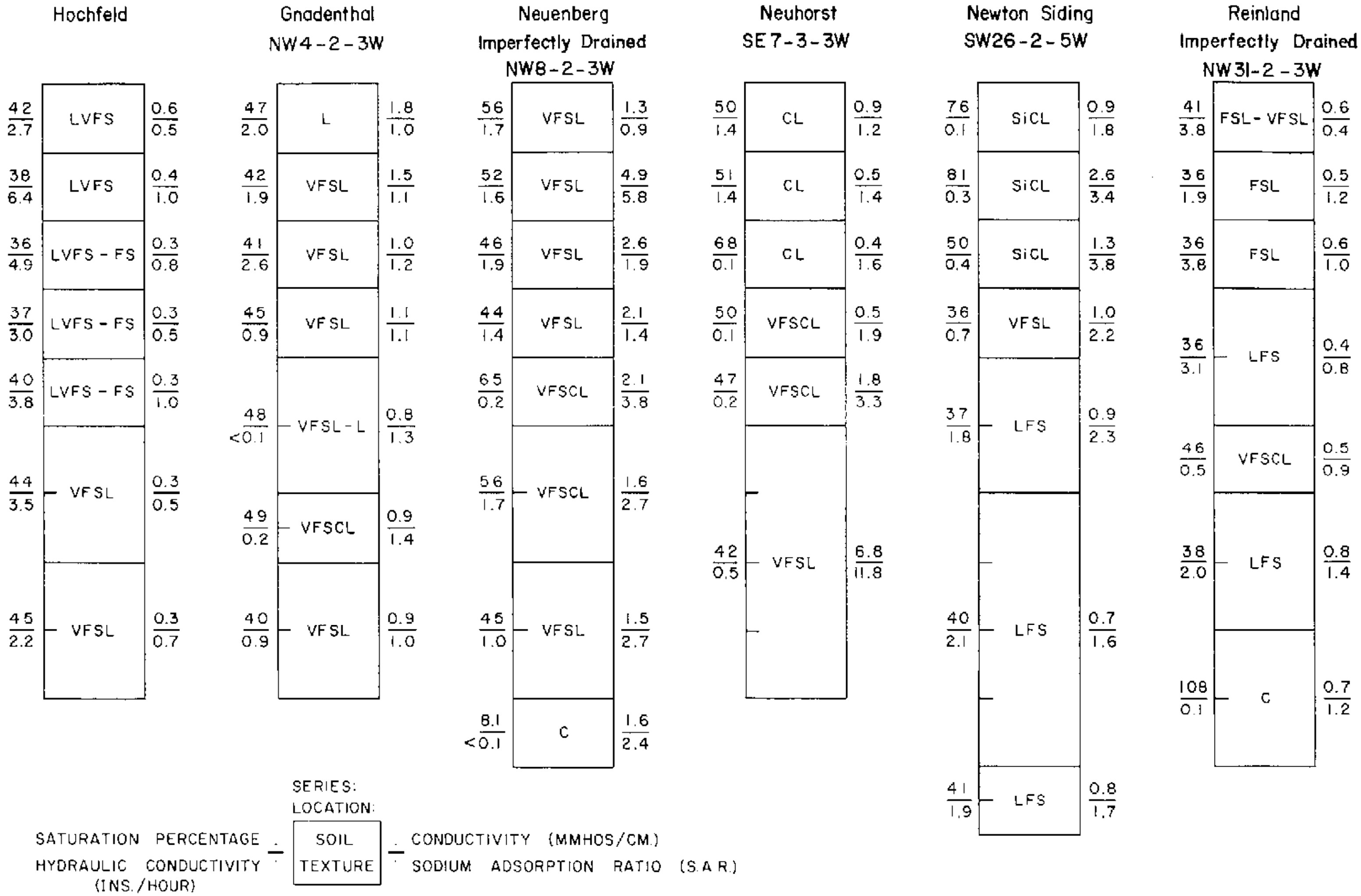


FIGURE 31
Drill logs of Class 2 irrigation soils showing texture, saturation percentage, hydraulic conductivity, electrical conductivity and sodium adsorption ratio at one foot intervals.

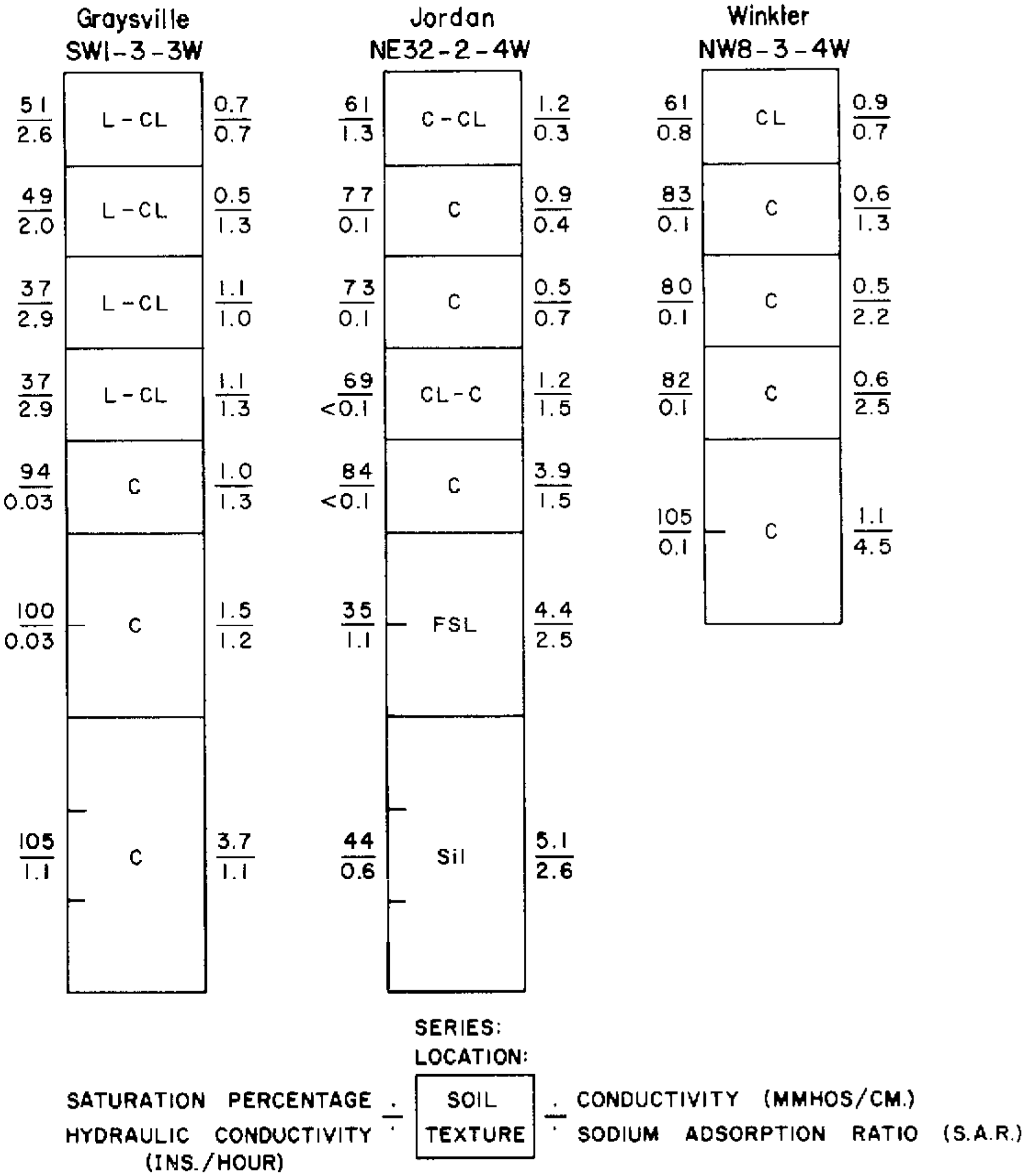


FIGURE 32

Drill logs of Class 3 irrigation soils showing texture, saturation percentage, hydraulic conductivity, electrical conductivity and sodium adsorption ratio at one foot intervals.

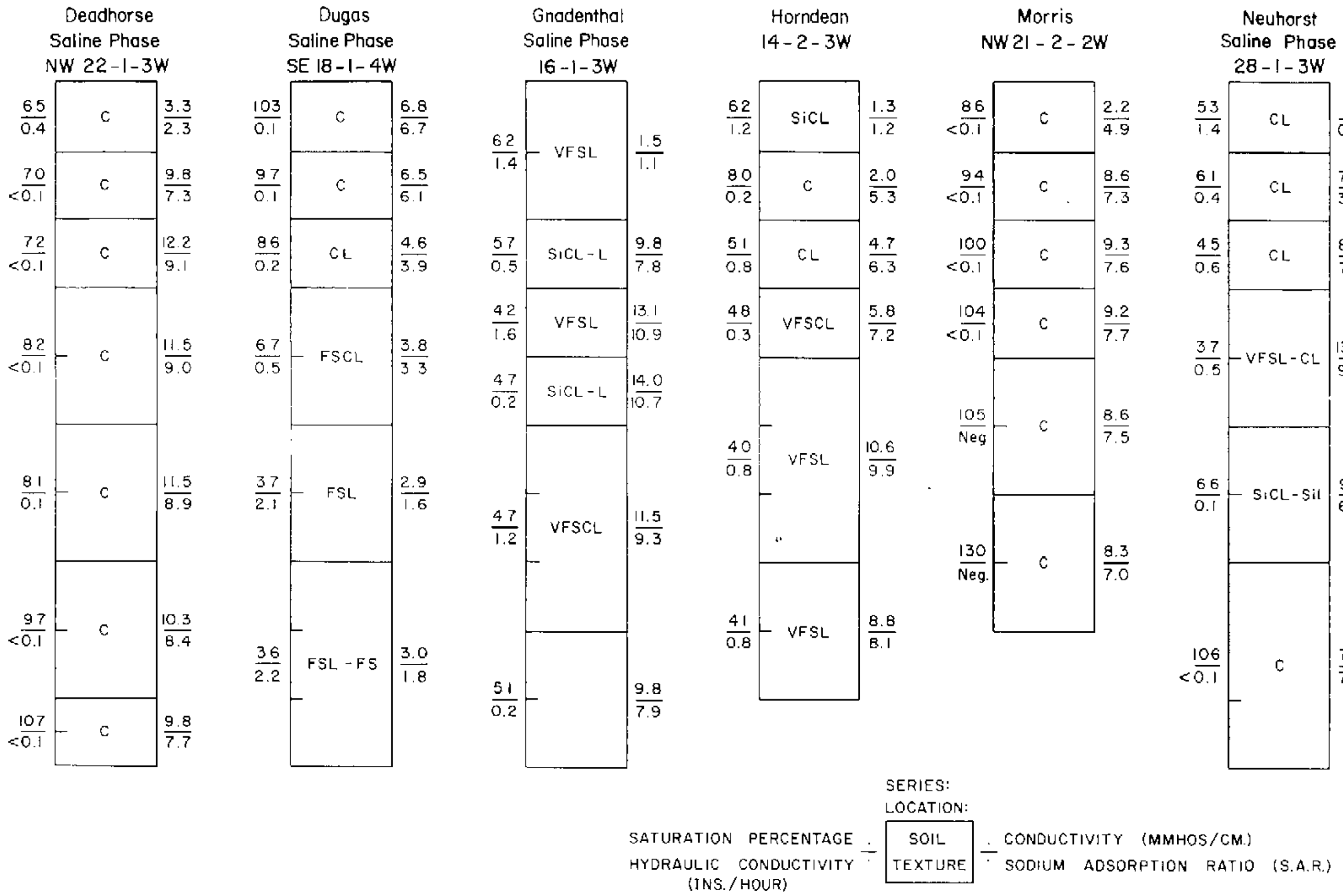


FIGURE 33
Drill logs of Class 4 irrigation soils showing texture, saturation percentage, hydraulic conductivity, electrical conductivity and sodium adsorption ratio at one foot intervals.

4SaD – These are imperfectly drained, medium to moderately fine textured soils that are slightly to moderately saline in their surface horizons and moderately to strongly saline in subsurface horizons. While salinity in these soils only slightly affects crop growth under dryland farming conditions, it does pose a potentially severe problem should they be irrigated. The soils are:

Gnadenthal, loam, slightly saline phase	Gb
Neuhorst clay loam, slightly saline phase	Nf
Newton Siding, clay loam, slightly saline phase	Nk
Newton Siding, clay, slightly saline phase	Nm

4Sh – These are imperfectly to somewhat poorly drained clay textured soils. These soils have severe internal drainage problems because of their texture and lack of macro pore spaces. They also are subject to seasonal high groundwater levels as well. Their impermeability makes drainage improvement unfeasible. The soils are:

Blumengart clay	Bd
Deadhorse clay	Da
Deadhorse clay loam	Dc
Deadhorse loam	De
Dugas clay	Df
Dugas clay loam	Dh
Dugas loam	Dk
Elias clay	Ef
Horndean clay	He
Horndean clay loam	Hf
Horndean loam	Hh
Morris clay	Mo
Plum Coulee clay	Pa
Plum Coulee clay loam	Pb
Plum Coulee loam	Pc
Red River clay	Rr

4Sha – These are imperfectly to somewhat poorly drained, saline, clay textured soils. These soils not only have a severe internal drainage problem but also a potentially severe salinity problem. The salinity problem is compounded by the fact that salts initially present in the soils would be extremely difficult to remove by percolating irrigation water because of the impermeable nature of these soils. The soils are:

Deadhorse clay, slightly saline phase	Db
Deadhorse, clay loam, slightly saline phase	Dd
Dugas, clay, slightly saline phase	Dg
Dugas loam, slightly saline phase	Dl

C. Irrigation Requirement

The climate date described in Section II are indicative that the Morden-Winkler area is generally suitable for a wide range of crops. Moisture on the average is not a limiting factor in the production of these crops, but to maintain maximum production and good quality, moisture may be limiting at some period in the growing season.

Risk analyses* of weekly and seasonal climatic data for irrigation planning for Morden are presented in Table 32. The risk analysis are for a soil with a storage capacity of 5.00 inches. The percent risk values of 1 to 75 imply a water deficiency hazard and indicate the number of years out of 100 years when the amount of water required as irrigation exceeds the value presented in the Table. For example, for a week beginning on July 16, there is a 50 percent probability that more than 0.4 inches of irrigation water will be required for optimum plant growth but only a 10 percent probability that more than 1.3 inches of irrigation water will be required.

Consumptive use factor depends upon the type of crop, stage of crop growth, amount of leaf area and is generally lower than 1.00 for vegetable crops and some special crops. Calculated risk at a consumptive use factor of 0.75 for the same date as above indicated that there is a 25 percent probability that more than 0.3 inches of irrigation water would be required and a 10 percent probability that more than 0.6 inches of water would be required for the week beginning July 16**.

Good yields of farm crops can be maintained or improved upon by proper management and fertility practices without irrigation in most years. Often the Morden-Winkler area suffers from inadequate drainage of surplus rainfall. If irrigation facilities are established, provision must be made to dispose of surplus rainfall by providing adequate drainage. "Short time" peak requirements of water during dry periods may, however, be quite high.

PREDICTED AVERAGE YIELDS OF PRINCIPAL CROPS

Predicted average yields of the principal crops grown in the Morden-Winkler area under a dryland farm management system are given in Table 38. They are based on historical records of actual yields obtained from the records of the Manitoba Crop Insurance Corporation, from records compiled by the Provincial Soil Testing Laboratory, University of Manitoba, and information provided by members of the staff of the Department of Soil Science, University of Manitoba.

An examination of the available data (see Tables 35, 36 and 37) indicates that yields are significantly affected by genetic soil type, soil drainage, soil texture and management. Higher yields can be expected when crops are grown on well drained to somewhat poorly drained, moderately coarse to fine textured Orthic Black and Gleyed Black soils. Crops do not do as well on saline or poorly drained of very fine or coarse textured soils. Additions of fertilizers improve the yield of crops grown on all soils. Available data show that the average yields of wheat increases by 6 bushels per acre, oats by 13 bushels, barley by 8 bushels, flas by 3 bushels and sunflowers by 117 lbs. per acre when nitrogen and phosphorus fertilizers are added at rates common to the district, approximately 20 lbs. N and 10 lbs. P_2O_5.

Historical yields for crops listed are averages obtained under the management common in the map area when the soil survey was made. While present management is difficult to define in precise terms, it can be said that the Morden-Winkler area is one of the better managed areas in the province. Some indication of the nature of management in this area is shown in Tables 36 and 37.

* Coligado, M.C., Baier, W., and Sly, W. K., 1968. Risk Analyses of Weekly Climatic Data for Agricultural and Irrigation Planning — Morden, Manitoba. Tech. Bull. 35, Canada Department of Agriculture, Ottawa.

** Ibid. Table 25.

While management practices listed in the tables may have changed somewhat since the reported date, they do suggest that use of fertilizer, weed spray,'use of certified seed, seed treatment, custom seed cleaning and purchase of crop insurance increases with increasing size of farm and that wheat enjoys preferred treatment over such crops as oats, barley and flax. The average size of farm in the district is approximately 400 acres.

Numerous other significant factors affect prediction of average yields of crops. While use of fertilizers may be a common practice in the area, the amount applied is often not sufficient for optimum yields. Furthermore, while surface drainage has been greatly improved over natural conditions in the area, substantial losses in terms of reduced yields are incurred due to ponding of water after heavy rains on the level, fine and moderately fine textured soils that occupy a very significant portion of the area. Such losses are reflected in the kind of statistical information available on crop yields.

Comparison of crop yields by soil type are complicated by the use of different cropping rotations which reflect the variations in soil capability. For example, continuous cropping systems employing rotations which include row crops and/or vegetable crops are common on moderately well drained, moderately coarse to medium textured soils. Such rotations are not common nor suitable on the somewhat poorly to poorly drained, fine textured soils where forage crops are substituted for row crops. Furthermore, historical records of yield reflect, in large measure, farming practices that may not now be relevant. They cannot be expected to reflect future significant advances in agronomic practice and plant breeding. Predicted average yields, such as those presented in Table 38, therefore, only provide an approximate comparison of the relative differences in the yielding capacity of the different kinds of soils that exist in the Morden-Winkler area.

TABLE 32

Weekly and Seasonal Irrigation Requirements for a Given Risk
Storage Capacity 5.00 IN. Consumptive Use Factor 1.00*

Week Beginning		Lowest Estimate	75	50	25	20	15	10	5	1	Highest Estimate
Month	Day										
4	30	0.0	–	–	–	–	–	–	–	–	0.0
5	7	0.0	–	–	–	–	–	–	.1	.1	0.0
5	14	0.0	–	–	–	–	.1	.1	.2	.3	0.2
5	21	0.0	–	–	–	.1	.1	.2	.3	.6	0.9
5	28	0.0	–	–	–	.1	.2	.4	.6	.9	1.1
6	4	0.0	–	–	.1	.2	.4	.5	7.	1.2	1.1
6	11	0.0	–	–	.2	.3	.4	.6	.8	1.2	0.9
6	18	0.0	–	–	.3	.4	.5	.7	.9	1.3	1.0
6	25	0.0	–	–	.4	.5	.6	.8	1.1	1.5	1.2
7	2	0.0	–	–	.5	.7	.8	1.0	1.3	1.8	1.8
7	9	0.0	–	.2	.7	.9	1.0	1.2	1.5	2.0	2.1
7	16	0.0	–	.4	.9	1.0	1.1	1.3	1.6	2.0	1.5
7	23	0.0	.1	.6	1.0	1.1	1.2	1.4	1.6	2.0	1.7
7	30	0.0	.1	.6	1.0	1.1	1.2	1.3	1.6	2.0	1.5
8	6	0.0	–	.4	.9	1.0	1.1	1.2	1.5	1.9	1.6
8	13	0.0	–	.4	.8	.9	1.0	1.1	1.4	1.8	1.4
8	20	0.0	–	.3	.7	.8	.9	1.1	1.3	1.7	1.3
8	27	0.0	–	.3	.7	.8	.9	1.0	1.2	1.5	1.2
9	3	0.0	–	.3	.6	.7	.8	.9	1.0	1.3	0.8
9	10	0.0	–	.2	.5	.6	.7	.8	.9	1.2	1.0
9	17	0.0	–	.1	.4	.5	.6	.7	.9	1.2	0.9
9	24	0.0	–	–	.3	.4	.5	.6	.8	1.1	0.9
Seasonal		0.5	4.2	6.7	9.1	9.8	10.5	11.4	12.7	15.3	15.2

*Ibid. Table 26.

TABLE 33*

Yields of Crops Grown on the Major Genetic Soil Types in the Morden-Winkler Area

Soil Type	Yield of Crop (bu/ac and lbs/ac)				
	Wheat	Oats	Barley	Flax	Sunflowers
Orthic Black	28	55	45	12	750
Gleyed Black	28	52	41	10	739
Gleyed Saline Black	24.4	**	38.5	10	506
Gleyed Regosol	28	44.9	34.6	10	644
Rego Humic Gleysol	20.5	43.9	29.5	7	537

TABLE 34*

Yields of Crops by Major Soil Textural Groups

Textural Group	Yield of Crop (bu/ac and lbs/ac)				
	Wheat	Oats	Barley	Flax	Sunflowers
Very Fine	21	44	34	8	621
Fine	27	48	37	10	656
Moderately Fine	28	60	41	12	829
Medium	30	56	45	12	**
Moderately Coarse	30	57	42	12	794
Coarse	21	39	36	8	699

TABLE 35*

Yield of Crops Grown in the Morden-Winkler Area As Affected by Fertilizer Application+

Crop	Management Treatment					
	Stubble		Fallow		Both Stubble and Fallow	
	Unfert.	Fert.	Unfert.	Fert.	Unfert.	Fert.
Wheat	22 (bu/ac.)	27	28	30	25	28
Oats	42	56	59	71	48	61
Barley	34	40	33	42	33	41
Flax	10	13	8	10	10	13
Sunflowers	574 (lbs/ac.)	727	633	**	589	706

TABLE 36

Percentage of Farms Reporting Selected Cultural Practices and Crop Services According to Size of Farms – Winkler Area, 1962†

	Size of Farms (acres)				
	10-69	70-149	150-239	240-399	400-759
	Percent of Farms Reporting				
Fertilizer	11	23	50	38	82
Weed Spray	26	64	80	100	91
Seed Purchased	79	100	90	90	95
Seed Treatment	5	5	–	21	27
Custom Seed Cleaning	–	18	40	28	23
Crop Insurance	5	23	15	52	73

TABLE 37

Percent of Crop Fertilized According to Farm Size – Winkler Area – 1962†

Size of Farm (acres)	Percent of Acreage Fertilized			
	Wheat	Oats	Barley	Flax
10- 69	–	–	–	–
70-149	3	14	–	5
150-239	46	36	–	–
240-399	37	15	–	–
400-759	65	50	54	6

*Obtained from records from the Manitoba Crop Insurance Corporation for the years 1965–1970.

**Not sufficient data.

+ Approximately 20 lbs. of N and 10 lbs. of P_2O_5, based on Provincial Soil Testing Laboratory records for the period 1967–1971.

†Adapted from joint Investigation for the Development of water Resources of the Pembina River Basin, Manitoba and North Dakota, V–III, Dec., 1964.

TABLE 38

Estimated Average Yields of Wheat, Oats, Barley, Flax and Sunflowers

Soil Series	Map Symbol	Wheat Bu/Ac	Oats Bu/Ac	Barley Bu/Ac	Flax Bu/Ac	Sunflowers Lbs/Ac
Birkenhead, loamy sand	Ba	20	39	36	8	600
Blumenfeld loam	Bb	21	40	29	8	540
Blumengart clay	Bd	28	44	30	9	720
Blumenort clay	Be	21	43	29	7	538
Chortitz loam	Cal	28	49	39	11	540
Chortitz loam, undulating	Ca2	27	48	38	10	500
Deadhorse clay	Da	29	53	44	10	720
Deadhorse clay, saline	Db	23	51	40	9	500
Deadhorse clay loam	Dc	29	53	44	10	716
Deadhorse clay loam, saline	Dd	23	51	40	9	500
Deadhorse loam	De	29	53	44	10	720
Dugas clay	Df	29	53	44	10	720
Dugas clay, saline	Dg	29	53	44	10	720
Dugas clay loam	Dh	29	53	44	10	720
Dugas loam	Dk	29	53	44	10	720
Eigenhof clay loam	Ec	32	69	49	13	860
Edenburg clay loam	Ed	32	69	49	13	860
Elias clay	Ef	29	41	30	9	775
Gnadenthal loam	Ga	31	57	45	11	775
Gnadenthal loam, saline	Gb	29	53	43	10	400
Gnadenthal clay loam	Gc	31	57	45	11	775
Gnadanthal clay	Gd	31	57	45	11	775
Graysville loam	Gf	31	57	45	11	775
Glencross loam	Gg	31	57	45	11	775
Hochfeld fine sandy loam	Hb	30	55	43	10	725
Hochfeld, Eroded	Hc	29	53	41	9	700
Hochfeld, Overblown	Hd	29	53	41	9	700
Horndean clay	He	29	53	44	10	720
Horndean clay loam	Hf	29	53	44	10	720
Horndean loam	Hh	29	53	44	10	720
Hobson fine sandy loam	Hj	29	53	41	9	700
Huddlestone loamy fine sand	Hk	23	40	38	9	650
Jordan clay	Ja	27	48	44	11	750
Jordan clay loam	Jb	27	48	44	11	750
Morris clay	Mo	22	44	34	9	700
Neuenberg very fine sandy loam	Na	31	57	45	11	775
Neuenberg, imperfectly drained	Nb	31	57	45	11	775
Neuenberg loam	Nc	31	57	45	11	775
Neuhorst clay loam	Ne	30	52	41	11	775
Neuhorst, saline	Nf	21	48	32	9	675
Neuhorst loam	Ng	30	52	45	11	775
Neuhorst clay	Nh	30	52	45	11	775
Newton Siding clay loam	Nj	32	69	49	13	860
Newton Siding, saline	Nk	29	53	43	10	400
Newton Siding clay	Nl	32	69	49	13	860
Newton Siding clay, saline	Nm	29	53	43	10	400
Osterwick, fine sandy loam	Oa	21	40	25	7	500
Osborne clay	Oc	21	44	30	8	575
Plum Coulee clay	Pa	29	43	44	10	720

TABLE 38 Cont'd.

Soil Series	Map Symbol	Wheat Bu/Ac	Oats Bu/Ac	Barley Bu/Ac	Flax Bu/Ac	Sunflowers Lbs/Ac
Plum Coulee clay loam	Pb	29	53	44	10	720
Plum Coulee loam	Pc	29	53	44	10	720
Reinland fine sandy loam	Ra	31	56	44	11	800
Reinland, Eroded	Rb	29	53	40	10	775
Reinland, Overblown	Rc	29	53	40	10	775
Reinland, Imperfectly drained	Rd	30	54	41	11	800
Reinfeld loam	Re	31	59	53	12	850
Rignold loam	Rg	31	57	45	11	775
Roseisle loam	Rh	29	53	40	10	720
Roseisle loam, stony	Ri	29	53	40	10	720
Rosebank, fine sandy loam	Rj	30	55	41	10	700
Rosengart loam	Rm	31	57	45	12	850
Rosengart, very fine sandy loam	Rn	31	57	45	12	850
Red River clay	Rr	22	44	34	9	700
Winkler clay	Wa	27	48	44	11	750
Winkler clay loam	Wb	27	48	44	11	750
Winkler loam	Wc	27	48	44	11	750

ENGINEERING AND LAND USE PLANNING

The objective of this chapter is to supplement the engineering information given on the Soils Map of the Morden-Winkler area with additional data; to present interpretations of this data and to form a guide to the use of both the Soils Map and the Soils Report.

A. HOW TO USE THE SOILS REPORT

Both the report and the map contain information which can be of great value to engineers, land use planners and others interested in these aspects. However, because there are likely to be many different types of people (both professional and non-professional) included under this general heading it is difficult to write a report of a general nature to suit everyone. To make this easier it has been necessary to group potential users into the following three categories:

1. Conservation and Transportation Engineers
2. Land Use Planners
3. Geotechnical Engineers and Geologists

1. Conservation and Transportation Engineers

Engineers involved with Soil Conservation and with the pavement design aspects of transportation engineering can probably make most direct use of the Soils Map (they might be better termed Pedological Maps) than any of the other groups.

For instance, transportation routes (whether they be highways, airstrips or even railroads) may for long stretches be constructed directly on "the soil", as defined in pedology, and the soil profile often represents the foundations for these pavement structures. The pedological classification system considers the soil "in situ" and takes into account not only the parent materials but also the effects of soil climate, topography, drainage, capillarity, etc. Specialists in such fields as pavement design thus, often find the pedological classification system preferable to most engineering systems for their particular needs.

Many specialists in these fields of engineering are already familiar with the science of pedology, but for those not so fortunate, Section F of this chapter should be consulted.

Generally, it may be found that the performance of highway (or airstrip) pavements can be correlated with the Soil Series. This is normally done by plotting the existing highway (or airstrip) locations on the Soils Map (or alternatively transferring the map data to the general layout plans). The performance data, if available, is then added and analyses made to determine to what degree performance can be related to the mapping units shown. An excellent method of predicting performance elsewhere on the map is thus provided because all conditions pertaining to the soil should be the same, wherever a particular Soil Series is shown. Likewise, the performance of pavements in all areas marked by the same map symbol should be the same.

Similar types of "performance correlations" are often applied to soil stabilization (e.g. by soil cement application), runoff and infiltration characteristics (in the USA those are termed Hydrological Soil Factors), etc. Still further relationships have yet to be established.

For those interested in establishing this type of performance correlation the following procedure could be followed:

(i) Become familiar with the engineering significance of pedology as given in Section F.

(ii) Identify the Soil Series in the particular area of interest by their names.

(iii) Consult Chapter III, "Soils" in this report; identify the type of terrain and soil profile from the coloured photographs and descriptions of these particular Soil Series; select those parts of the detailed descriptions of the mapping units which are of engineering significance.

(iv) Tabulate all of this data and add the relevant engineering test data included in Tables 39 to 43 in this chapter.

(v) Visit the site to identify the terrain characteristics and dig test holes to identify the soil profiles as given in the photographs.

(vi) Verify that these are definitely characteristic of that particular mapping unit as described.

(vii) Apply the performance data available and extrapolate this known performance to the project sites.

The pedological Soil Map can then become an excellent base on which to store performance data; the pedological report becomes a handy reference document.

Of most interest to specialists in this category will be the tables of typical soil properties given in Section C.

2. Land Use Planners

For specialists in this field, the interpretive type of information may be most relevant. It is assumed that the information is preferred in the form of recommendations rather than as data for design.

The Sections D, "Soils and Community Developments" and E, "Soils and Recreation" should be consulted for this type of information.

This information can be used either as described or it can be reinterpreted.

Thus, for use of soils for community development with septic tanks, for example, special coloured plans can be drawn up showing areas which have "severe limitations" and "slight limitations", for disposal fields according to the recommendations given. Thus the information in Section D can be used in the same form as it is presented.

Alternatively after studying the interpretations in detail the planner can reinterpret this data and (in conjunction with other factors) adapt it to convey a particular planning philosophy as desired.

3. *Geotechnical Engineers and Geologists*

For specialists in foundation engineering, site investigations and supply of construction materials, the pedological classification system itself may not be directly applicable for the majority of every day problems. This is mainly because the system was conceived for the surface layers of surficial deposits, i.e. for the soil defined as being "earth that can be plowed and planted".

Nevertheless, people interested or engaged in the above fields of specialization may find soil surveys of the pedological type of great value for two main reasons:

(i) There are special engineering problems which are definitely concerned with the altered and unaltered soil material within 1 to 2 meters of the surface.

(ii) While making the soil survey, the pedologist is himself also very much interested in the underlying materials, including the bedrock.

For those engineering problems which definitely do concern the upper layers of the soil, the reader is referred to the previous section (written for Conservation and Transportation Engineers). Typical examples of such problems include:

- Urban Engineering – shallow foundations, septic tanks
- Hydraulic Engineering – watershed control of runoff and drainage
- Corrosion Engineering – pipelines, concrete foundations
- Construction Engineering – search for sand and gravel, topsoil.

A brief outline of the interaction of pedology and engineering is given in Section F and this should be consulted.

For those engineering problems which concern more than just the upper layers of soil, valuable information can be obtained from the soil map by inference. The interpreted grid sections which accompany some of the map sheets have also been prepared especially for this purpose.

For example, by inference, when (dense) glacial till deposits are given as the parent material, one is not likely to find soft alluvial clay deposits at depth. Similarly, where soft alluvial clay deposits are shown as the parent material, one could expect deeper drilling for adequate exploration and more expensive foundations.

4. *Differences between "Pedological" and "Engineering" soils*

There are a number of terms and concepts used by pedologists which are similar in name but rather different in meaning to those used by Soil Engineers. This is a "pedological" report and the terms used should generally be interpreted in the pedological sense.

Figure No. 34 below shows the comparison between the Textural classes used in the Canadian System of (pedological) Soil Classification and a typical engineering textural soil classification chart. Again, note the differences, for example the "engineers clay" starting at clay contents in excess of 30 percent compared to the "pedologists clay" which starts at 40 percent (Figure 40).

There are also definitions of some words which have significant differences when used in the two disciplines - "consistence" is one. This is not a misspelling of the soil engineers term "consistency" and it is not synonymous. Most of these differences are covered in the Glossary.

5. *Limitations*

The reader is reminded that the data given in this report were never intended and never could be used in place of a site investigation. This point is more fully discussed in the section dealing with the soil map.

However, for certain types of problems, for example in "pavement design", the time and money spent on site exploration can be much more effectively used by using the Soil Series as a base. It would thus be preferable to soil test within the boundaries of the Soil Series than to drill holes at specified intervals regardless of this information.

B. THE SOIL MAP

1. *Purpose and Scale*

The Morden-Winkler soil map, on a scale of 1/20,000 represents the second in a new series of soil maps describing the soils in Manitoba. The purpose of this new series is to replace the old reconnaissance maps. The latter are too small in scale to show many important local soils; they are also out of date with respect to present state of knowledge of soils and systems of soil classification and little, if any, information of significance to engineering problems was previously given.

2. *Current Status of Soil Mapping in Manitoba*

Figure No. 1, on the cover of this report, shows the published soil reports in Manitoba and the areas covered by the new series is indicated.

It also shows the users where some soil mapping has been carried out and for which (unpublished) data is available.

3. *How to Use the Soils Map*

The Soils Map of Morden-Winkler is included at the end of the report as separate sheets prepared directly from aerial photographs. The Index Sheet and legend included with the map should normally make the map self-explanatory. However, rather specialized concepts are involved in this type of mapping and some additional explanations are necessary to indicate clearly what is being portrayed.

All areas outlined on the map and marked with the same symbol are characterized by soils of the same Soil Series, the same Soil Type or the same Phase. This does not mean that the only soil profile existing in that area belongs to the Soil Series or type which typifies that name.

At this point the philosophy of pedological mapping comes into the picture. Soil Series as a "mapping unit" is not synonymous with Soil Series as a soil profile, landform or taxonomic unit. The difference is that in the mapping unit there may be (in fact, there generally are) inclusions of other soil "individuals" or even on "non-soil" (i.e. bedrock, etc.).

It is thus, first of all necessary to read carefully the definitions of what constitutes the "mapping unit". This may refer to the degree to which the area outlined contains inclusions of other soils, i.e. the unit may actually be a "complex" of more than one Soil Series; or it may be relatively uniform or it may be entirely transitional between one Soil Series and another.

Even if it is relatively uniform, it is only implied that, in the estimation of the pedologist, at least 85 percent of the area outlined should be truly representative of the Soil Series named. Thus, small localized pockets of unlike soil may be known to occur inside the boundaries of a certain Soil Series and yet if it is too small to be shown on that map scale, it will not be indicated but becomes part of the "untypical" 15 percent for the mapping unit in which it occurs.

Thus, the map was never intended to show site specific data and it never could be used in lieu of site investigations.

The reader is referred to page 19 for further details concerning the mapping procedures used and, in particular, to the "Descriptions of the Soil Series and Mapping Units". Each Soil Series is described in alphabetical order.

When using the Soil Map in the field it should thus be borne in mind that if inclusions of other soils or "non-soils" are found within Soil Series boundaries, this does not necessarily indicate lack of accuracy. The definitions used for that particular "mapping unit" should be studied and the remarks given above noted carefully.

4. *Limitations: In the Use of This Map*

Neither the data given on the map nor that given on the interpreted sections can be used in place of site investigations. This has been fully discussed in the text above.

For design purposes, therefore, a site investigation by specialists in this field should always be made.

The information given here, however, can be used for general assessment and, for the specialist, it should prove to be an excellent guide for planning effective investigations.

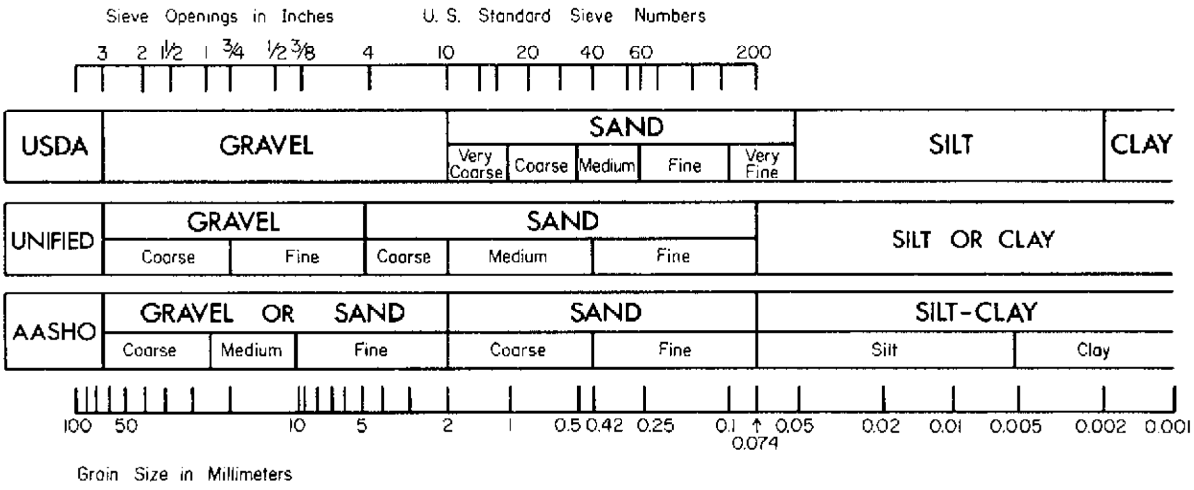


FIGURE 34

Comparison of soil particle sizes for the USDA, Unified and AASHO systems of textural classification commonly used in Canada.

C. ENGINEERING PROPERTIES OF THE SOILS

1. *Geotechnical Setting*

The geotechnical setting could be defined as the total three dimensional model encompassing an area of geotechnical interest. Thus, for a detailed site investigation the specific area of geotechnical interest may be the top of the first soil layer which is adequately strong to take the bearing loads imposed by building projects. The boundaries of this area of interest would thus appear to be within the limits of the particular building project and the "setting" would tbus be the three dimensional model bounded by these areal boundaries and limited in depth to the top of this bearing soil layer.

Detailed knowledge of a very limited model such as this may yield poor predictive results in engineering. For instance, the major problem for this particular project may not be the properties of this top soil layer but the presence of very soft and unstable soils at some depth. Alternatively, the major problem may not even be within the boundaries of the project site; in landslide-prone areas it could be the condition of a hillside which may be at a considerable distance from the project.

For the engineer, knowledge of the general setting of the area is thus of first priority, before a detailed site investigation gets underway. As it happens, there is a parallel with pedological survey because knowledge of this general setting is generally necessary for an adequate understanding of the soil, the landscape and for realistic predictions of soil productivity. Thus, a number of sketch maps have been prepared for the various chapters of this report. These illustrate the role in pedology of such factors as the bedrock geology, the surficial geology and geohydrology. In fact, for the engineer, these general sketch maps have a dual role: they also portray the geotechnical setting of the area.

For this latter purpose, it is necessary to be able to locate ourself rapidly at any point in the area and consequently the main communication lines have been added. By adding still further the grid sections interpreted for the perimeter of the area, the three dimensional setting is also portrayed.

Because these general sketch maps are used to characterize the geotechnical setting, the relevant ones have been grouped together in this section for ready reference purposes.

2. *Engineering Description of the Soils*

Engineering properties have been estimated for the significant soil series mapped in the Morden-Winkler area (Table 43). The estimated classification according to the USDA, AASHO and the Unified classification systems is given for each important layer. These estimates are based on soil test data and on information contained in other sections of the report. Some of the more significant properties of these soils are discussed below.

(a) *Particle Size Distribution*

Particle size distribution was determined by employing a combined sieve and pipette method developed by V.J. Kilmer and L.T. Alexander*.

With the exception of the Birkenhead series, which are developed on Beach sand, the soils of the map area are fine grained, virtually 100% passing a No. 40 (.042 mm) sieve. The dominant sand fraction in the Birkenhead soils is medium and fine (0.50 to 0.10mm) sand. The dominant sand fraction in the other soils is the very fine sand fraction (0.10 to 0.05 mm). In the Rosengart and Neuenberg series this fraction comprises about 60 percent of the total soil.

The clay content (0.002 mm) of the fine textured soils range from about 45 percent to more than 70 percent in the Winkler series. Weak textured B. horizons may be present in the Winkler, Eigenhof, and Reinfeld series but in most cases accumulation of clay and/or organic matter is not in excess of the variability expected from the nature of the deposits.

Particle size distribution curves for some of the major soil textural groups are shown in Figure 39.

(b) *Moisture Relations*

Saturation percentage. The saturation percentage, a measure of moisture content of soil in a puddled or saturated condition, increases from about 18 percent in the C horizon of the coarse textured soils to over 100 percent in some fine textured soils. In soils with uniform texture, surface horizons have higher saturation percents than subsurface horizons, due to their higher organic matter content. Data in Table 39 show the saturation percentage expected in soils with increasing clay content.

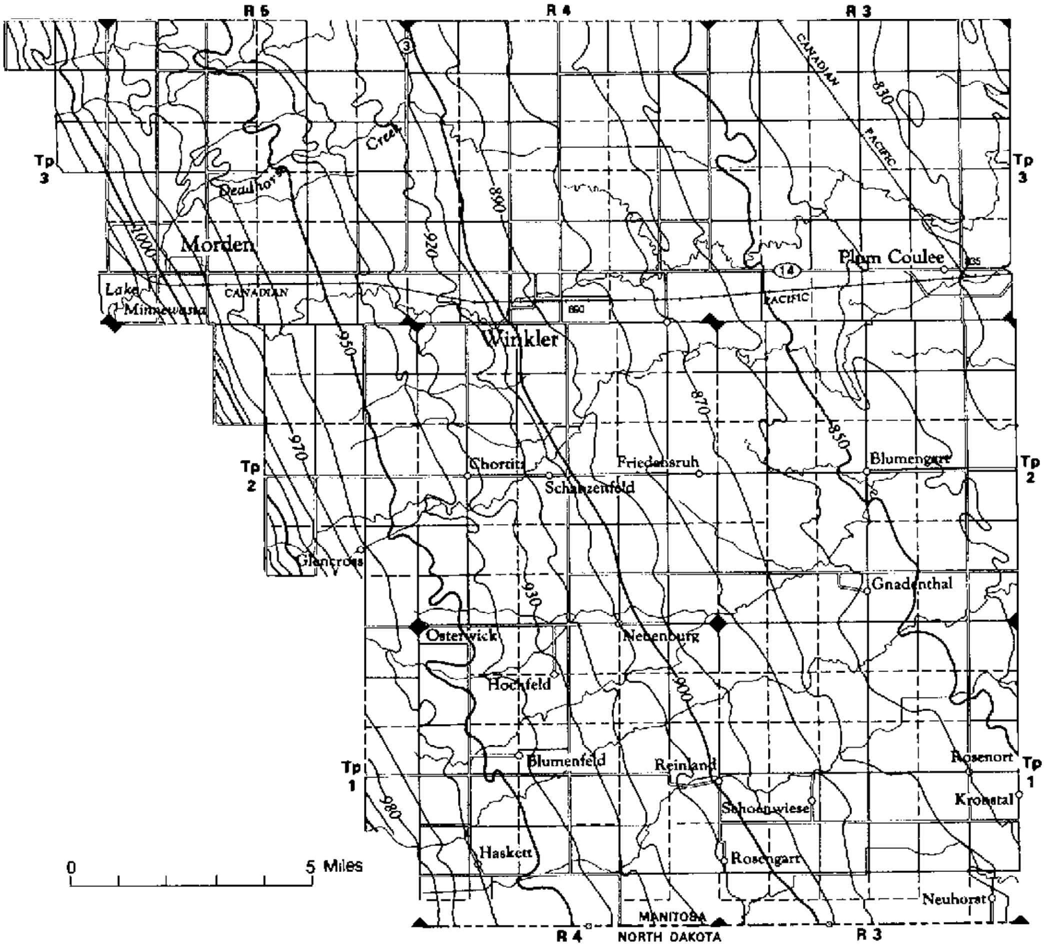
Field capacity. Field capacity, a measure of moisture retention capacity, increases with clay content and organic matter content. It varies from 12 percent in coarse textured soils to 40 percent in fine textured soils.

Soil permeability. That property of soil allowing it to transmit water. It depends on the size and number of continuous soil pores which in turn varies with such factors as particle size distribution or texture void ratio, soil structure, degree of cementation in certain kinds of soil horizons and degree of saturation. It will also vary with degree of compaction since this greatly influences the size of soil pores. Loosely packed soil will be more permeable than the same soil tightly packed.

In the absence of measurement, permeability may be inferred from such morphological features of soil horizon, as texture, structure, consistence, presence of natural cracks, root channels and faunal burrows. Estimates of permeability are

*Kilmer, V. J. and L. T. Alexander, 1949. Methods of making mechanical analysis of soils. Soil Sci. 68: 15-24.

GENERALIZED MAP, MORDEN-WINKLER
PHYSIOGRAPHY
fig 35



Cartography by the Soil Research Inventory Program (Cartography Section)
Soil Research Institute, Research Branch, Agriculture Canada

FIGURE 35
Generalized Map of the Morden-Winkler Area -- Physiography

LEGEND

(for fig 36)

SYMBOL	BASIC LITHOLOGY	APPROX THICKNESS	MEMBER	FORMATION	PERIOD
8	Surficial deposits				
7	Carbonaceous and calcareous SHALE, septarian concretions and bentonite	200 ft	MORDEN	VERMILION RIVER	
6	Calcareous speckled SHALE with Limestone bands and bentonite	100 ft		FAVEL	CRETACEOUS
5	Non-calcareous silty SHALE with minor silt, sand, limestone and bentonite	120 ft		ASHVILLE	
4	SAND, sandstone, shale, clay & lignite; varicoloured SHALE	100 ft 100 ft		SWAN RIVER WASKADA	
3	Varicoloured SHALE calcareous shale & limestone	300 ft		MELITA	
2	Argillaceous LIMESTONE and SHALE			RESTON	JURASSIC
1	ANHYDRITE, gypsum & shale		UPPER EVAPORITE	AMARANTH	
×	Bedrock outcrop				
<1°△	Dip of strata (less than 1°)				
—500—	Bedrock surface contour				
•	Borehole				

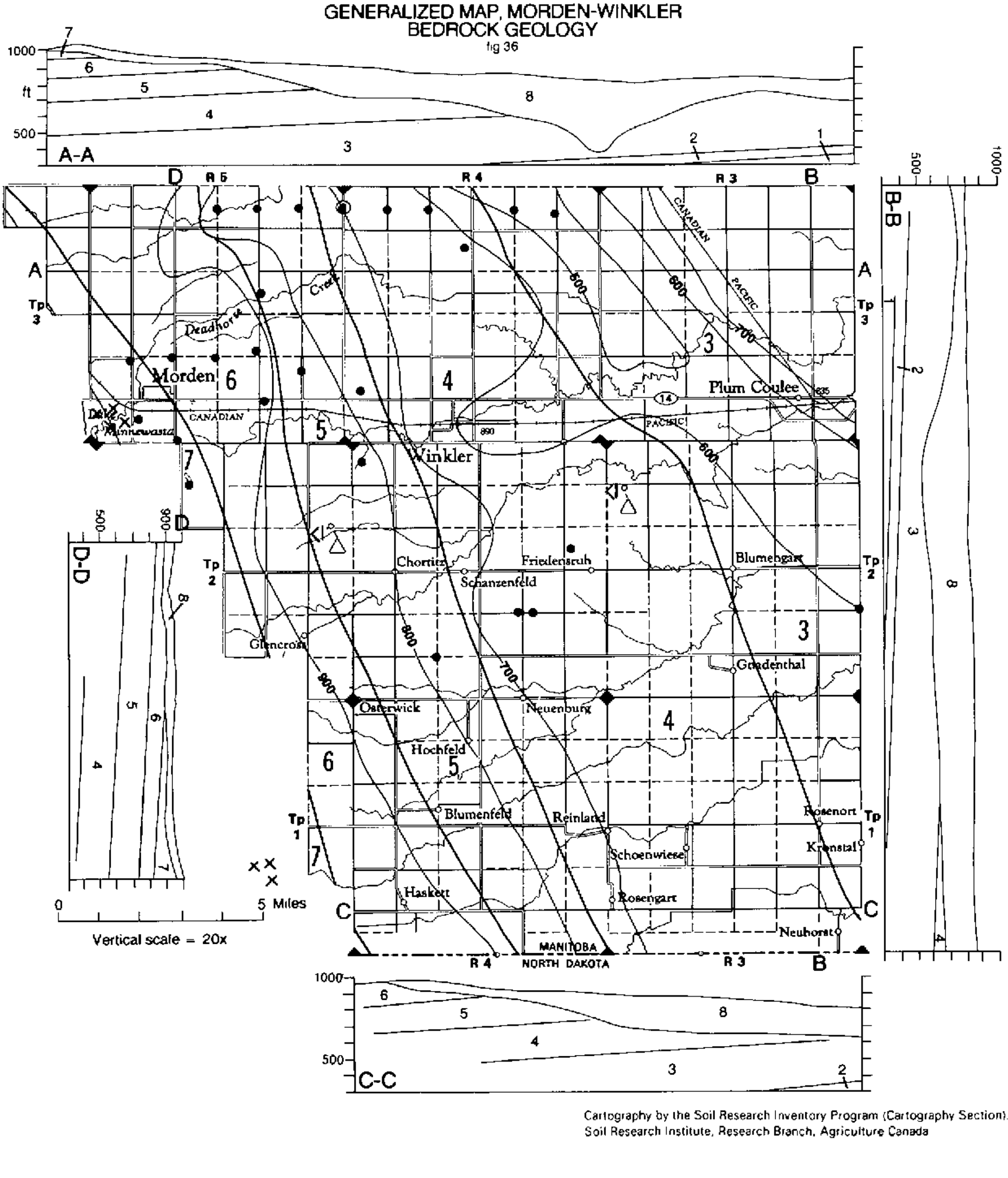


FIGURE 36

Generalized Map of the Morden-Winkler Area – Bedrock Geology (reproduced from references 1, 2 and 3).

LEGEND

for fig 32

PLEISTOCENE AND RECENT

- \\\\ — Lake Beaches (shore deposits of glacial Lake Agassiz) (gravelly sand and coarse sand sorted by wave-action
- **6** — Off-shore Bars of glacial Lake Agassiz (gravelly sand and coarse sand sorted and stratified)
- **5** — Lake-bed and Flood-plain Deposits: sandy
- **4** — Lake-bed and Flood-plain Deposits: silty
- **3** — Lake-bed and Flood-plain Deposits: sandy and clayey
- **2** — Lake-bed and Flood-plain Deposits: clayey
- **1** — Glacial Till or Boulder Clay Modified by Wave-action
- Winkler Aquifer
- ● Water well

SECTIONS

- Silt
- Clay
- Sand
- Gravel
- Till
- Bedrock surface
- ▼ Water Rest level in well

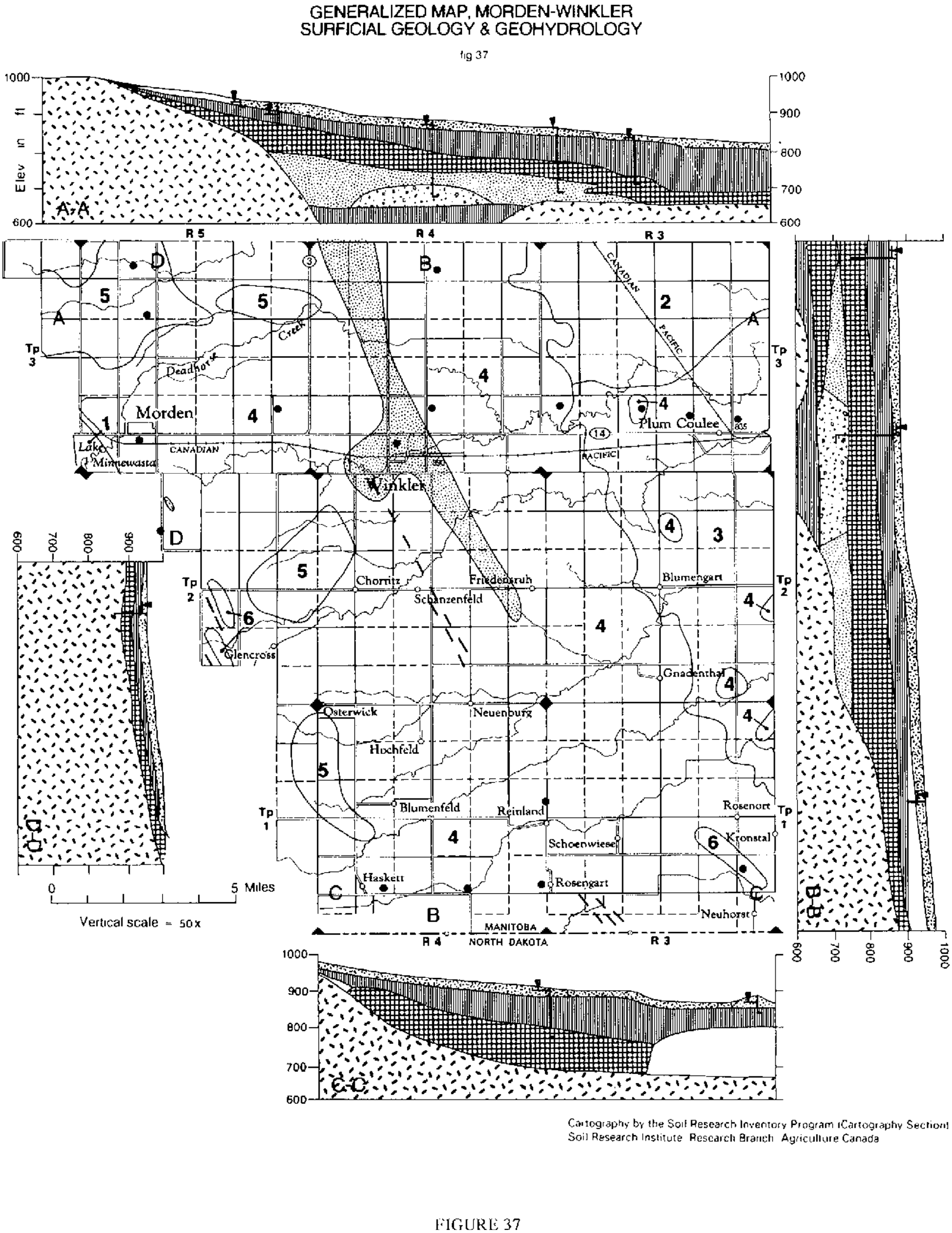


FIGURE 37

Generalized Map of the Morden-Winkler Area – Surficial Geology and Hydrogeology (reproduced from references 4, 5, 6 and 7).

LEGEND

(for figure 38)

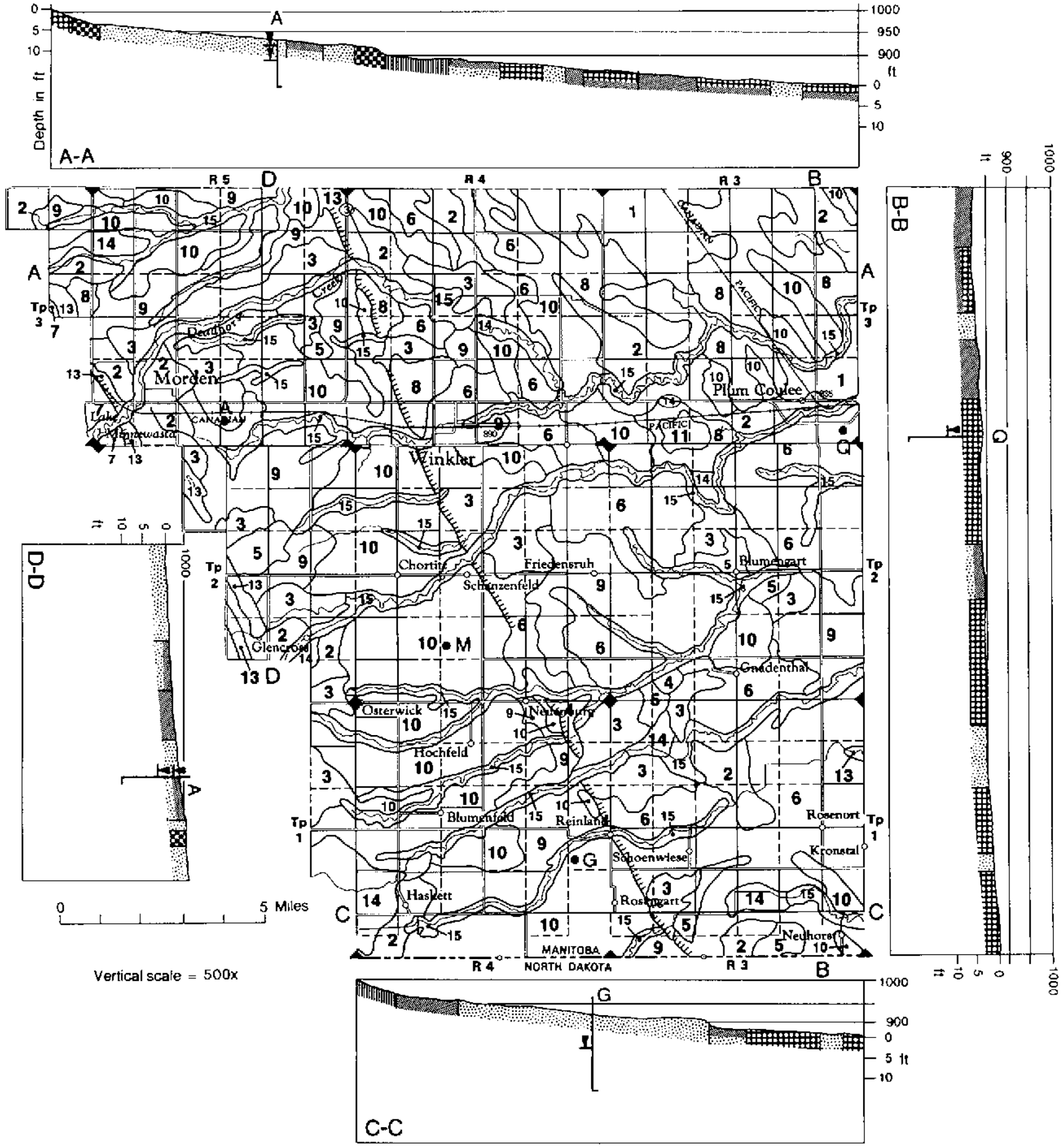
BLACK CHERNOZEMIC SOILS
developed on Calcareous Lacustrine
and Deltaic deposits as follows -

	SOIL SERIES	
deep CLAY	Red River Morris Osborne	1
deep stratified CLAY	Winkler Deadhorse Plum Coulee	2
less than 3 ft CLAY overlying SAND and LOAM	Jordan Dugas Horndean	3
deep CLAY LOAM	Eigenhoff Neuhorst	4
less than 3 ft CLAY LOAM overlying SAND and SANDY LOAM	Edenburg Newton Siding	5
deep stratified LOAM and CLAY LOAM	Reinfeld Gnadenthal Blumenfeld	6
less than 3 ft CLAY LOAM overlying TILL	Roseisle Glencross	7
less than 3 ft LOAM and CLAY LOAM overlying CLAY	Rignold Graysville	8
deep LOAM and SANDY LOAM	Rosengart Neuenberg	9
deep SAND and SANDY LOAM	Hochfeld Reinland Osterwick	10
less than 3 ft SAND and SANDY LOAM overlying CLAY	Hobson Rosebank	11
less than 3 ft SAND and SANDY LOAM overlying TILL	Huddlestone	12
Beach and Outwash SAND and GRAVEL	Birkenhead	13
REGOSOLIC SOILS developed on —		
Shaley alluvial CLAY	Blumengart Elias Blumenort	14
Alluvial CLAY LOAM and SANDY LOAM	Chortitz	15
Ground Water Observation Well		•
Ground Water Level		

Soil Series separations are based on drainage and pedogenetic properties. Soil Type and Phase separations are given in the Key to the Soils of Morden-Winkler.

GENERALIZED MAP, MORDEN-WINKLER
PEDOLOGY

fig 38



Cartography by the Soil Research Inventory Program (Cartography Section), Soil Research Institute, Research Branch, Agriculture Canada

FIGURE 38
Generalized Map of the Morden-Winkler Area – Pedology.

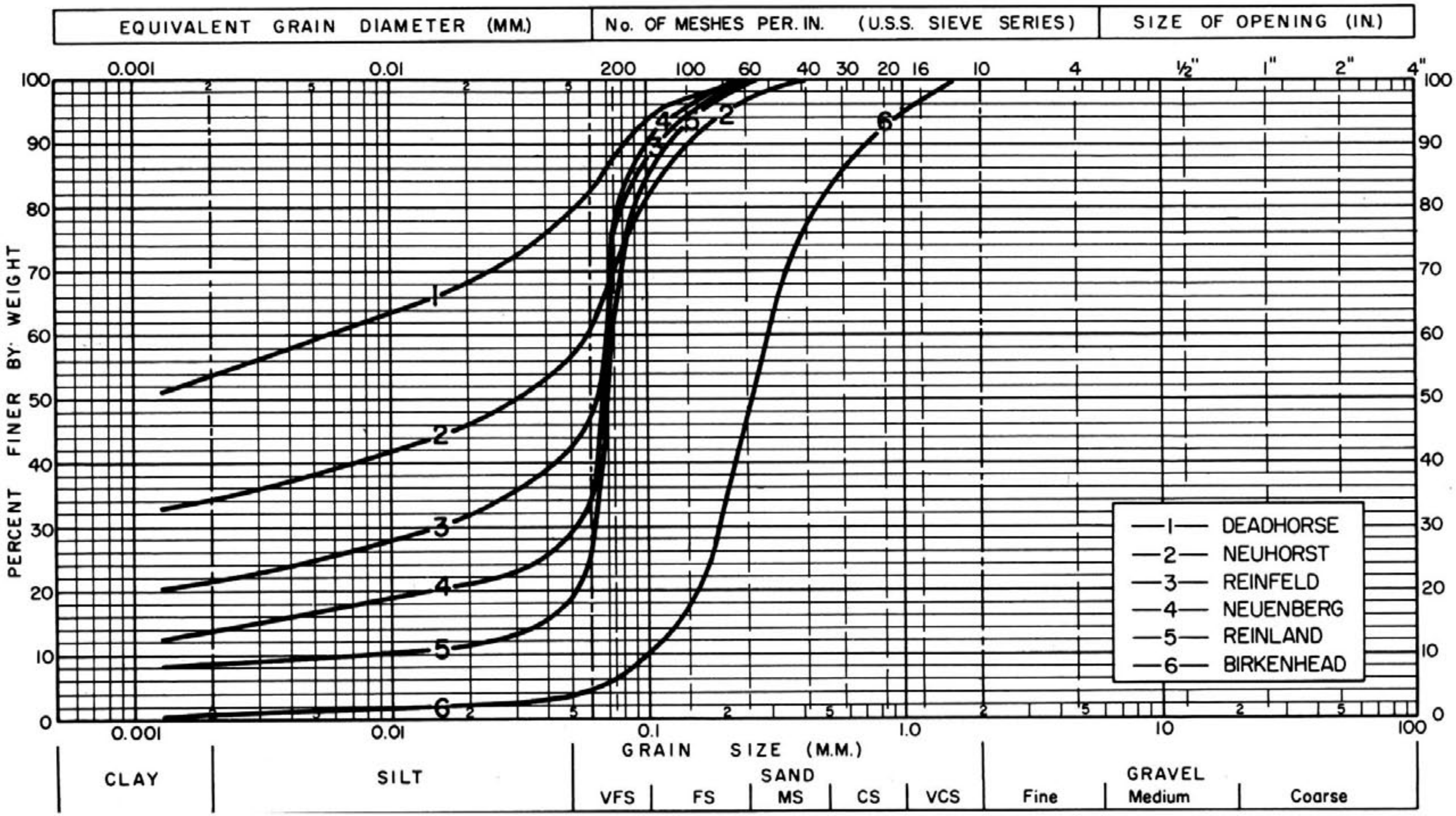


FIGURE 39
Particle size distribution curves for some of the major soil groups in the Morden-Winkler area.

determined in the laboratory by measuring the quantity of water that will seep through a given cross-section of disturbed soil in a given time and distance (inches per hour) under a known head of water. This estimate of permeability is referred to as disturbed hydraulic conductivity (D.H.C.). These estimates are shown in Table 31 in the section of the report dealing with irrigation suitability of soils.

In general, disturbed hydraulic conductivity varies from very rapid in such soils as the Birkenhead series to very slow in clayey soils such as the Morris and Red River series. Because permeability is often limited by the least permeable layer in soils, Tables 41 and 42 show percent distribution of disturbed hydraulic conductivity of samples from 0 to 3 foot depth and 3 to 10 foot depth of the major soils in the map area.

TABLE 39

Percent of Samples in Various Range Classes of Saturation Percentage

Series	Number of Samples	Average Saturation Percentage	Saturation Percentage Class						
			<25	25-35	35-40	40-60	60-65	65-75	75-100
			Percent of Samples						
Hochfeld (Hb)	10	42	0	0	40	60	0	0	0
Reinland (Ra)	26	42	0	0	23	77	0	0	0
Neuenberg (Na)	65	46	0	0	5	94	0	1	0
Gnadenthal (Gb)	62	49	0	0	5	92	2	1	0
Neuhorst (Ne)	7	63	0	0	0	72	14	14	0
Plum Coulee (Pa)	14	68	0	0	0	50	14	0	36
Deadhorse (Da)	9	74	0	0	0	22	22	12	44

TABLE 40

Average Disturbed Hydraulic Conductivity (inches/hour) and Percent Distribution of Seven Soil Series of the Winkler Area in D.H.C. Classes*

Soil Series	Number of Samples	Average D.H.C. in./hr.	Very Slow <0.1	Slow 0.1-0.3	Moderately Slow 0.3-0.8	Moderate 0.8-3.0	Moderately Rapid 3.0-5.0	Rapid 5.0-7.0
			Percent Distribution					
Hochfeld (Hb)	10	3.29	0	0	0	30	70	0
Reinland (Ra)	27	2.68	0	0	0	63	37	0
Neuenberg (Na)	65	2.29	0	0	5	75	20	0
Gnadenthal (Gb)	62	1.76	0	0	9	81	10	0
Neuhorst (Ne)	7	1.14	0	14	14	72	0	0
Plum Coulee (Pa)	13	0.72	24	0	38	38	0	0
Deadhorse (Da)	9	0.40	22	0	67	11	0	0

*Ranges for D.H.C. Classes are taken from "Handbook for the classification of irrigated land in the prairie provinces." P.F.R.A., Canada Dept. of Agriculture, Regina, Sask., 1964.

(c) Other Properties

Reaction (pH) of the soil was estimated from analysis of selected profiles and parent material from the map area. All soils in the map area range from mildly alkaline to strongly alkaline (pH 7.6 to about pH 8.2).

Sulphate Hazard refers to the relative degree of attack on concrete by soil and water containing various amounts of sulphate anions. It was estimated from electrolyte measurements and salt analysis on selected soil profiles and soil samples and by visual examination for free gypsum within the profile during the course of field mapping.

The *Shrink-Swell Potential* is an indication of the volume change to be expected of the soil material with change in moisture content. It is estimated on the basis of the amount of clay with a high shrink-swell potential in the soil layers. In general, soils classified as A-7 and Ch have a high shrink-swell potential. Clean sands and gravels and those having a small amount of non-plastic to slightly plastic fines have low shrink-swell potential.

TABLE 41

Percent Distribution of Disturbed Hydraulic Conductivity of Samples from the 0 to 3 foot depth of Different Soil Series

Soil Series	Number of Samples	Classes of D.H.C.* (inches/hr.)					
		0.0	0.1-0.3	0.3-0.8	0.8-3.0	3.0-5.0	5.0-7.0
		Percent Distribution					
Hochfeld (Hb)	10	0	10	20	50	20	0
Reinland (Ra)	27	0	7	15	63	15	0
Neuenberg (Na)	64	3	13	28	52	5	0
Gnadenthal (Gb)	62	3	24	28	44	1	0
Neuhorst (Ne)	7	29	28	0	43	0	0
Plum Coulee (Pa)	13	54	8	23	15	0	0
Deadhorse (Da)	7	71	29	0	0	0	0

*Disturbed Hydraulic Conductivity based on minimum D.H.C.

TABLE 42

Percent Distribution of Disturbed Hydraulic Conductivity of Samples from the 3 to 10 foot depth of Different Soil Series

Soil Series	Number of Samples	Classes of D.H.C.* (inches/hr.)					
		.05	.05-0.1	0.1-0.3	0.3-0.8	0.8-3.0	3.0-5.0
		Percent Distribution					
Hochfeld (Hb)	7	0	0	43	43	14	0
Reinland (Ra)	22	0	0	23	55	18	4
Neuenberg (Na)	43	2	10	70	9	9	0
Gnadenthal (Gb)	33	0	18	70	12	0	0
Plum Coulee (Pa)	13	31	7	38	15	9	0
Deadhorse (Da)	7	43	14	43	0	0	0

*Disturbed Hydraulic Conductivity based on minimum D.H.C.

TABLE 43

Estimated Engineering Properties of the Soils of the Morden-Winkler Area

Map Symbol	Soil Series and Phase	Depth From Surface (inches)	Textural Classification: USDA	Textural Classification: Unified	Textural Classification: AASHO	Percent Passing Sieve: No. 10	Percent Passing Sieve: No. 40	Percent Passing Sieve: No. 200	Disturbed Hydraulic Conductivity (ins./hr.)	Reaction (pH)	Conductivity mmhos/cm	Sulphate Hazard	Shrink-Swell Potential
Ba	Birkenhead loamy sand	0- 6	FS	SM to SP	A-2-4 (0)	100	70-85	5-15	6.0 to 10.0+	7.6	0.4	Low	Low
		6-15	FS	SM to SP	A-2-4 (0)	100	70-85	5-15	6.0 to 10.0+	7.7	0.3	Low	Low
		15-24	MS	SM to SP	A-2-4 (0)	95-100	70-85	5-15	6.0 to 10.0+	7.8	0.4	Low	Low
		24-28	MS-FS	SM to SP	A-2-4 (0)	95-100	70-85	5-15	6.0 to 10.0+	7.9	0.3	Low	Low
		28-36	LMS	SM to SP	A-2-4 (0)	95-100	70-85	5-15	6.0 to 10.0+	7.9	0.3	Low	Low
		36-48	FS	SM to SP	A-2-4 (0)	95-100	70-85	5-15	6.0 to 10.0+	7.9	0.3	Low	Low
Bb	Blumenfeld loam	0-17	L	CL to OL	A-6 (13)	100	98-100	55-75	1.0 to 3.0	8.0	0.7	Low to Mod.	Mod. to High
		17-32	VFSCL	CL to ML	A-6 (13)	100	98-100	55-75	1.0 to 2.0	8.0	1.2	Low to Mod.	Mod. to High
		32-48	L	CL to ML	A-6 (14)	100	98-100	50-75	1.0 to 2.0	8.0	1.0	Low to Mod.	Mod. to High
Bd	Blumengard clay	0-12	SiC-C	CH to OH	A-7-6 (20)	100	100	95-100	0.05 to 0.1	7.5-7.8	0.5	Low	High
		12-24	SiC-C	CH to MH	A-7-6 (20)	100	100	95-100	0.05 to 0.1	7.8-8.1	1.0	Low to Mod.	High
		24-28	SiC-C	CH to MH	A-7-6 (20)	100	100	95-100	0.05 to 0.1	7.8-8.1	2to 3	Mod. to High	High
Ca	Chortitz loam	0- 6	L-CL	MH to CL	A-7-6 (12)	100	100	96-100	1.0 to 3.0	7.0-7.5	0.5	Low	Mod. to High
		6-12	L-CL	MH to CL	A-7-6 (16)	100	100	98-100	0.5 to 3.0	7.5-8.0	1.0	Low to Mod.	Mod. to High
		12-24	L-CL	MH to CL	A-7-6 (16)	100	100	98-100	0.5 to 3.0	8.0	1.0 to 2.0	Low to Mod.	Mod. to High
		24-48	L-CL	MH to CL	A-7-6 (16)	100	100	98-100	0.5 to 3.0	8.0	1.5 to 3.0	Mod.	Mod. to High
Da	Deadhorse clay	0-12	C	CH to OH	A-7-6 (20)	100	100	90-100	0.05 to 0.3	7.6-7.8	0.5 to 1.0	Low	High
		12-24	C	CH	A-7-6 (20)	100	100	90-100	0.01 to 0.1	7.8-8.0	0.7 to 1.5	Low	High
		24-48	C	CH	A-7-6 (20)	100	100	90-100	0.01 to 0.1	8.0-8.2	4.0 to 8.0	Mod. to High	High
Db	Deadhorse, clay saline phase	0-12	C	CH to OH	A-7-6 (20)	100	100	90-100	0.05 to 0.4	7.6-7.8	3.0 to 4.0	High	High
		12-24	C	CH	A-7-6 (20)	100	100	90-100	0.02 to 0.1	7.8-8.0	4.0 to 8.0	High	High
		24-48	C	CH	A-7-6 (20)	100	100	90-100	0.02 to 0.1	7.8-8.0	8.0 to 12.0	High	High
		48-120	C	CH	A-7-6 (20)	100	100	90-100	0.01 to 0.1	7.8-8.0	8 to 12.0	High	High
Df	Dugas, clay	0-12	C	CH to OH	A-7-6 (20)	100	100	90-100	0.05 to 1.0	7.6-7.8	1.0	Low	High
		12-24	C	CH	A-7-6 (20)	100	100	90-100	0.03 to 0.1	7.6-7.8	1.0 to 3.0	Mod.	High
		24-48	FSL-CL	SM to MH	A-4 (6) to A-7-6 (12)	100	95-100	50-65	1.0 to 2.0	7.8-8.0	3.0 to 5.0	Mod. to High	Mod.
		48-72	FSL-VFSL	SM to MH	A-4 (6) to A-7-6 (12)	100	90-100	50-65	1.0 to 2.0	7.8-8.0	2.0 to 3.0	Mod. to High	Mod. to Low
Dg	Dugas, clay, saline phase	0-12	C	CH to OH	A-7-6 (20)	100	100	100	0.05 to 0.5	7.6-7.8	4.0 to 6.0	High	High
		12-24	C	CH	A-7-6 (20)	100	100	100	0.03 to 0.1	7.6-7.8	4.0 to 6.0	High	High
		24-48	FS-VFSL	SM to MH	A-4 (6) to A-7-5 (14)	100	60-70	25-50	1.0 to 3.0	7.6-7.8	4.0 to 6.0	High	High
Ec	Eigenhof clay loam	0-12	CL	MH to OH	A-7-5 (16)	100	95-100	70-80	1.0 to 2.0	6.8-7.1	0.5 to 1.0	Low	Mod. to High
		12-24	CL-C	MH to CH	A-7-5 (18)	100	95-100	75-95	0.3 to 0.8	7.1-7.3	1.0 to 2.0	Low	Mod. to High
		24-48	CL	MH to CH	A-7-5 (18)	100	95-100	75-95	0.05 to 0.3	7.6-7.8	1.0 to 2.0	Low	Mod. to High

TABLE 43 Cont'd.

Estimated Engineering Properties of the Soils of the Morden-Winkler Area

Map Symbol	Soil Series and Phase	Depth From Surface (inches)	Textural Classification			Percent Passing Sieve			Disturbed Hydraulic Conductivity (ins./hr.)	Reaction (pH)	Conductivity mmhos/cm	Sulphate Hazard	Shrink-Swell Potential
			USDA	Unified	AASHO	No. 10	No. 40	No.100					
Ed	Edenburg clay loam	0-12	CL	MH to CH	A-7-5 (16)	100	95-100	70-90	1.0 to 2.0	6.8-7.1	0.5 to 1.0	Low	Mod. to High
		12-24	CL	MH to CH	A-7-5 (16)	100	95-100	75-95	0.4 to 1.0	7.5-7.8	1.0 to 2.0	Low to Mod.	Mod. to High
		24-48	LFS-L	ML to MH	A-5 (10)	100	95-100	40-70	0.4 to 2.0	7.8-8.2	0.5 to 1.5	Low to Mod.	Mod.
Ga	Gnadenthal loam	0-12	L	CL to OL	A-5 (10)	100	95-100	65-75	1.5 to 3.0	7.8-8.0	1.0 to 1.5	Low	Mod.
		12-24	VFSL	CL	A-5 (10)	100	95-100	65-75	1.0 to 2.5	8.0-8.2	1.0 to 1.5	Low	Mod.
		24-48	VFSL	CL	A-5 (10)	100	95-100	65-75	0.5 to 2.0	8.0-8.2	1.0 to 1.5	Low to Mod.	Mod.
Gb	Gnadenthal loam, saline phase	0-12	L	CL to OL	A-5 (10-12)	100	95-100	65-75	1.5 to 3.0	8.0-8.2	3.0 to 7.0	High	Mod.
		12-24	VFSL-L	CL	A-5	100	95-100	65-75	1.0 to 2.5	8.0-8.2	5.0 to 10.0	High	Mod.
		24-48	VFSL-L	CL	A-5	100	95-100	65-75	0.5 to 2.0	8.0-8.2	10.0 to 15.0	High	Mod.
Gf	Graysville loam	0-12	L-CL	CL to MH	A-5 (12) to A-7-6 (14)	100	95-100	65-80	1.5 to 3.0	7.5-7.8	0.5 to 1.0	Low	Mod.
		12-24	L-CL	CL to MH	A-5 (10) to A-7-6 (14)	100	95-100	65-80	1.0 to 2.5	7.8-8.0	0.5 to 1.0	Low	Mod.
		24-48	L-CL	CL to MH	A-5 (12) to A-7-6 (14)	100	95-100	65-80	1.0 to 2.5	7.8-8.0	1.0 to 1.5	Low to Mod.	Mod.
		48-96	C	CH to MH	A-7-6 (20)	100	100	100	0.01 to 0.03	7.8-8.0	1.5 to 3.0	Mod.	High
Hb	Hochfeld, fine sandy loam	0-12	VFSL	SM	A-2-4 (0)	100	95-100	20-35	3.0 to 6.0	7.0-7.4	0.0 to 0.5	Low	Low
		12-24	LVFS	SM	A-2-4 (0)	100	95-100	20-35	3.0 to 6.0	7.4-7.8	0.3 to 0.5	Low	Low
		24-48	LVFS	SM	A-2-4 (0)	100	95-100	20-35	3.0 to 6.0	7.8-8.0	0.3 to 0.5	Low	Low
He	Horndean clay	0-12	C	CH to OH	A-7-6 (20)	100	100	85-95	0.5 to 1.5	7.5-7.8	1.0 to 1.5	Low	High
		12-24	C	CH	A-7-6 (20)	100	100	85-95	0.05 to 0.5	7.8-8.0	1.0 to 1.5	Low	High
		24-48	CL	CL to MH	A-7-5 (17)	100	95-100	85-98	1.0 to 2.0	7.8-8.0	1.5 to 2.0	Low to Mod.	Mod. to High
Hf	Horndean clay, saline phase	0-12	C	CH to OH	A-7-6 (20)	100	100	85-95	0.5 to 1.5	7.5-7.8	1.5 to 3.0	Mod. to High	High
		12-24	C	CH	A-7-6 (20)	100	100	85-95	0.05 to 0.5	7.8-8.0	4.0 to 8.0	High	High
		24-48	VFSCL	CL to MH	A-5 (10)	100	95-100	50-70	0.5 to 1.0	8.0-8.2	5.0 to 10.0	High	Mod.
		48-96	VFSCL	CL to MH	A-5 (10)	100	95-100	50-70	0.5 to 1.0	8.0-8.2	8.0 to 12.0	High	Mod.
Ja	Jordan clay	0-12	C	CH to OH	A-7-6 (20)	100	100	85-100	0.5 to 1.5	6.5-6.8	0.5 to 1.0	Low	High
		12-24	C	CH	A-7-6 (20)	100	100	85-100	0.05 to 0.2	7.2-7.5	0.5 to 1.0	Low	High
		24-48	L-CL	CL to MH	A-5 (12)	100	95-100	50-70	0.5 to 1.0	7.5-7.8	1.0 to 3.0	Low to Mod.	Mod.
		48-96	L	CL to MH	A-5 (10)	100	95-100	50-70	0.7 to 1.5	7.8-8.0	3.0 to 8.0	Mod	
Mo	Morris clay	0-12	C	CH to OH	A-7-6 (20)	100	100	100	0.02 to 0.05	7.5-7.8	1.0 to 2.0	Low	High
		12-24	C	CH	A-7-6 (20)	100	100	100	0.02 to 0.05	7.8-8.0	4 to 8.0	Mod. to High	High
		24-48	C	CH	A-7-6 (20)	100	100	100	0.01 to 0.03	7.8-8.0	6.0 to 10.0	High	High
		49-96	C	CH	A-7-6 (20)	100	100	100	0.01 to 0.03	7.8-8.0	6.0 to 10.0	High	High

TABLE 43 Cont'd.

Estimated Engineering Properties of the Soils of the Morden-Winkler Area

Map Symbol	Soil Series and Phase	Depth From Surface (inches)	Textural Classification			Percent Passing Sieve			Disturbed Hydraulic Conductivity (ins./hr.)	Reaction (pH)	Conductivity mmhos/cm	Sulphate Hazard	Shrink-Swell Potential
			USDA	Unified	AASHO	No. 10	No. 40	No. 100					
Na	Neuenberg very fine sandy loam ..	0-12	VFSL	ML to OL	A-4 (5)	100	100	40-60	2.0 to 3.5	7.5-7.8	0.5 to 1.0	Low to Mod.	Mod.
		12-24	VFSL	ML	A-4 (3)	100	100	40-60	1.5 to 3.5	7.8-8.0	0.5 to 1.0	Low to Mod.	Mod.
		24-48	VFSL	ML	A-4 (3)	100	100	40-60	1.5 to 4.0	7.8-8.0	0.5 to 1.0	Low to Mod.	Mod.
		48-96	VFSL-VFSCL	ML to CL	A-4 (8)	100	100	50-75	0.5 to 1.5	7.8-8.0	1.0 to 1.5	Low to Mod.	Mod.
Nb	Neuenberg very fine sandy loam, imperfectly drained phase	0-12	VFSL	ML to OL	A-4 (5)	100	100	40-60	2.0 to 3.5	7.5-8.0	1.0 to 2.0	Mod.	Mod.
		12-24	VFSL	ML	A-4 (5)	100	100	40-60	2.0 to 3.5	8.0-8.2	1.0 to 2.0	Mod.	Mod.
		24-48	VFSL	ML	A-4 (5)	100	100	40-60	1.5 to 2.5	8.0-8.2	1.0 to 2.0	Mod.	Mod.
		48-96	VFSL-VFSCL	ML to CL	A-4 (8)	100	100	50-75	0.5 to 1.5	8.0-8.2	1.0 to 2.0	Mod.	Mod.
Ne	Neuhorst clay loam ...	0-12	CL	MH to OH	A-7-5 (16)	100	100	70-90	0.5 to 1.5	7.0-7.5	0.5 to 1.0	Low	Mod. to High
		12-24	CL	MH to CH	A-7-5 (16)	100	100	70-90	0.2 to 0.5	7.5-7.8	0.5 to 1.0	Low	Mod. to High
		24-48	CL	MH to CH	A-7-5 (16)	100	100	70-90	0.2 to 0.5	7.8-8.0	0.5 to 1.0	Low	Mod. to High
Nf	Neuhorst clay loam, saline phase	0-12	CL	MH to OH	A-7-5 (16)	100	100	70-90	0.5 to 1.5	7.5-7.8	1.0 to 2.0	Mod.	Mod. to High
		12-24	CL	MH to CH	A-7-5 (16)	100	100	70-90	0.2 to 0.5	7.8-8.0	2.0 to 4.0	High	Mod. to High
		24-48	CL	MH to CH	A-7-5 (16)	100	100	70-90	0.2 to 0.5	8.0-8.2	4.0 to 8.0	High	Mod. to High
Nj	Newton Siding, clay loam	0-12	CL	MH to OH	A-7-5 (16)	100	100	70-90	0.5 to 1.5	7.0-7.5	0.5 to 1.0	Low	Mod. to High
		12-24	CL	MH to CH	A-7-5 (16)	100	100	70-90	0.5 to 1.0	7.5-7.8	1.0 to 2.0	Low to Mod.	Mod. to High
		24-48	VFSL-LFS	ML to SM	A-4 (5)	100	100	40-70	1.5 to 2.0	8.0-8.2	0.5 to 1.0	Low	Mod.
		48-96	VFSL-LFS	ML to SM	A-4 (5)	100	100	40-70	1.5 to 2.0	8.0-8.2	0.5 to 1.0	Low	Mod.
Oc	Osborne clay	0-12	C	CH to OH	A-7-6 (20)	100	100	100	0.05 to 0.7	7.5-7.8	0.5 to 1.0	Low	High
		12-24	C	CH	A-7-6 (20)	100	100	100	0.01 to 0.05	7.8-8.0	2.0 to 4.0	Mod. to High	High
		24-48	C	CH	A-7-6 (20)	100	100	100	0.01 to 0.05	8.0-8.2	4.0 to 6.0	High	High
		48-96	C	CH	A-7-6 (20)	100	100	100	0.01 to 0.05	8.0-8.2	6.0 to 9.0	High	High
Pa	Plum Coulee clay	0-12	CL-C	CH to OH	A-7-6 (20)	100	100	95-100	0.5 to 1.5	7.5-7.8	0.5 to 1.0	Low	High
		12-24	C	CH	A-7-6 (17)	100	100	95-100	0.03 to 0.5	7.5-7.8	0.5 to 1.0	Low	High
		24-48	SiCL-CL	MH to CH	A-7-6 (17)	100	100	90-100	0.1 to 0.5	7.8-8.0	1.0 to 1.5	Mod.	High
		48-96	SiL-LVFS	MH to CH	A-7-5 (15)	100	100	70-90	0.5 to 1.0	8.0-8.2	0.5 to 1.0	Low	High
		96-120	C	CH	A-7-6 (20)	100	100	100	0.01 to 0.1	7.8-8.0	0.5 to 1.0	Low	High
Ra	Reinland, fine sandy loam	0-12	FSL	SM to OL	A-4 (3)	100	100	35-60	2.0 to 3.0	7.5-7.8	0.5 to 1.0	Low	Low
		12-24	FSL	SM to ML	A-4 (5)	100	100	35-60	3.0 to 3.5	7.8-8.0	0.1 to 0.5	Low	Low
		24-48	FSL	SM to ML	A-4 (5)	100	100	35-60	2.5 to 3.0	8.0-8.2	0.1 to 0.4	Low	Low
		48-96	FSL	SM to ML	A-4 (5)	100	100	35-60	1.0 to 2.0	8.0-8.2	0.1 to 0.4	Low	Low
Rb	Reinland, fine sandy loam, imperfectly drained phase	0-12	FSL-VFSL	SM to OL	A-4 (5)	100	100	35-60	2.0 to 4.0	7.5-7.8	0.2 to 0.5	Low	Low
		12-24	FSL	SM	A-4 (3)	100	100	35-60	2.0 to 3.0	8.0-8.2	0.5 to 1.0	Low	Low
		24-48	FSL	SM	A-4 (3)	100	100	35-60	3.0 to 4.0	8.0-8.2	0.5 to 1.0	Low	Low
		48-96	FSL-VFSCL	SM to MH	A-4 (5)	100	100	35-60	0.5 to 2.0	8.0-8.2	0.5 to 1.0	Low	Low
		96-120	C	CH	A-7-6 (20)	100	100	100	0.01 to 0.1	7.8-8.0	0.5 to 1.0	Low	High

TABLE 43 Cont'd.

Estimated Engineering Properties of the Soils of the Morden-Winkler Area

Map Symbol	Soil Series and Phase	Depth From Surface (inches)	Textural Classification			Percent Passing Sieve			Disturbed Hydraulic Conductivity (ins./hr.)	Reaction (pH)	Conductivity mmhos/cm	Sulphate Hazard	Shrink-Swell Potential
			USDA	Unified	AASHO	No. 10	No. 40	No.100					
Re	Reinfeld, loam	0-12	L-VFSL	CL to OL	A-5 (9)	100	100	50-70	2.0 to 3.0	7.0-7.3	0.5 to 1.0	Low	Mod.
		12-24	L-VFSL	CL	A-5 (10)	100	100	50-70	2.0 to 3.0	7.5-7.8	0.5 to 1.0	Low	Mod.
		24-48	L-VFSL	CL	A-5 (10)	100	100	50-70	2.0 to 3.0	7.8-8.0	0.5 to 1.0	Low	Mod.
		48-96	L-VFSL	CL	A-5 (12)	100	100	50-70	1.0 to 2.0	7.8-8.0	0.5 to 1.0	Low	Mod.
Rg	Rignold, loam	0-12	FSL	CL to OL	A-5 (10)	100	100	50-70	2.5 to 3.0	7.5-7.8	0.5 to 1.0	Low	Mod.
		12-24	FSL	CL	A-5 (10)	100	100	50-70	2.5 to 3.0	7.8-8.0	0.5 to 1.0	Low	Mod.
		24-48	FSL-VFSCL	CL to MH	A-6 (16)	100	100	60-70	1.5 to 2.0	7.8-8.0	1.0 to 2.0	Mod.	Mod. to High
		48-96	C	CH	A-7 (20)	100	100	100	0.01 to 0.1	7.8-8.0	4.0 to 6.0	High	High
Rn	Rosengart, very fine sandy loam	0-12	VFSL	ML to OH	A-4 (4)	100	100	50-60	2.5 to 3.0	7.3-7.5	0.5 to 1.0	Low	Mod.
		12-24	VFSL	ML	A-4 (4)	100	100	50-60	2.5 to 3.0	7.8-8.0	0.5 to 1.0	Low	Mod.
		24-48	VFSL-VFSCL	ML to MH	A-4 (8) to A-6 (12)	100	100	50-70	0.5 to 1.0	8.0-8.2	0.5 to 1.0	Low	Mod.
		48-96	FS & SiCL	ML & CH	A-4 (8) to A-7-5 (18)	100	100	60-80	0.3 to 1.0	8.0-8.2	0.5 to 1.0	Low	Mod. to High
Rr	Red River	0-12	C	CH to OH	A-7-6 (20)	100	100	100	0.02 to 0.05	7.5-7.8	0.5 to 1.0	Low	High
		12-24	C	CH	A-7-6 (20)	100	100	100	0.02 to 0.05	7.8-8.0	1.0 to 2.0	Mod.	High
		24-48	C	CH	A-7-6 (20)	100	100	100	0.01 to 0.05	8.0-8.2	2.0 to 4.0	Mod. to High	High
		48-96	C	CH	A-7-6 (20)	100	100	100	0.01 to 0.05	8.0-8.2	3.0 to 6.0	High	High
Wa	Winkler, clay	0-12	CL-C	CH to OH	A-7-6 (18)	100	100	90-100	0.5 to 1.0	6.8-7.0	0.5 to 1.0	Low	High
		12-24	C	CH	A-7-6 (18)	100	100	90-100	0.05 to 0.1	7.5-7.8	0.5 to 1.0	Low	High
		24-48	C	CH	A-7-6 (19)	100	100	90-100	0.05 to 0.1	7.8-8.0	0.5 to 1.0	Low	High
		48-96	C	CH	A-7-6 (20)	100	100	95-100	0.01 to 0.05	7.8-8.0	0.5 to 1.0	Low	High

3. *Engineering Interpretations for Various Uses*

Soil interpretations for engineering uses involve relating relevant soil and landscape qualities and characteristics to specific uses. Estimated suitability or limitations of soils in the Morden-Winkler area for various engineering uses are given in Table 44.

1. *Suitability as source of topsoil*

The term "topsoil" includes soil materials used to cover barren surfaces exposed during construction, and materials used to improve soil conditions on lawns, gardens, flower beds, etc. The factors considered include not only characteristics of the soil itself, but also the ease or difficulty of excavation and where removal of topsoil is involved, accessibility to the site. The soil and landscape properties important to this use are texture or engineering class, organic matter content, thickness of surface layer and reaction, degree of salinity, degree of stoniness, slope, degree of wetness, risk of flooding.

2. *Suitability as a source of sand and gravel*

The purpose of this interpretation is to provide guidance on the probable supply as well as quality of the sand or gravel for use as road base material and concrete. The interpretation pertains mainly to the characteristics of the soil substratum to a depth of 5 to 6 feet, augmented by observations in deep cuts as well as geological knowledge. The important soil and landscape criteria for this interpretation are texture or engineering class, thickness of layers, depth to water table, ease of excavation.

3. *Suitability as a source of fill material*

Fill material for buildings or roads are included in this use. Performance of material when removed from its original location and placed under load at the building site or road bed are considered. Since surface materials are generally removed during road or building construction their properties are usually ignored. The whole soil to a depth of 5 to 6 feet is evaluated. Parameters of importance include texture or engineering class, soil drainage class, depth to water table, depth to bedrock, slope plasticity index, susceptibility to flooding, and ease of excavation.

4. *Soil features affecting location of roads and highways*

Soil and landscape properties that affect design, construction and performance of highways and all weather roads are considered here. It is not the intention to suggest that soil maps possess adequate information to conduct engineering design; however, the soil map and interpretations are an invaluable aid in planning and conducting an engineering soil survey for design purposes.

Aside from the organic enriched surface horizon which is generally removed in construction, the entire soil profile in its undisturbed state was evaluated for this use. Those properties of importance are texture or engineering class, thickness of significantly different layers, soil drainage class, depth to water table, permeability, depth to bedrock, type of bedrock, slope, stoniness, mineralogy, atterberg limits, susceptibility to flooding.

5. *Soil features affecting foundation construction*

These interpretations apply to those features of soil and landscape influencing the support and construction of foundations suitable for low buildings, generally less than three stories high. As foundations are placed in the substratum below the average depth of penetration of frost, properties of the subsoil to a depth of at least 5 to 6 feet are considered. Properties influencing foundation support are those affecting bearing strength and settlement under load. Important parameters include density, wetness, flooding, plasticity, texture and shrink-swell potential, susceptibility to frost heaving. Properties affecting ease of excavation and cost of foundation construction are wetness, risk of flooding, slope, depth to bedrock, stoniness and rockiness.

6. *Soil features affecting reservoir areas*

Factors affecting the ability of undisturbed soils to impound water and prevent seepage are considered for evaluating soil suitability for reservoir areas. As impounded liquids could be potential sources of contamination of nearby water supplies, e.g. sewage lagoons, the landscape position of the reservoir as it affects risk of flooding must also be considered. Important characteristics include depth to water table, risk of flooding, soil permeability, texture, slope, depth to bedrock, nature of bedrock, thickness of slowly permeable layers.

7. *Soil features affecting embankments*

Evaluation of soil suitability for embankment materials including dikes and levees is based on the ability of disturbed soil to restrain water flow when compacted. Important soil qualities affecting evaluation for this use are shear strength, compressibility,compaction characteristics,permeability of compacted material and susceptibility to piping.

8. *Suitability for septic tank disposal fields*

Criteria employed for rating soils for this use are based on their ability to absorb effluent. Effluent should move through soil at a moderate rate. Severe limitations may exist where rapid permeability might permit contamination of water supplies and restricted effluent movement, as a consequence of impermeable materials or high water table, result in surface overflow. Soils with slope gradients that contribute to side hill seepage of effluent also are considered to have severe limitations even though other characteristics are favorable. When evaluating the significance of fluctuating water table levels for septic fields, the seasonal high level is considered in order to express soil suitability in the most limiting situation. Important soil and landscape features for effluent absorption fields include soil permeability, depth to water table, risk of flooding, slope, depth to bedrock, nature of bedrock, stoniness and rockiness.

TABLE 44

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of —			Soil Features Affecting —					Soil Limitations for use as Septic Tank Filter Field
		Topsoil	Sand and Gravel	Fill Material	Road Location	Foundation Construction	Agricultural Drainage	Water Retention Structures: Reservoir Area	Water Retention Structures: Embankment	
Ba	Birkenhead, loamy sand	Fair	Good for sand	Good	Slight limitation. Gravelly sands, stable, may become loose and dusty in dry periods; suitable as subgrades for bituminous surfaces.	Slight limitation. Good to excellent bearing strength, low shrink-swell potential; low risk of frost heaving.	Not needed.	Severe limitation. Rapid to very rapid permeability; excessive seepage	Good to fair, medium to shear strength, low compressibility, high to medium permeability, moderately susceptible to piping.	Slight — rapid effluent absorption; moderate risk of groundwater contamination.
Bb	Blumenfeld, loam	Fair	Unsuited	Poor	Severe limitation. High water table; low stability at high moisture content; not suitable as subgrades for bituminous surfaces; risk of frost heaving.	Severe limitation. Poor bearing strength at high moisture content; moderate to high shrink-swell potential; poorly drained.	Surface drainage and lowering of water table required.	Severe limitation. High water table; slow to moderate seepage rates; suitable for dugouts.	Fair to poor, medium to low shear strength, moderate compressibility, low permeability, low to medium susceptibility to piping	Severe — high water table, moderately slow effluent absorption; risk of groundwater contamination moderately high.
Bd	Blumengart, clay	Poor because of clayey texture	Unsuited	Poor	Severe limitation. Seasonal high water table; low stability at high moisture content; not suitable as subgrades for bituminous surfaces; high risk of frost heaving.	Severe limitation. Poor bearing strength at high moisture content; high shrink-swell potential; high seasonal water table.	Surface drainage required.	Moderate limitation. Seasonal high water table; slow seepage rates; suitable for dugouts.	Fair to poor compaction properties, low shear strength, high compressibility, low permeability, not susceptible to piping.	Severe — seasonal high water table; slow effluent absorption rate.
Be	Blumenort, clay	Poor because of clayey texture	Unsuited	Poor	Severe limitation. High water table; low stability at high moisture content; not suitable as subgrades for bituminous surfaces; risk of frost heaving.	Severe limitation. Poor bearing strength at high moisture content; high shrink-swell potential; poorly drained.	Surface drainage and lowering of water table required.	Severe limitation. High water table; very slow seepage rate; suitable for dugouts.	Same as Bd	Severe — high water table; very slow effluent absorption rate; risk of groundwater contamination.

TABLE 44 Cont'd.

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of — Topsoil	Sand and Gravel	Fill Material	Soil Features Affecting — Road Location	Foundation Construction	Agricultural Drainage	Water Retention Structures Reservoir Area	Embankment	Soil Limitations for use as Septic Tank Filter Field
Cal	Chortitz, loam	Fair	Unsuited	Poor	Severe limitation. Seasonal high water table; low stability at high moisture content; risk of frost heaving; not suitable as subgrades for butiuminous surfaces.	Severe limitation. Poor bearing strength at high moisture content, moderate to high shrink-swell potential, occasional flooding.	Surface drainage and protection from flooding is required.	Severe limitation. Moderately slow seepage; variable material; subject to flooding.	Poor to fair compaction properties, low shear strength, high compressibility, low permeability, medium to low susceptibility to piping.	Severe — seasonal high water table; moderate risk of groundwater contamination.
Ca2	Chortitz, loam, gently undulating phase	Fair	Unsuited	Poor	Same as Ca1	Same as Ca1	Same as Ca1	Same as Ca1	Same as Ca1	Same as Ca1
Da	Deadhorse, clay	Poor because of clayey textures	Unsuited	Poor	Severe limitation. Seasonal high water table; poor stability at high moisture content, some risk of frost heaving; not suitable as subgrades for bituminous surfaces.	Severe limitation. Poor bearing strength at high moisture content; high shrink-swell potential, somewhat poorly drained.	Surface drainage required.	Slight limiation. Very slowly permeable to impervious; suitable for dugouts and lagoons.	Fair to poor compaction properties, medium to low shear strength; high compressibility, low permeability, low susceptibility to piping.	Severe — very slow rate of effluent absorption; high seasonal water table.
Db	Deadhorse, clay, slightly saline phase	Poor because of clayey textures and salinity	Unsuited	Poor	Same as Da	Same as Da	Same as Da	Same as Da	Same as Da	Same as Da
Dc	Deadhorse, clay loam	Fair	Unsuited	Poor	Same as Da	Same as Da	Same as Da	Same as Da	Same as Da	Same as Da
Dd	Deadhorse, clay loam, slightly saline phase	Poor because of salinity	Unsuited	Poor	Same as Da	Same as Da	Same as Da	Same as Da	Same as Da	Same as Da

TABLE 44 Cont'd.

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of — Topsoil	Sand and Gravel	Fill Material	Soil Features Affecting — Road Location	Foundation Construction	Agricultural Drainage	Water Retention Structures — Reservoir Area	Embankment	Soil Limitations for use as Septic Tank Filter Field
De	Deadhorse, loam	Good	Unsuited	Poor	Same as Da	Same as Da	Same as Da	Same as Da	Same as Da	Same as Da
Df	Dugas, clay	Poor because of clayey textures	Unsuited	Poor	Severe limitation. Seasonal high water table; poor stability at high moisture content; not suitable as subgrades for bituminous surfaces.	Severe limitation. Poor bearing strength at high moisture content; high shrink-swell potential; subsoils variable and subject to high risk of frost heaving.	Surface drainage required.	Moderate limitation. Very slow seepage rate; subsoils are variable and moderate seepage rates.	Surface 2 to 4 feet same as Da; subsoils variable; Unified class, ranges SM to MH, poor to fair compaction properties; medium to low shear strength; high compressibility.	Severe — very slow to slow absorption of effluent, high seasonal water table.
Dg	Dugas, clay slightly saline phase	Poor because of clayey textures and salinity.	Unsuited	Poor	Same as Df	Same as Df	Same as Df	Same as Df	Same as Df	Same as Df
Dh	Dugas, clay loam	Fair	Unsuited	Poor	Same as Df	Same as Df	Same as Df	Same as Df	Same as Df	Same as Df
Dk	Dugas, loam	Good	Unsuited	Poor	Same as Df	Same as Df	Same as Df	Same as Df	Same as Df	Same as Df
Dl	Dugas, loam slightly saline phase	Poor because of salinity	Unsuited	Poor	Same as Df	Same as Df	Same as Df	Same as Df	Same as Df	Same as Df
Ec	Eigenhof, clay loam	Good	Unsuited	Poor	Severe limitation. Poor stability at high moisture content; compressible; not suitable as subgrades for bituminous surfaces; risk of frost heaving.	Severe limitation. Low bearing capacity at high moisture content; moderate to high shrink-swell potential; compressible, making them difficult to compact.	Not needed.	Moderate limitation. Slow to very slow seepage rates; suitable for dugouts.	Poor to fair compaction properties, medium to low strength, high compressibility, low permeability, medium to low susceptiblity to piping.	Moderate to severe — slow rate of effluent absorption.

TABLE 44 Cont'd .

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of: Topsoil	Suitability as Source of: Sand and Gravel	Suitability as Source of: Fill Material	Soil Features Affecting – Road Location	Soil Features Affecting – Foundation Construction	Soil Features Affecting – Agricultural Drainage	Soil Features Affecting – Water Retention Structures: Reservoir Area	Soil Features Affecting – Water Retention Structures: Embankment	Soil Limitations for use as Septic Tank Filter Field
Ed	Edenburg, clay loam	Good	Unsuited	Poor	Severe limitation. Poor stability at high moisture content; compressible, not suitable as sub-grades for bituminous surfaces; risk of frost heaving.	Severe limitation. Low bearing strength at high moisture content; moderate to high shrink-swell potential in surface 2 to 3 feet and moderate in subsurface soils.	Not needed.	Moderate limitation. Slow to very slow seepage rates in upper 2 to 3 feet; variable water below 2 to 3 feet; seepage rates are moderate to moderately slow.	Surface 2 to 4 feet same as Ec; subsurface material fair compaction properties, medium to low strength, medium compressibility, medium to low permeability, susceptible to piping.	Slight to moderate – rate of effluent absorption in surface soil material is slow to very slow, absorption in subsurface soils below 2 to 3 feet is moderate.
Ef	Elias, clay	Poor	Unsuited	Poor	Severe limitation. Clay soil, poor stability at high moisture content; compressible; poor subgrade for bituminous surfaces; risk of frost heaving.	Severe limitation. Low bearing capacity at high moisture contents; high shrink-swell potential; compressible and difficult to compact.	Surface drainage required; subject to flooding.	Slight limiation. Very slow seepage rates; subsurface soils are variable.	Poor to fair compaction properties, medium to low strength, low permeability, low susceptibility to piping.	Severe – slow to very slow rate of effluent absorption; high seasonal water table; moderate risk of groundwater contamination.
Ga	Gnadenthal, loam	Good	Unsuited	Poor	Severe limiation. Poor stability at high moisture contents; compressible and difficult to compact; poor sub-grade for bituminous surfaces; subject to frost heaving.	Severe limitation. Low bearing capacity at high moisture content; moderate shrink-swell potential.	Surface drainage required.	Moderate limitation. Moderately slow to slow seepage rates.	Fair to good compaction properties, medium to low strength, medium compressibility, medium to low permeability.	Severe – high seasonal water table; moderate risk of groundwater contamination
Gb	Gnadenthal, loam, slightly saline phase	Poor because of salinity	Unsuited	Poor	Same as Ga	Same as Ga	Same as Ga	Same as Ga	Same as Ga	Same as Ga
Gc	Gnadenthal, clay loam	Fair	Unsuited	Poor	Same as Ga	Same as Ga	Same as Ga	Same as Ga	Same as Ga	Same as Ga

TABLE 44 Cont'd.

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of – Topsoil	Suitability as Source of – Sand and Gravel	Suitability as Source of – Fill Material	Soil Features Affecting – Road Location	Soil Features Affecting – Foundation Construction	Soil Features Affecting – Agricultural Drainage	Soil Features Affecting – Water Retention Structures – Reservoir Area	Soil Features Affecting – Water Retention Structures – Embankment	Soil Limitations for use as Septic Tank Filter Field
Gd	Gnadenthal, clay	Poor due to clayey texture	Unsuited	Poor	Same as Ga	Same as Ga	Same as Ga	Same as Ga	Same as Ga	Same as Ga
Gf	Graysville, loam	Good	Unsuited	Poor	Severe limitation. High seasonal water table; poor stability at high moisture content; subject to frost heaving; poor subgrades for bituminous surfaces.	Severe limitation. Poor bearing capacity at high moisture content; shrink-swell potential moderate in surface 2 to 4 feet; high in subsurface materials.	Surface drainage required.	Moderate limitation. Seepage rates moderate to moderately slow in surface 2 to 4 feet; impervious subsurface material.	Surface 2 to 4 feet same as Ga; subsurface material has poor to fair compaction properties, high compressibility, low permeability, low susceptibility to piping.	Severe – high seasonal water table, moderately slow to very slow effluent absorption rate; moderate risk of groundwater contamination.
Gg	Glencross, loam	Good	Unsuited	Poor	Severe limitation. High seasonal water table, poor stability at high moisture content; erosive; subject to frost heaving; material below 2 to 4 feet fair to poor stability when wet.	Severe limitation. Surface 2 to 4 ft. poor bearing capacity at high moisture content; moderate to high shrink-swell potential; subsurface material fair to poor bearing capacity.	Surface drainage required.	Moderate limitation. Seepage rates in surface and subsurface materials is moderate to moderately slow.	Same as Ga; subsurface material is moderately stony.	Severe – high seasonal water table, moderately slow effluent absorption; moderate risk of groundwater contamination.
Hb	Hochfeld, fine sandy loam	Good	Fair to poor for sand	Good	Slight limitation. Stable when dry, may soften during wet weather; satisfactory as a base; erosive.	Slight limitation. Good bearing strength; low shrink-swell potential.	Not needed.	Severe limitation. Rapid seepage rates, unsuitable for dugouts.	Fair to good compaction properties, medium strength, low compressibility, medium to high permeability, medium to high susceptibility to piping.	Slight – rapid effluent absorption; some risk of groundwater contamination.
Hc	Hochfeld, fine sandy loam, eroded phase	Poor	Fair for sand	Good	Same as Hb	Same as Hb	Same as Hb	Same as Hb	Same as Hb	Same as Hb

TABLE 44 Cont'd.

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of — Topsoil	Sand and Gravel	Fill Material	Soil Features Affecting — Road Location	Foundation Construction	Agricultural Drainage	Water Retention Structures: Reservoir Area	Embankment	Soil Limitations for use as Septic Tank Filter Field
Hd	Hochfeld, fine sandy loam, overblown phase	Poor	Fair for sand	Good	Same as Hb	Same as Hb	Same as Hb	Same as Hb	Same as Hb	Same as Hb
He	Horndean, clay	Poor because of clayey textures	Unsuited	Poor	Severe limitation. High seasonal water table; poor stability at high moisture content; sub-surface material subject to frost heaving; erosive, poor subgrade for bituminous surfaces.	Severe limitation. Surface 2 to 4 ft. poor bearing capacity, high shrink-swell potential; sub-surface material poor to fair bearing capacity.	Surface drainage required.	Moderate limitation. Very slow to slow seepage rates in surface 2 to 4 feet, subsurface moderately slow seepage rates.	Poor to fair compaction properties, high compressibility, low permeability, medium to low susceptibility to piping.	Severe — surface 2 to 4 feet very slow to slow effluent absorption; sub-surface moderately slow to slow absorption rates; some risk of groundwater contamination because of seasonal high water table levels.
Hf	Horndean, clay loam	Good	Unsuited	Poor	Same as He	Same as He	Same as He	Same as He	Same as He	Same as He
Hg	Horndean, loam	Good	Unsuited	Poor	Same as He	Same as He	Same as He	Same as He	Same as He	Same as He
Hj	Hobson, fine sandy loam	Good	Poor for sand top 2 to 4 ft.	Fair, top 2 to 4 feet.	Severe limitation. Surface 2 to 4 ft. good stability, may soften in wet weather; erosive; subsurface clay poor stability when wet, not suitable as subgrade for bituminous surfaces.	Severe limitation. Surface 2 to 4 ft. good bearing capacity and low shrink-swell potential; subsurface clay poor bearing strength when wet, high shrink-swell potential.	Not needed.	Moderate limitation. Surface 2 to 4 feet rapid seepage rates; subsurface consists of impervious clay.	Surface 2 to 4 ft. same as Ga; subsurface clay material fair to poor compaction properties, high compressibility, low permeability, low susceptibility to piping.	Slight to moderate limitation depends on thickness of the porous sandy surface material; substratum has slow effluent absorption rate.

TABLE 44 Cont'd.

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of —			Soil Features Affecting					Soil Limitations for use as Septic Tank Filter Field
		Topsoil	Sand and Gravel	Fill Material	Road Location	Foundation Construction	Agricultural Drainage	Water Retention Structures: Reservoir Area	Water Retention Structures: Embankment	
Hk	Huddlestone, loamy fine sand	Good	Poor for sand top 2 to 4 ft.	Fair, top 2 to 4 ft. remainder poor, thickness variable.	Severe limitation. Surface 2 to 4 ft. good stability; erosive; subsurface material fair to poor stability when wet, moderately compressible; not suitable as subgrade for bituminous surfaces.	Moderate limitation. Surface 2 to 4 ft. good bearing capacity and low shrink-swell potential; subsurface material fair to poor bearing strength, moderate shrink-swell potential.	Not needed.	Severe limitation. Surface 2 to 4 ft. rapid seepage rates; subsurface moderate to moderately slow seepage rates.	Surface 2 to 4 ft. same as Hb; subsurface material has fair compaction properties, medium to low strength, medium to high compressibility, low permeability, low susceptibility to piping.	Slight to moderate — limitation depends on thickness of the porous, sandy surface material; sub-stratum has moderately slow effluent absorption rate.
Ja	Jordan, clay	Poor because of clay textures	Unsuited	Poor	Severe limitation. Poor stability when wet, highly compressible; substratum moderate to high shrink-swell potential and unstable when wet; poor subgrade for bituminous surfaces.	Severe limitation. Surface 2 to 4 ft. low bearing strength; high shrink-swell potential; substratum moderately compressible and moderate to large volume changes with changing moisture content.	Not needed.	Moderate limitation. Surface 2 to 4 ft. slow seepage rates; substratum moderately slow to rapid seepage rates.	Poor to fair compaction properties, medium to low strength, high compressibility, low permeability, low susceptibility to piping.	Moderate — moderate rate of effluent absorption in surface material; substratum variable, absorption rates moderately slow to slow.
Jb	Jordan, clay loam	Same as Ja	Unsuited	Poor	Same as Ja	Same as Ja	Same as Ja	Same as Ja	Same as Ja	Same as Ja
Mo	Morris, clay	Poor because of clay textures	Unsuited	Poor	Severe limitation. Highly plastic clay; poor stability when wet, highly compressible; poor subgrade for bituminous surfaces.	Severe limitation. Low bearing strength when wet; very high shrink-swell potential.	Surface drainage required.	Slight limitation. Very slow seepage rates.	Poor compaction properties; medium to low strength, high compressibility, low permeability, low susceptibility to piping.	Severe — Extremely low effluent absorption rates.

TABLE 44 Cont'd .

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of: Topsoil	Suitability as Source of: Sand and Gravel	Suitability as Source of: Fill Material	Soil Features Affecting — Road Location	Soil Features Affecting — Foundation Construction	Soil Features Affecting — Agricultural Drainage	Soil Features Affecting — Water Retention Structures: Reservoir Area	Soil Features Affecting — Water Retention Structures: Embankment	Soil Limitations for use as Septic Tank Filter Field
Na	Neuenberg, very fine sandy loam	Good	Unsuited	Poor	Severe limitation. Unstable when wet; subject to frost heaving; poor subgrade for bituminous surfaces.	Severe limitation. Low bearing strength when wet; moderate shrink-swell potential; difficult to compact.	Surface drainage required.	Severe limitation. Moderate to rapid seepage rates.	Fair to poor compaction properties, medium to low strength, medium compressibility, medium permeability; high susceptibility to piping.	Moderate — Filter fields may occur below surface of groundwater level during spring runoff; some risk of groundwater contamination.
Nb	Neuenberg, very fine sandy loam, imperfectly drained phase	Good	Unsuited	Poor	Same as Na	Same as Na	Required to remove surface water and to lower water table.	Same as Na	Same as Na	Severe — seasonal high water table for significant period in spring; moderate risk of groundwater contamination.
Nc	Neuenberg, loam	Good	Unsuited	Poor	Same as Na	Same as Na	Same as Na	Same as Na	Same as Na	Same as Na
Ne	Neuhorst, clay loam	Good	Unsuited	Poor	Severe limitation. Unstable when wet; subject to frost heaving; highly compressible; difficult to compact; poor subgrade for bituminous surfaces.	Severe limitation. Low bearing strength when wet; high shrink-swell potential.	Surface drainage required.	Slight limitation. Slow seepage rates.	Poor to fair compaction properties, low to medium strength, high compressibility; low permeability; low susceptibility to piping.	Severe — slow effluent absorption rates; high seasonal water table; some risk of groundwater contamination.
Nf	Neuhorst, clay loam, slightly saline phase	Poor because of salinity	Unsuited	Poor	Same as Ne	Same as Ne	Same as Ne	Same as Ne	Same as Ne	Same as Ne
Ng	Neuhorst, loam	Good	Unsuited	Poor	Same as Ne	Same as Ne	Same as Ne	Same as Ne	Same as Ne	Same as Ne

TABLE 44 Cont'd.

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of – Topsoil	Suitability as Source of – Sand and Gravel	Suitability as Source of – Fill Material	Soil Features Affecting – Road Location	Soil Features Affecting – Foundation Construction	Soil Features Affecting – Agricultural Drainage	Water Retention Structures – Reservoir Area	Water Retention Structures – Embankment	Soil Limitations for use as Septic Tank Filter Field
Nh	Neuhorst, clay	Poor because of clay	Unsuited	Poor	Same as Ne	Same as Ne	Same as Ne	Same as Ne	Same as Ne	Same as Ne
Nj	Newton Siding, clay loam	Good	Unsuited	Poor	Severe limitation. Poor stability at high moisture content; compressible; substratum variable. erosive, high risk of frost heaving.	Severe limitation. Low bearing capacity at high moisture content; moderate to high shrink-swell potential; substratum below 2 to 4 feet of the surface is variable; subject to moderate volume change with changing moisture contents.	Surface drainage required.	Severe limitation. Slow to very slow seepage rates in surface 2 to 4 ft.; variable substratum; seepage rates vary from moderate to moderately slow.	Surface 2 to 4 ft. same as Ne, subsurface material has fair compaction properties; medium to low strength, medium compressibility, low to medium permeability, high susceptibility to piping.	Severe – slow effluent absorption rates; high seasonal water table; risk of groundwater contamination.
Nk	Newton Siding, clay loam, slightly saline phase	Poor because of salinity	Unsuited	Poor	Same as Nj	Same as Nj	Same as Nj	Same as Nj	Same as Nj	Same as Nj
Nl	Newton Siding, clay	Poor because of clay texture	Unsuited	Poor	Same as Nj	Same as Nj	Same as Nj	Same as Nj	Same as Nj	Same as Nj
Nm	Newton Siding, clay, slightly saline phase	Poor because of texture and salinity	Unsuited	Poor	Same as Nj	Same as Nj	Same as Nj	Same as Nj	Same as Nj	Same as Nj
Oa	Osterwick, fine sandy loam	Fair	Poor	Poor	Severe limitation. High water table, poor stability at high moisture content.	Severe limitation. High water table, poor drainage.	Surface drainage and lowering of water table required.	Severe limitation. High water table, moderate seepage rates.	Same as Ra, high water table.	Severe – high water table levels, high risk of groundwater contamination.

TABLE 44 Cont'd.

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of – Topsoil	Suitability as Source of – Sand and Gravel	Suitability as Source of – Fill Material	Soil Features Affecting – Road Location	Soil Features Affecting – Foundation Construction	Soil Features Affecting – Agricultural Drainage	Soil Features Affecting – Water Retention Structures: Reservoir Area	Soil Features Affecting – Water Retention Structures: Embankment	Soil Limitations for use as Septic Tank Filter Field
Oc	Osborne, clay	Poor, clayey texture	Unsuited	Poor	Severe limitation. Poor stability at high moisture content; high shrink-swell potential, not suitable for bituminous subgrade.	Severe limitation. Poor drainage, high shrink-swell potential.	Surface drainage required.	Slight limitation. Impermeable clay, suitable for dugouts and lagoons.	Fair to poor compaction properties, medium to low strength, high compressibility, low permeability, and low susceptibility to piping.	Severe – very slow rate of effluent absorption, high water table conditions.
Pa	Plum Coulee, clay	Poor, clayey texture	Unsuited	Poor	Severe limitation. Poor stability at high moisture content; high shrink-swell potential.	Severe limitation. High shrink-swell potential, somewhat poorly drained.	Surface drainage required.	Moderate limitation. Variable subsurface materials, moderately slow permeability.	Poor to fair compaction properties, medium to low strength, high compressibility, low permeability, low susceptibility to piping.	Severe – slow effluent absorption, seasonal high water table conditions.
Pb	Plum Coulee, clay loam	Fair	Unsuited	Poor	Same as Pa	Same as Pa	Same as Pa	Same as Pa	Same as Pa	Same as Pa
Pc	Plum Coulee, loam	Good	Poor	Poor	Same as Pa	Same as Pa	Same as Pa	Same as Pa	Same as Pa	Same as Pa
Ra	Reinland, fine sandy loam	Good	Poor for sand	Good to fair	Slight limitation. Moderately well drained, suitable as bituminous subgrade, low shrink-swell potential.	Slight limitation. Good bearing strength, low shrink-swell potential.	Not required.	Severe limitation. Moderately rapid to rapid seepage rates.	Fair to good compaction properties, medium strength, low to medium compressibility, medium permeability, medium to high susceptibility to piping.	Slight – moderate to rapid effluent absorption.
Rb	Reinland, fine sandy loam, eroded phase	Fair	Poor for sand	Good to fair	Same as Ra	Same as Ra	Same as Ra	Same as Ra	Same as Ra	Same as Ra

TABLE 44 Cont'd.

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of — Topsoil	Sand and Gravel	Fill Material	Soil Features Affecting — Road Location	Foundation Construction	Agricultural Drainage	Water Retention Structures — Reservoir Area	Embankment	Soil Limitations for use as Septic Tank Filter Field
Rc	Reinland, fine sandy loam, over-blown phase	Poor	Poor for sand	Good to fair	Same as Ra	Same as Ra	Same as Ra	Same as Ra	Same as Ra	Same as Ra
Rd	Reinland, fine sandy loam, imperfectly drained phase	Good	Poor for sand	Good to fair	Moderate limitation. Somewhat poorly drained, may soften in wet weather.	Moderate limitation. Somewhat poorly drained, good bearing strength.	Surface drainage required.	Same as Ra, except water table is higher	Same as Ra	Moderate — moderate to rapid absorption of effluent, seasonal high water table poses some risk of groundwater contamination.
Re	Reinfeld, loam	Good	Unsuited	Poor	Severe limitation. Moderately high shrink-swell potential, unstable when wet, susceptible to frost heaving.	Severe limitation. Moderately high shrink-swell potential, poor bearing strength when wet.	Not required.	Moderate limitation. Moderately slow seepage rates.	Fair to good compaction properties, medium to low strength, medium compressibility, low permeability, moderately susceptible to piping.	Moderate — moderately rapid effluent absorption
Rg	Rignold, loam	Good	Unsuited	Poor	Severe limitation. Moderately high shrink-swell potential; unstable when wet, susceptible to frost heaving.	Severe limitation. Poor bearing strength when wet, somewhat poorly drained.	Surface drainage required.	Severe limitation. Variable material, surface layers have rapid seepage rates; sub-surface material slow to very slow seepage rates.	Surface 2 to 4 ft. same as Re; subsoils fair to poor compaction properties; medium to low strength, high compressibility; low permeability; low susceptibility to piping.	Severe — shallow permeable layer overlies impermeable clay; seasonal high water table conditions.

TABLE 44 Cont'd .

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of			Soil Features Affecting –					Soil Limitations for use as Septic Tank Filter Field
								Water Retention Structures		
		Topsoil	Sand and Gravel	Fill Material	Road Location	Foundation Construction	Agricultural Drainage	Reservoir Area	Embankment	
Rh	Roseisle, loam	Good	Unsuited	Poor	Severe limitation. Moderately high shrink-swell potential, unstable when wet, subject to frost heaving.	Moderate limitation. Good drainage, moderately high shrink-swell potential.	Not required.	Moderate limitation. Moderately slow seepage rates.	Fair to poor compaction properties, medium to low strength, medium compressibility, medium to low permeability, low to medium susceptibility to piping.	Slight – moderately rapid effluent absorption.
Rj	Rosebank fine sandy loam	Good	Unsuited	Poor	Severe limitation. High shrink-swell potential, unstable when wet.	Severe limitation. High shrink-swell potential, somewhat poorly drained.	Surface drainage required.	Severe limitation. Variable material, rapid surface permeability, slow permeability in subsurface layers.	Same as Rh	Severe – thin moderately permeable layers overlie impervious clay, high water table conditions.
Rm	Rosengart, loam	Good	Unsuited	Poor	Severe limitation. Moderately high shrink-swell potential, unstable when wet, subject to frost heaving.	Moderate limitation. Good drainage, moderately high shrink-swell potential.	Not required.	Severe limitation. Variable material, rapid to moderately rapid seepage rates in surface layers, slow in subsurface layers.	Fair to poor compaction properties, medium to low strength, medium compressibility, medium to low permeability, medium to high susceptibility to piping.	Slight – moderate to moderately rapid effluent absorption.
Rn	Rosengart, very fine sandy loam	Good	Unsuited	Poor	Same as Rm	Same as Rm	Same as Rm	Same as Rm	Same as Rm	Same as Rm
Rr	Red River, clay	Poor, clayey textures	Unsuited	Poor	Severe limitation. High shrink-swell potential, unstable when wet.	Severe limitation. High shrink-swell potential, somewhat poorly drained, low bearing strength when wet.	Surface drainage required.	Slight limitation. Impermeable clay.	Fair to poor compaction properties, medium to low strength, high compressibility, low permeability, low susceptibility to piping.	Severe – very slow effluent absorption, seasonal high water table conditions.

TABLE 44 Cont'd.

Engineering Interpretations of Soils in the Morden-Winkler Map Area

Map Symbol	Soil Series and Phase	Suitability as Source of – Topsoil	Sand and Gravel	Fill Material	Soil Features Affecting – Road Location	Foundation Construction	Agricultural Drainage	Water Retention Structures: Reservoir Area	Embankment	Soil Limitations for use as Septic Tank Filter Field
Wa	Winkler, clay	Poor, clayey textures	Unsuited	Poor	Severe limitation. High shrink-swell potential.	Severe limitation. High shrink-swell potential.	Not required.	Moderate limitation. Slowly permeable clay, variable subsurface material.	Same as Rr	Moderate – moderately slow to slow rate of effluent absorption.
Wb	Winkler, clay loam	Fair	Unsuited	Poor	Same as Wa	Same as Wa	Same as Wa	Same as Wa	Same as Wa	Same as Wa
Wc	Winkler, loam	Good	Unsuited	Poor	Same as Wa	Same as Wa	Same as Wa	Same as Wa	Same as Wa	Same as Wa

REFERENCES

1. Wickendon, R.T.D. 1945. Mesozoic Stratigraphy of the Eastern Plains, Manitoba and Saskatchewan. Geological Survey Memoir 239, Canada Dept. of Mines and Resources.
2. Bannatyne, B.B. 1970. The clays and shales of Manitoba. Dept. of Mines & Nat. Resources, Mines Branch, Publication 67-1.
3. Klassen, R.W., J.E. Wyer, B.B. Bannatyne. 1970. Bedrock Topography and Geology of Southern Manitoba. Geol. Survey of Canada Paper 70-51.
4. Charron, J.E. 1961. Groundwater Resources of Plum Coulee Area, Manitoba. Geol. Survey of Canada Paper No. 60-22.
5. Mayer-Oakes, William J. 1966. Life, Land and Water. Proc. of the 1966 Conf. on Environmental Studies of the Glacial Lake Agassiz Region.
6. Bannatyne, B.B., S.C. Zoltai and M.J. Tamplin. 1970. Annotated Bibliography of the Quaternary in Manitoba and the Adjacent Lake Agassiz Region (Including Archaeology of Manitoba). Geological Survey of Canada Paper 2/70. Manitoba Mines Branch, Dept. of Mines and Nat. Resources.
7. Rutulis, M. Personal Communication. Man. Dept. of Mines, Resources and Environmental Management, Water Resources Branch.

D. SOILS AND COMMUNITY DEVELOPMENT

The purpose of this section is to present soil and landscape information in a form that can be more readily understood by urban planners. Important agricultural service centers such as Morden and Winkler attract population and thus the demand for land suitable for housing, schools, shopping centers, parks, golf courses and other development is increasing. In selecting sites for such needs, suitability of soils must be considered to avoid costly errors and to prevent waste, abuse and loss for all time of the very valuable agricultural soils that are the heritage of this area.

The following paragraphs bring together, in a generalized descriptive form, an evaluation of the soils for such uses. For purposes of discussion, all soils in the area have been placed into 9 groups on the basis of common characteristics affecting their use for residential area development. These general evaluations consider sueh properties of soil as *texture*, a property affecting sewage absorption, rate of internal drainage, stability and bearing strength for foundations, and risk of frost heaving; *natural soil drainage*, a feature of soil and landscape affecting location of residences, roads, services and sewage disposal fields; *topography* or percentage slope, a feature of landscape that determines drainage and site location; *flooding hazard*, soils on flood plains of streams are subject to flooding and should not be used as sites for residences.

GROUP 1

Winkler-Jordan Group

Soil Series, Types and Phases included are:

		Acres	Percent of Area
Winkler	Wa	576	0.32
Winkler clay loam	Wb	1,005	0.56
Winkler loam	Wc	307	0.17
Jordan clay	Ja	678	0.39
Jordan clay loam	Jb	467	0.26
		3,033	1.70

This group of moderately well drained, fine textured (clayey) soils have developed on thick, stratified, clayey deposits. They occur on level to smooth, very gently sloping terrain, have slow to very slow permeability and high moisture retention capacity. Runoff is moderately slow. Groundwater levels during the runoff period in late spring are usually at depths below 5 feet.

These fertile agricultural soils only provide poor to fair sites for housing areas. These clayey soils with a high shrink-swell potential are also susceptible to frost action. Their trafficability depends entirely on moisture content, ranging from poor when saturated to good when dry.

These soils are not suitable for septic tank disposal fields because of their very slow rates of effluent absorption. On-site sewage systems would require the use of sand and gravel filters to ensure satisfactory service. Disposal fields would require large sized lots. Intensive development would necessitate use of communal collection systems and lagoons. Soils in this group are not well adapted to landscaping, establishment of lawns and gardens because of their plastic, sticky condition when wet and very hard, cloddy condition when dry.

GROUP 2

Deadhorse-Horndean-Red River Group

Soil Series, Types and Phases included are:

		Acres	Percent of Area
Blumengart clay	Bd	2,317	1.31
Deadhorse clay	Da	4,973	2.78
Deadhorse clay, saline phase	Db	1,408	0.79
Deadhorse clay loam	Dc	960	0.53
Deadhorse clay loam, saline phase	Dd	493	0.27
Deadhorse loam	De	211	0.11
Dugas clay	Df	5,005	2.82
Dugas clay, saline phase	Dg	102	0.05
Dugas clay loam	Dh	710	0.39
Dugas loam	Dk	218	0.12
Dugas loam, saline phase	Dl	45	0.02
Horndean clay	He	3,898	2.18
Horndean clay loam	Hf	3,930	2.20
Horndean loam	Hh	90	0.05
Morris clay	Mo	2,178	1.22
Plum Coulee clay	Pa	4,563	2.56
Plum Coulee clay loam	Pb	2,278	1.28
Plum Coulee loam	Pc	301	0.17
Red River clay	Rr	2,180	1.23
		35,860	21.39

These moderately well and imperfectly drained, fine textured (clayey) soils have developed on thick, massive to stratified lacustrine clay deposits. They occur on level terrain, have slow to very slow permeability and high moisture retention capacity. Runoff is very slow and ponding in the spring and after heavy summer rains is common. The groundwater will occur within 4 feet of the surface during the spring runoff period and very gradually recede to more than 6 or 8 feet by fall.

These fertile agricultural soils only provide fair to poor sites for building areas. Their trafficability depends entirely on water content ranging from good when dry, to poor when saturated. They are subject to large volume changes with changing moisture content and are also susceptible to frost heaving. Granular fill should be used as frost protection and to keep basement floors above the water table. Supplementary drainage must be provided to avoid water in basements and to avoid moisture content changes in the clayey sediments.

These soils are not suitable for septic tank fields becuase of their very slow permeability and high seasonal water table.

The clayey texture of these soils make them difficult to landscape including grass seeding and sodding for lawns and the planting of shrubs and trees. They are also difficult to work as garden soil because of their plastic, sticky condition when wet and very hard, cloddy condition when dry.

GROUP 3

Eigenhof-Rosengart Group

The Series, Types and Phases included are:

		Acres	Percent of Area
Eigenhof clay loam	Ec	550	0.30
Edenburg clay loam	Ed	1,660	0.89
Huddlestone loamy fine sand	Hk	90	0.05
Reinfeld loam	Re	1,837	1.03
Roseisle loam	Rh	282	0.16
Roseisle loam, moderately stony phase	Ri	422	0.24
Rosengart loam	Rm	1,043	0.59
Rosengart very fine sandy loam	Rn	3,443	1.93
		9,267	5.19

This group consists of moderately well and well drained, medium (loamy) textured soils developed on stratified, loamy sediments ranging in thickness from 5 feet to more than 30 feet. These sediments can range in texture from fine sand to silty clay. Very often massive impermeable clay underlies these sediments. They occur on level to smooth very gently sloping terrain. They generally do not have high groundwater levels during the spring runoff period and are not subject to ponding after heavy summer rains.

Soils in this group are excellent agricultural soils.

These soils provide good to fair sites for residences and other low buildings. They have good to fair bearing capacity and moderate shrink-swell potential. The clay loam textured Eigenhof and Edenburg soils contain more expansive clays than the lighter textured Reinfeld and Rosengart soils and are somewhat more susceptible to volume changes with changing moisture content. All of these soils are moderately susceptible to frost heaving.

This group of soils are suitable for sewage filter fields because of their good surface drainage, moderate permeability and freedom from high groundwater levels. However, percolation tests to determine their effluent absorption capacity would be desirable because of variable textures in the subsurface layers.

All of these soils are good for landscaping and gardening because of their fertility and good tilth.

GROUP 4

Hochfeld-Birkenhead Group

Soil Series, Types and Phases included are:

		Acres	Percent of Area
Birkenhead, loamy sand	Ba	1,165	0.65
Hochfeld fine sandy loam	Hb	12,819	7.20
Hochfeld eroded phase	Hc	102	0.06
Hochfeld overblown phase	Hd	134	0.07
		14,220	7.98

This group of well drained to rapidly drained coarse (sandy) textured soils have formed on relatively uniform, coarse (sandy) textured lacustrine and ancient beach deposits. The coarse textured Birkenhead soils occur in the form of low, narrow beach ridges that occur mainly in the western section of the map area. Hochfeld soils occupy smooth, very sloping terrain in the western section as well. This group is characterized by moderately rapid to rapid permeability and low moisture retention capacity. Depth of the uniform sandy deposits ranges from 4 feet to more than 30 feet and are usually underlain by massive impervious clay. Groundwater level is low but may rise to within 5 feet of the surface in the Hochfeld soils.

The droughty Birkenhead series is only fair agricultural soil, while the Hochfeld soil is good agricultural soil. All of these soils provide good sites for residences and other low buildings. These sandy soils have good bearing strength, low shrink-swell potential, low compressibility, little or no susceptibility to frost heaving and conduct water and sewage effluent rapidly. These soils, if disturbed, however, are susceptible to wind erosion.

They are suitable for septic tank filter fields, however, some risk of groundwater contamination may exist. Placement and protection of wells for domestic use may cause some problems.

While these soils may be somewhat droughty, they are nevertheless good soils for landscaping and gardening.

GROUP 5

Gnadenthal-Neuenberg-Neuhorst Group

The Series, Types and Phases included are:

		Acres	Percent of Area
Gnadenthal loam	Ga	21,571	12.13
Gnadenthal loam, saline phase	Gb	2,259	1.26
Gnadenthal clay loam	Gc	224	0.12
Gnadenthal loam	Gd	301	0.16
Glencross loam	Gg	493	0.28
Neuenberg very fine sandy loam	Na	11,699	6.57
Neuenberg, imperfectly drained phase	Nb	14,893	8.47
Neuenberg, loam	Nc	5,830	3.27
Neuhorst, clay loam	Ne	496	0.28
Neuhorst clay loam, saline phase	Nf	358	0.20
Neuhorst loam	Ng	57	0.03
Neuhorst clay	Nh	64	0.03
Newton Siding, clay loam	Nj	2,490	1.40
Newton Siding clay loam, saline phase	Nk	378	0.21
Newton Siding clay	Nl	122	0.07
Newton Siding clay, saline phase	Nm	90	0.05
		61,325	34.53

This group consists of imperfectly drained, medium (loamy) textured soils developed on stratified, medium (loamy) textured lacustrine sediments. All soils in this group occupy level to very gently sloping terrain. Like their better drained counterparts in the Eigenhof-Rosengart Group, the loamy stratified sediments of these soils range in thickness from 4 to 5 feet in the eastern section of the map area to more than 30 feet in the western section. These variable sediments will range from fine sand to silty clay. Massive impervious clay usually underlies these deposits. All of the soils in this group are affected by seasonal high groundwater table.

These are excellent agricultural soils, when adequate surface drainage is provided. They only provide fair sites for residences and other engineering installations because of moderate and slow runoff of meltwater and heavy summer precipitation. Bearing strength of these soils ranges from fair to poor depending on moisture content and content of high shrink-swell clay. The more clayey Newton Siding and Neuhorst soils are not as suitable as the loamy Gnadenthal, Glencross and Neuenberg soils. All of these soils are susceptible to frost heaving and moderate volume changes with changing moisture content. Granular fill should be used to keep foundations above the water table.

These soils have moderate to severe limitations for use as effluent absorption fields because of their moderate permeability and high seasonal groundwater level. There is also the probability that distribution lines will be below the water table for significant periods if placed below 3 or 4 feet below the surface in natural soil.

Except for the saline members, all soils in this group are very good for landscaping and gardening.

GROUP 6

Reinland Group

Series, Types and Phases included are:

		Acres	Percent of Area
Reinland fine sandy loam	Ra	20,948	11.77
Reinland, eroded phase	Rb	224	0.12
Reinland, overblown phase	Rc	499	0.28
Reinland, imperfectly drained phase	Rd	7,789	4.38
		29,460	16.55

This group of imperfectly drained, coarse (sandy) textured soils have formed on coarse (sandy) textured lacustrine deposits. Soils of this group are level to very gently sloping, have a seasonal high water table, have rapid to moderately rapid surface permeability when artificially drained and low moisture holding capacity. The depth of the sandy sediments varies from about 4 feet in the eastern section of the map area to more than 30 feet in the western section. These sediments are usually underlain by impervious lacustrine clay.

Soils in this group are only fair for building sites because of the seasonal high water table. They have rapid surface permeability, have a low shrink-swell potential and compact readily. The chief engineering problems of these soils are those of stability under saturated conditions. Excavations below the water table are likely to be difficult and costly. Other problems would include wet basements if adequate drainage were not provided, improper functioning of on-site sewage disposal systems and susceptibility to wind erosion if devoid of vegetation.

The soils in this group, particularly those that occur east of the Emerado Beach, are not suitable for use as septic tank fields because of seasonal high water table and risk of groundwater contamination. If used for this purpose, the distribution lines would be below water for significant periods, particularly in seasons of high rainfall.

These soils are good for landscaping. However, they would benefit from a top dressing of loamy soils before grass seeding or sodding and the planting of shrubs and trees.

GROUP 7

Graysville-Rosebank Group

Soil Series, Types and Phases included are:

		Acres	Percent of Area
Graysville loam	Gf	6,355	3.58
Hobson fine sandy loam	Hj	96	0.05
Rignold loam	Rg	3,866	2.17
Rosebank, fine sandy loam	Rj	365	0.20
		10,682	6.00

These somewhat poorly drained coarse to medium textured soils have developed on thin (usually less than 4 feet) sandy sediments overlying thick massive to stratified, impervious lacustrine clay. All soils in this group occupy level to smooth very gently sloping terrain, have seasonal high water tables, have moderately rapid to slow surface permeability and good moisture holding capacity. Depth of the permeable surface material varies from 6 inches to 4 feet and averages about two feet in thickness. The thick massive clay underlying these sediments is virtually impervious to water movement and is subject to large volume changes on wetting and drying.

These good agricultural soils provide poor sites for buildings and engineering works chiefly because of the occurrence of impermeable, high shrink-swell lacustrine clay at shallow depths. Internal drainage is restricted and ability to absorb sewage effluent is restricted to the more permeable shallow surface layers. Bearing strength of these soils is determined in large part by the presence of the clay. They are unsuitable for sewage disposal fields because of the impermeable nature of the underlying soil and seasonal high water table. If used for housing sites, granular fill should be used to keep foundations above the water table. If onsite sewage disposal fields are required, distribution lines should be placed in a suitably designed granular filter above the water table.

All soils in this group are good for landscaping and gardening.

GROUP 8

Chortitz-Elias Group

The Soil Series, Types and Phases included are:

		Acres	Percent of Area
Chortitz loam	Ca1	1,159	0.65
Chortitz loam, gently undulating phase	Ca2	9,312	5.33
Elias clay	Ef	480	0.26
		10,851	6.24

These somewhat poorly drained soils have developed on medium to fine (loamy to clayey) textured, recently deposited river alluvium. The sediments on which these soils have formed are stratified having layers that range in texture from fine sand to clay. They occupy the level and irregular gently sloping lands adjacent to streams and creeks that traverse the map area. They are subject to periodic risk of flooding. Runoff is variable ranging from slow in level bottom land areas to rapid in the sloping areas adjacent to creeks. Permeability ranges from slow to very slow. They are also affected by seasonal high groundwater levels in the spring.

Except for the irregular gently undulating phase of the Chortitz series, the soils in this group are very good agricultural soils. However, they provide poor sites for residences due to periodic risk of flooding, high seasonal water table and variable permeability characteristics. Bearing strength of these clayey soils is generally low. They are not suitable for septic field locations because of high water table and slow effluent absorption rates.

These soils are good for landscaping and only fair for gardening. The clayey Elias soils tend to lack desirable tilth because of texture and lack of organic matter.

GROUP 9

Osborne-Osterwick Group

Series, Types and Phases included are:

		Acres	Percent of Area
Blumenfeld, loam	Bb	486	0.27
Blumenort series	Bc	102	0.05
Osborne clay	Oc	1,152	0.65
Osterwick, fine sandy loam	Oa	358	0.26
		2,098	1.17

This group consists of poorly and very poorly drained soils that range in texture from sandy loam to clay. Members of this group occur in level to depressional positions in the landscape and have a high water table or are saturated over most of the year. Unless artificially drained, they are subject to water ponding after runoff and heavy summer rain storms. Bearing strength, permeability, shrink-swell potential and workability are all dependent upon clay content and degree of wetness. The sandy Osterwick soils, if artificially drained, are more permeable, more stable and less subject to volume change with changing moisture content than the other members of the group.

These soils are poor for building sites because of wetness. Susceptibility to frost heaving is high because of wetness. If used for building sites, granular fill material should be used to keep foundations above the water table. Additional surface drainage must be provided.

These soils are not suitable for sewage disposal fields because of high water table and very slow effluent absorption rates. Distribution lines will be below the water table for long periods.

Areas of Osborne soils are fair agricultural soils if adequate surface drainage is provided. They are not very suitable for landscaping and gardening because they become cloddy and very hard when dry. They are plastic and very sticky when wet.

E. SOILS AND RECREATION

This section is designed to help determine the suitability of the various soils for recreational development. In Table 45 each soil in the Morden-Winkler map area is rated according to its soil features for a specific recreational use*.

*Guidelines and criteria used in this interpretive classification were taken from the mimeographed report on the "Use of Soil Surveys in Planning for Recreation" by P. H. Montgomery and F. C. Edminster of the Soil Conservation Service, U.S.D.A.

A rating of *none to slight limitations* means the soil is very suitable for the particular use; a rating of *moderate* indicates that the soil has limitations in use but that it can be used under good management; a rating of *severe* means that the soil has limiting characteristics that make its use for recreation purposes unsound or very expensive. Use of soils with severe limitations would probably require major soil reclamation work.

These ratings do not include the many other aesthetic, economic and physical considerations that determine the potential of an area for recreation. Soils, however, dictate, to a large degree, the type and location of recreational facilities. For example, soils which are subject to frequent flooding have severe limitations for use as sites for camps and most recreational buildings. These soils would be put to better use as parks, green belt open space or as biking and nature study areas. Wet soils are not suitable for campsites, roads, playgrounds and picnic areas. Soils that pond and dry out slowly after heavy rains present problems where intensive use is contemplated. Droughty soils make it difficult to maintain grass cover for playing fields and golf courses. Depth to bedrock, stoniness, topography, natural fertility are additional basic soil qualities that determine the feasibility of many kinds of outdoor activities.

1. *Playgrounds*

These ratings apply to soils that are to be used intensively for organized games such as football, baseball, etc., and as such are subject to heavy foot traffic. It should be assumed that this interpretation applies to soils in their natural condition with minimal re-shaping of the site, drainage, etc., being undertaken. Presumably, re-seeding of the site would be expected.

The most suitable sites are those with nearly level surface, good drainage, freedom from rock outcrops, and a soil texture and consistence that provides a firm surface, but not slippery or sticky when wet. Soils that present good trafficability properties are desirable in that they resist compaction with consequent development of bare patches. The ability of the soil to grow and maintain a vegetative cover is an important item to consider in the final evaluation of a site. Soil suitability classes for this use are proposed by Montgomery and Edminster (1966)*.

2. *Camp Areas*

These areas are considered to be used intensively for tenting, parking camp trailers and accompanying activity for short-term outdoor living. It is assumed that the area will require little site preparation other than levelling for tent and parking areas.

The soils should possess good trafficability properties to withstand heavy foot traffic and limited vehicle traffic. The vegetative cover should be easily maintained and the soils present no erosion hazard so that the site can be subject to prolonged use without deteriorating in quality.

3. *Picnic Areas*

Picnic areas are considered to be extensively used as park-type picnic grounds. It is assumed that most vehicle traffic would be confined to access roads and parking areas.

Soil properties that affect foot trafficability, problems of dust, surface wetness during season of use and the ability to grow and maintain a vegetative cover are very important in evaluating sites for this use.

4. *Paths and Trails*

The limitations of soils for riding or hiking trails apply to areas as they occur naturally and where little soil will be moved to provide for this recreational use.

The soils must have good trafficability for both humans and riding horses, good stability, free of coarse fragments or rock outcrops and are not subject to erosion. Where relief is sloping paths and trails should tend to follow the contour to help prevent erosion. Variability in slope gradient may add to the interest of the path or trail, but slopes should not exceed 12 per cent for prolonged distances. Although the trail or path itself is generally devoid of vegetation, the vegetative potential of the soil is important in the areas through which the trail or path is developed.

*Ibid, page 270.

TABLE 45

Ratings and Limitations of Soils in the Morden-Winkler Area for Recreational Purposes

Soil Name, Type and Phase	Map Symbol	Playgrounds	Camp Areas	Picnic Areas	Paths and Trails	Soil Feature Affecting Use
Birkenhead, loamy sand	Ba	None to slight	None to slight	None to slight	None to slight	Rapidly drained, moderately coarse to coarse textured, somewhat droughty.
Blumenfeld, loam	Bb	Severe	Severe	Severe	Severe	Poorly drained, high seasonal water table.
Blumengart, clay	Bd	Severe	Severe	Severe	Severe	Somewhat poorly drained, clay textured surface layers, poor trafficability after rain.
Blumenort, clay	Be	Severe	Severe	Severe	Severe	Poorly to very poorly drained, very sticky and slippery when wet.
Chortitz, loam	Ca1	Moderate	Moderate	Moderate	Moderate	Risk of periodic flooding, somewhat sticky and slippery when wet.
Chortitz, loam gently undulating phase	Ca2	Moderate	Moderate	Moderate	Moderate	Risk of periodic flooding, somewhat sticky, topographic irregularity.
Deadhorse, clay	Da	Severe	Severe	Severe	Severe	Somewhat poorly drained clay, subject to ponding, very sticky and slippery when wet.
Deadhorse, clay, slightly saline phase	Db		Same as Deadhorse, clay			
Deadhorse, clay loam	Dc		Same as Deadhorse, clay			
Deadhorse, clay loam, slightly saline phase	Dd		Same as Deadhorse, clay			
Deadhorse, loam	De		Same as Deadhorse, clay			
Dugas, clay	Df	Severe	Severe	Severe	Severe	Somewhat poorly drained, subject to ponding, very sticky when wet.
Dugas, clay, slightly saline phase	Dg		Same as Dugas, clay			
Dugas, clay loam	Dh		Same as Dugas, clay			
Dugas, loam	Dk		Same as Dugas, clay			
Dugas, loam, slightly saline phase	Dl		Same as Dugas, clay			
Eigenhoff, clay loam	Ec	Moderate	Moderate	Moderate	None to slight	Moderate slow permeability, sticky when wet.
Edenburg, clay loam	Ed	Moderate	Moderate	Moderate	None to slight	Moderate slow permeability, sticky when wet.
Elias, clay	Ef	Severe	Severe	Severe	Moderate	Risk of periodic flooding, somewhat poorly drained, very sticky when wet.

TABLE 45 Cont'd.

Ratings and Limitations of Soils in the Morden-Winkler Area for Recreational Purposes

Soil Name, Type and Phase	Map Symbol	Playgrounds	Camp Area	Picnic Area	Paths and Trails	Soil Feature Affecting Use
Gnadenthal, loam	Ga	Moderate	Moderate	Moderate	Moderate	Somewhat poorly drained, somewhat sticky and unstable when wet, high seasonal water table, moderately slow permeability.
Gnadenthal, loam slightly saline phase	Gb		Same as Gnadenthal loam			
Gnadenthal, clay loam	Gc		Same as Gnadenthal loam			
Graysville, loam	Gf	Moderate	Moderate	Moderate	Moderate	Somewhat poorly drained, high seasonal water table, slow to very slow permeability.
Glencross, loam	Gg	Moderate	Moderate	Moderate	Moderate	Somewhat poorly drained, highly seasonal water table, slow to very slow permeability.
Hochfeld, fine sandy loam	Hb	None to slight	None to slight	None to slight	None to slight	Moderately well drained, no ponding, moderately rapid permeability.
Hochfeld, fine sandy loam, eroded phase	Hc	Moderate	Moderate	Moderate	Moderate	Subject to some blowing, somewhat droughty.
Hochfeld, fine sandy loam, overblown phase	Hd		Same as Hochfeld eroded phase			
Horndean, clay	He	Severe	Severe	Severe	Severe	Somewhat poorly drained, seasonal high water table, slow to very slow permeability, sticky and slippery when wet.
Horndean, clay loam	Hf		Same as Horndean clay			
Horndean, loam	Hh		Same as Horndean clay			
Hobson, fine sandy loam	Hj	None to slight	None to slight	None to slight	None to slight	Moderately well drained, permeability rapid in the surface layers to very slow in the subsoil.
Huddlestone, loamy fine sand, moderately to very stony	Hk	Moderate	Moderate	Moderate	Moderate	Well drained, stony.
Jordan, clay	Ja	Moderate	Moderate	Moderate	None to slight	Moderately well drained, slow permeability, sticky and slippery when wet.
Jordan, clay loam	Jb		Same as Jordan clay			
Morris, clay	Mo	Severe	Severe	Severe	Moderate	Somewhat poorly drained, very slow permeability, subject to ponding after heavy rains.

TABLE 45 Cont'd.

Ratings and Limitations of Soils in the Morden-Winkler Area for Recreational Purposes

Soil Name Type and Phase	Map Symbol	Playgrounds	Camp Area	Picnic Areas	Paths and Trails	Soil Feature Affecting Use
Neuenberg, very fine sandy loam	Na	Moderate	Moderate	Moderate	None to slight	Moderately well drained, moderately slow permeability.
Neuenberg, very fine sandy loam, imperfectly drained	Nb		Same as Neuenberg very fine sandy loam			Somewhat poorly drained, moderately slow permeability, high seasonal water table.
Neuenberg, loam	Nc		Same as Neuenberg very fine sandy loam			
Neuhorst, clay loam	Ne	Moderate	Moderate	Moderate	None to slight	Somewaht poorly drained, seasonal high water table, sticky and slippery when wet.
Neuhorst, clay loam slightly saline phase	Nf		Same as Neuhorst, clay loam			
Neuhorst, loam	Ng		Same as Neuhorst, clay loam			
Neuhorst, clay	Nh	Severe	Severe	Severe	Moderate	Same as Newton clay loam except for a more sticky surface layer when wet.
Newton Siding, clay loam	Nj	Moderate	Moderate	Moderate	Moderate	Somewhat poorly drained, seasonal high water table, sticky and slippery when wet.
Newton Siding, clay loam, slightly saline phase	Nk		Same as Newton Siding clay loam			
Newton Siding, clay	Nl	Severe	Severe	Severe	Moderate	The same as Newton Siding, except for surface layer which becomes more sticky when wet, subject to ponding.
Newton Siding, clay slightly saline phase	Nm		Same as Newton Siding clay			
Osterwick, fine sandy loam	Oa	Severe	Severe	Severe	Severe	Poorly to very poorly drained, high water table.
Osborne clay	Oc	Severe	Severe	Severe	Severe	Poorly to very poorly drained, subject to ponding, very slow permeability, very sticky when wet.
Plum Coulee, clay	Pa	Severe	Severe	Severe	Moderate	Somewhat poorly drained, slow to very slow permeability, sticky and slippery when wet.
Plum Coulee, clay loam	Pb	Severe	Severe	Severe	Moderate	Same as Plum Coulee clay.
Plum Coulee, loam	Pc	Moderate	Moderate	Moderate	Moderate	Same as Plum Coulee clay except for surface layer which is more permeable, less sticky and slippery when wet.

TABLE 45 Cont'd.

Ratings and Limitations of Soils in the Morden-Winkler Area for Recreational Purposes

Soil Name, Type and Phase	Map Symbol	Playgrounds	Camp Area	Picnic Area	Paths and Trails	Soil Feature Affecting Use
Reinland, fine sandy loam	Ra	None to slight	None to slight	None to slight	None to slight	Moderately well drained, Moderately rapid permeability.
Reinland, fine sandy loam, eroded phase	Rb		Same as Reinland fine sandy loam			
Reinland, fine sandy loam, overblown phase	Rc		Same as Reinland fine sandy loam			
Reinland, fine sandy loam, imperfectly drained phase	Rd	Moderate	Moderate	Moderate	None to slight	Somewhat poorly drained, seasonal high water table, moderately permeable.
Reinfeld, loam	Re	None to slight	None to slight	None to slight	None to slight	Moderately well drained, moderately slow permeability, somewhat sticky when wet.
Rignold, loam	Rg	Moderate	Moderate	Moderate	None to slight	Somewhat poorly drained, very slowly permeable, sticky, plastic subsoil.
Roseisle, loam	Rh	None to slight	None to slight	None to slight	None to slight	Moderately well to well drained, moderately permeable, slightly stony.
Roseisle, loam, moderately stony phase	Ri	Moderate	Moderate	Moderate	None to slight	Well drained, moderately to very stony.
Rosebank, fine sandy loam	Rj	Moderate	Moderate	Moderate	None to slight	Somewhat poorly drained, very slowly permeable, sticky, plastic subsoil.
Rosengart, loam	Rm	None to slight	None to slight	None to slight	None to slight	Well drained, moderately slow permeability, somewhat sticky when wet.
Rosengart, very fine sandy loam	Rn		Same as Rosengart loam			
Red River, clay	Rr	Severe	Severe	Severe	Moderate	Somewhat poorly drained, very slow permeability, very sticky and slippery when wet.
Winkler, clay	Wa	Moderate	Moderate	Moderate	None to slight	Moderately well drained, slow permeability, sticky and slippery when wet.
Winkler, clay loam	Wb	Moderate	Moderate	Moderate	None to slight	Same as Winkler clay except for somewhat less sticky surface layer.
Winkler, loam	Wc	Moderate	Moderate	Moderate	None to slight	Same as Winkler clay, except for somewhat less sticky surface layer.

F. THE ENGINEERING SIGNIFICANCE OF PEDOLOGY

Both Geological and Pedological Sciences identify soil deposits and soil profiles as they exist in the field. The nomenclature used in Surficial Geology defines the general characteristics of the sedimentary materials overlying the bedrock, that of Pedology further subdivides those sediments which constitute the parent material, primarily on the basis of chemical composition, and drainability.

Thus, the geological terms for a certain deposit may be "lacustrine silt", whereas the pedological designation for soil developed on this same deposit may recognize "Rosengart Series - lacustrine, medium textured, moderately calcareous, well drained", or "Gnadenthal Series - lacustrine, medium textured, moderately calcareous, imperfectly drained".

There is no conflict here between geology and pedology; rather, one science compliments the other and for the engineer concerned with the soil, pedology provides a very useful additional tool. To show how this can be effectively used, some of the fundamentals of the science as it can be applied to engineering are discussed below.

1. *The Pedological Concept*

Of greatest consequence to the engineer is the fact that the science of pedology identifies the "in-place" soils profile - the texture and composition of the materials in situ and their variation with depth.

The pedological concept is based on the premise that similar parent materials, if subjected to identical environmental conditions of climate, biological activity, topography and time, will develop identical soil profiles. (Some idea of the complex processes involved in soil formation is given earlier in this report in Chapter III, "Soil Morphology and Soil Genesis").

Now, instead of trying to separately evaluate each different factor in soil formation (i.e. the effect of the parent material and the separate effects of each of the environmental factors), the pedologist has fortunately recognized their combined effects and got around this problem. He identifies the "in-place" soils profile which exhibits the effects of each of these environmental factors and these are then automatically included within the classification system.

2. *The Soil Profile*

It is this end product of the pedologist - the identified soil profile - which can be used as a very effective tool in engineering soil exploration, planning and design.

The Soil Profile is a vertical section of the soil through all its horizons and extending into the parent material. The figure (Figure 7) shows in a simplified form how many variations may be recognized in soil profiles. The science has developed over the years and the figure shows the nomenclature currently in use in Canada.

Despite considerable developments in this field the three major or master soil horizons A, B and C can generally be recognized. The surface layer (A horizon) is the zone of maximum removal of material in solution or maximum in situ accumulation of organic matter; the next layer, the B horizon is a transitional zone just below the A. The next horizon is C or the relatively unaltered parent material.

The A and B horizons are termed the "soil solum" and they reflect the effects of the climate, topography and vegetation. By the action of percolating water and many other factors, materials can be removed from the A horizon and deposited in the B horizon. Such transfers may occur as chemical solutions or as mechanical movements of soil particles. For example, in humid environments where the B horizon may be characterized by its compactness, this may be primarily due to filling of the voids with the fine particles carried mechanically from the A horizon. Such filling increases the percentage of fine-grained materials in the B horizon, often with an increase in plasticity and a decrease of permeability. The activity of clay horizons may be affected and cementing agents may produce hardpan layers.

While knowledge concerning the A and B horizons can be of great value to the engineer, in certain specialized fields, e.g. estimating rainfall runoff in watersheds, pavement design, etc., it is the C horizon and materials below this that are of more general significance. It should be noted that the C horizon refers to the parent (mineral) soil which is comparatively unaffected by the pedogenic processes. Now, the following definitions may be confusing to engineers and should be noted carefully. The symbol C is used for the true parent material, the material in which the soil was formed. The next underlying material which is lithologically or geologically different from the C material is termed IIC and subsequent contrasting (geologically) materials are termed IIIC, IVC, etc. The IIC layer is therefore not parent material, but it may have significance on the solum development.

In certain profiles, however, the C layer may be missing and, therefore, the profile may exhibit an A and B horizon directly overlying a IIC (non parent material) layer. It should also be noted that all single horizons may be subdivided by consecutive Arabic numerals for purposes of sampling; for example, Ck1, Ck2, and so on. Unlike Roman numeral prefixes, these symbols do not indicate major lithological discontinuities but rather accommodate minor differences that may or may not be apparent in the horizon.

Bedrock is denoted by R and particular attention should be paid to the pedologist's definition of a rock — "too hard to break with the hands or to dig with a spade when moist and greater than 3 on the mohs scale". The boundary between the R layer and any overlying unconsolidated material is termed a "lithic contact".

If the bedrock (R) or the IIC horizons exist at depths considered to be beyond the zone of their influence on the soil, then the pedologist may not record these horizons. The total depth of soil materials considered to constitute the "Soil Profile" in the Pedological sense, is normally less than 80 inches (2M).

3. *Pedological Classification*

The primary purpose of soil classification as far as the engineer is concerned is to make the soil recognizeable. If then, correlations with engineering properties can be made, engineering performance on similar soils can be predicted.

Highway engineers, especially those trained in Michigan, U.S.A. or similar schools have found that the pedological system can be adapted to their needs. This is because in areas of gentle relief where there are few deep cuts and fills, a subgrade on a particular soil series will perform the same wherever the location because such important factors as rainfall, freeze-thaw, capillarity, etc. are all factors in the identification and classification. In no other system in use, are all these factors employed directly as part of the system. In this way, quite accurate pavement design and performance data can be exchanged between engineers in different parts of the country (and even in different countries).

Direct applications such as this are obviously not restricted to pavement design engineers – the hydrologic soil factors used in the U.S.A. in Soil Conservation Engineering and soil cement stabilization are other examples.

The Canadian System of Soil Classification is partly described in Chapter III, "Soils", and some coverage is given in the Glossary of this report. However, as the science of pedology has developed over the years, the system is now quite complex and for full treatment of the subject, the reader is referred to "The System of Soil Classification for Canada, Canada Agriculture, 1970".

The following brief resume should, meanwhile, permit the reader to better understand the pedological approach.

The Canadian System is hierarchial and in descending order, we have:

(i) Order
(ii) Great Group
(iii) Subgroup
(iv) Family
(v) Series
(vi) Type

("Soil Phase" is not a category in this system and it can be used to subdivide any of the other classes).

It is the complete "Soil Profile" which is identified and classified and as we go from Order down to Type, the required number of differentiating characteristics in the profile increases.

For example, in the Podzolic Order – No. 4, this requires that soil profile, among other things, must have a podzolic B horizon (i.e. accumulation products of iron Bf or organic Bh, etc.); a light colored A horizon (Ae eluviated) and the soil must be acid.

In the Humo-Ferric-Podzol, Great Group, further criteria must be satisfied, e.g. they must have developed under mixed or coniferous forest cover, a moist cool region, on coarse, non-calcareous materials, etc.

In the Gleyed Humo-Ferric Podzol Subgroup still further criteria must be met. The profile must exhibit "mottling due to periodic wetness in the Ae or B horizons".

There are eight Orders, 22 Great Groups and 189 Subgroups in the Canadian System and every soil profile in the country must be fitted into this grouping. Soil maps may be prepared at the level of the Order, the Great Group or the Subgroup, but these usually are generalizations on very small scales (1/1,000,000; 1/10,000,000, etc).

To most people not well acquainted with the science, this is as far as pedology goes. In fact, it is just the beginning. In practise, pedological classification might be said to begin at the Soil Series level.

The Soil Family and Soil Type are respectively above and below the Soil Series in the hierarchial system. However, the "Soil Type" is a division of the series, which is definitely based on the texture of the Plow Layer. "Soil Family" is a grouping of Soil Series units which also have certain definite similarities, some of which are not applicable to engineering problems. Thus, for engineering and planning purposes, and incidentally, also for pedological reasons, the "Soil Series" is the most significant unit.

4. *The Significance of the Soil Series*

The concept of the Soil Series has changed considerably since soils were first mapped and classified. With recent development, the soil series is now recognized as a three-dimensional body occupying a geographical position on the landscape.

As the science develops, revisions must necessarily occur in the definitions of what exactly a certain Soil Series represents and new Soil Series are being recognized in previously unsurveyed areas. There are at present over 3,000 recognized Soil Series, in Canada and the number increases as more work is being done. The reader is, therefore, warned that, when referring to a number of different soil maps, there may be significant differences in the terminology, depending on the dates of the surveys.

Perhaps the most difficult concept for the engineer (and planner) to fully appreciate, is the three-dimensional nature of the Soil Series. The vertical dimension and the depth limitations, have been discussed under the heading, Soil Profile. The horizontal aspects have been implied with reference to the soil series as "a landscape unit". The areal boundaries of the soil series on the landscape are determined, mostly by experience, to be ". . . wide enough to permit reasonable uniformity of all criteria over a practical-sized area". The three-dimensional body is thus defined and this is represented on the soils map by its areal boundaries.

For sampling purposes, however, the minimum size of a soil body representing a Soil Series had recently been defined as the "pedon". This varies, but may often be one metre^2 in areal extent. As a mapping unit, however - in contrast to a sampling unit – the "pedon" is too small to be represented on a map and the Soil Series Mapping Unit can therefore, be regarded as being composed of several contiguous pedons or polypedons. In fact, the polypedon corresponds really to a Soil Individual and there may be, on the landscape, one or several Soil Individuals, whose properties may be individually different but all may be within the range defined for a given Soil Series.

There are, thus, differences between taxonomic units, sampling units and mapping units. Each may be termed "Soil Series". The taxonomic unit really is the "soil profile" – it is two dimensional in that it can be represented as a "profile", as a vertical slice through all the soil layers at one point on the landscape. The "pedon" is the sampling unit which really is the "test pit" used to define the "in situ" characteristics of that profile, to obtain samples for laboratory testing and to adequately express these characteristics as an average for a specified volume, also at one point on the landscape. The third unit, the "mapping unit", is also three dimensional but instead of representing one point on the landscape, it actually represents that landscape. But it is also implied, to a greater or lesser extent, that everywhere in that demarcated landscape unit, the actual sequence of soil layers are the same as those exhibited in the test pit (or "pedon") and the same as those described and classified in the "Soil profile". The whole purpose of this of course, is to predict the behaviour or performance of these same demarcated landscape units when subjected to given sets of conditions. These conditions are primarily, (but not necessarily only), of an "agricultural" nature. The pedological concept was conceived initially, out of necessity, as a method by which soil and land performance could be predicted for its agricultural use, using deductive reasoning.

This predictive aspect of pedological mapping is rarely fully appreciated or understood by specialists in other disciplines because it is probably unique as far as earth sciences are in this respect. First of all a prediction is made that, within the boundaries shown as a mapping unit, the sequence of soil layers should be the same as those exhibited in the "pedon" and described under the heading "soil profile" – to a greater or lesser extent. In pedological terms, the latter phrase is partly covered by the term "accuracy" and partly covered by the description of the "mapping unit". Thus, the mapping unit may simply be a Soil Series and the "accuracy 85 percent".

This means that the pedologist has enough confidence to predict that if one digs a test pit anywhere in that area, there is an 85 percent chance of revealing a soil profile as given for that Soil Series. It also means that even if he knows the location of a soil deposit quite different from that series described, he will *not* show it on the published map if it is less than 15 percent of the area.

In mapping, therefore, the individual pedologist may set up broader more generalized mapping units. Undoubtedly in this sense the "accuracy" of the survey as far as the mapping unit itself is concerned, may be very high. For the same area using very detailed mapping units, much greater effort would be required to obtain the same mapping "accuracy".

However, the predictive nature of pedological mapping does not refer only to the quality of the mapping process in the field but also to the degree to which the interpretations concerning the use of the soil and the landscape are realistic. This can only be done if the scope of the mapping units are sufficiently detailed.

In addition to detailed mapping units, the interpretive specialist must also be knowledgeable of more than just the top few feet of soil. Movement of moisture through the soil is but one example. To really understand this a general knowledge of the hydrology and geohydrology of the whole area is required. The mapping and interpretive process thus becomes progressively more interdisciplinary. At the same time, as more detailed work is done, the greater becomes the potential use of the survey and other disciplines like engineering and land use planning can be catered for.

But at the same time, as more and more data is collected it becomes progressively more difficult to communicate this to others.

APPENDIX

GLOSSARY OF TERMS

Acidity (Alkalinity) – The degree of acidity of the soil expressed in pH values, or in words, as follows:

	pH (water)
medium acid	5.6 - 6.0
slightly acid	6.0 - 6.5
neutral	6.6 - 7.3
mildly alkaline	7.4 - 7.8
moderately alkaline	7.9 - 8.4
strongly alkaline	8.5 - 9.0

1/3 Atmosphere Moisture Percentage – The moisture percentage on dry weight basis of a soil sample that has been air dried, screened, saturated and subjected to a soil moisture tension of 345 cm of water through a permeable membrane for a period of 48 hours. It approximates the soil moisture retention capacity.

Calcareous – A soil containing calcium carbonate. It effervesces visibly when treated with hydrochloric acid.

Calcium Carbonate Equivalent – refers to percent of carbonates in the soil expressed on the basis of calcium carbonate. Terms used to express the carbonate content in soils include:

noncalcareous	less than 2%
weakly calcareous	2 - 5%
moderately calcareous	6 - 15%
strongly calcareous	16 - 25%
very strongly calcareous	26 - 40%
extremely calcareous	greater than 40%

Cation Exchange Capacity (CEC) – A measure of the total amount of exchangeable cations that can be held by the soil. It is expressed in terms of milli-equivalents per 100 gms. of soil.

Clay – As a soil separate, the mineral soil particles less than .002 mm in diameter. As a soil textural class, soil materials that contain 40 percent or more of clay, less than 45 percent sand and less than 40 percent silt.

Concretions – Hard grains, pellets or nodules from concentration of compounds in the soil that cement soil grains together.

Conductivity, electrical – The reciprocal of the resistance in ohms of a conductor which is one cm. long and has a cross sectional area of one $cm.^2$ It is expressed in reciprocal ohms. per centimeter or mhos. per centimeter (or millimhos. per centimeter) at 25°C. It is used to express the concentration of salt in irrigation water or soil extracts.

Consistence – The combination of properties of soil material that determine its resistance to crushing and its ability to be molded or changed in shape.

Consumptive use factor – is the ratio of consumptive use of water by a crop to evaporation and transpiration. An actively growing crop that completely covers the soil over a large area and that has an ample supply of readily available soil water has a consumptive use factor of 1.0.

Contour – An imaginary line connecting points of equal elevation on the land surface.

Erosion – The wearing away of the land surface by detachment and transport of soil and rock material through the action of moving water, wind or other geological process.

Friable – Soil aggregates that are soft and easily crushed between thumb and forefinger.

Granular Structure – Soil structure in which the individual grains are grouped into small block-like aggregates with indistinct or round edges (spheroidal).

Groundwater – Water that fills all the unblocked pores of underlying material below the water table, which is the upper limit of saturation.

Hydraulic Conductivity – refers to the effective flow velocity or discharge velocity in soil at unit hydraulic gradient. It is an approximation of the permeability of the soil and is expressed in inches per hour.

Hydrophyte – Plants growing in water or dependent upon being partially immersed in liquid at all times.

Mesophyte – plants requiring intermediate moisture conditions and are not very resistant to drought.

Risk – is synonymous with probability, but usually implies a hazard. It is expressed as a cumulative percentage and indicates the number of years out of 100 when the values given in the body of the table are exceeded.

Saline Soil – A saline soil is a soil containing soluble salts in such quantities that they interfere with growth of most crop plants. The electrical conductivity of the saturated extract is greater than 4 millimhos. per centimeter at 25°C. Approximate limits of salinity classes are:

nonsaline	0- 4 millimhos/cm.
slightly saline	4- 8 millimhos/cm.
moderately saline	8-15 millimhos/cm.
strongly saline	15 millimhos/cm.

Sand – Individual rock or mineral fragments in soils having diameters ranging from 0.05 mm. to 2.00 mm. The textural class name of any soil that contains 85 percent or more of sand and not more than 10 percent of clay.

Saturation Percentage – The moisture percentage of a saturated soil paste, expressed on an oven dry weight basis.

Silt – (a) Individual mineral particles of soil that range in diameter between 0.05 to .002 mm. (b) Soil of the textural class silt contains 80 percent silt and less than 12 percent clay.

Sodium-Adsorption Ratio (S.A.R.) – A ratio for soil extracts and irrigation waters used to express the relative activity of sodium ions in exchange reactions with soil.

$$S.A.R. = \frac{Na^+}{\sqrt{(Ca^{++} + Mg^{++})/2}}$$

where the ionic concentrations are expressed as milliequivalents per litre.

Storage Capacity – refers to the maximum amount of readily available water that can be stored within the rooting zone of a crop in a given soil.

SURFACE DEPOSITS

Alluvial Deposits – deposits formed by streams and may occur either as flood plain deposition or alluvial fans.

Beach Deposits – deposits of gravel and sands marking the beach lines of former glacial lakes or present lakes.

Lacustrine Deposits – clays, silts and sands laid down in glacial or former lakes.

Texture or Textural Class – Names given to soil material, and refers to the proportion of various soil separates, sand, silt and clay making up the soil mass. A soil texture diagram is presented showing the textural class names and the limits of each class. For convenience, the soil texture classes are grouped together into five classes.
These are as follows:

Coarse textured –
sands, loamy sand, loamy fine sand

Moderately coarse textured –
loamy very fine sand, sandy loam, fine sandy loam

Medium-textured –
very fine sandy loam, loam, silt loam, silt

Moderately fine-textured –
clay loam, silty clay loam, sandy clay loam

Fine-textured –
sandy clay, silty clay, clay

Till or Glacial Till – an unstratified, unconsolidated, heterogeneous mixture of clay, silt, sand, gravel and sometimes boulders deposited directly by ice with little transportation by water.

Xerophyte – plants capable of surviving extended periods of soil drought.

METHOD OF SOIL ANALYSIS

pH and Conductivity – determined on a saturated paste as outlined in "Saline and Alkali Soils", U.S.D.A. Handbook No. 60.

Carbon – Total and Inorganic – A wet combustion method adopted from Adams: J. Md. Eng. Chem. Anal. Ed. 6:227, 1934 and Waynick: J. Amer. Soc. Agron. 28:337-351, 1936.

Cation Exchange Capacity–as outlined in "Chemical Methods of Soil Analysis, Ottawa, 1958".

Calcium and Magnesium – Versenate Method with modification from Cheng, K. L. and Bray, R. H. Soil Sci. 72:449, 1951 and Lott, P. F. and Cheng, K. L. Chemist Analysis Vol. 46, No. 2, 1957.

Mechanical Analysis – Kilmer, V. J. and Alexander, L. T. Method of making Mechanical Analysis, Soil Sci. 68:15-24, 1949.

1/3 Atmosphere Moisture Retention–determined by method outlined in "Saline and Alkali Soils", Handbook No. 60, U.S.D.A.

Liquid Limit – as outlined in "Procedure for Testing Soils" by American Society for Testing Materials, April, 1958, A.S.T.M. Designation D 423-54T pp. 94-98.

Plastic Limit and Plasticity Index – as outlined in "Procedure for Testing Soils", 1958, ASTM Designation 0434-54T. pp. 99-101.

Shrinkage Limit and Shrinkage Ratio – as outlined in "Procedure for Testing Soils", April, 1958, ASTM Designation D 427-39, pp. 76-79.

Saturation Percentage and Hydraulic Conductivity – as outlined in "Saline and Alkali Soils", Handbook No. 60, U.S.D.A.

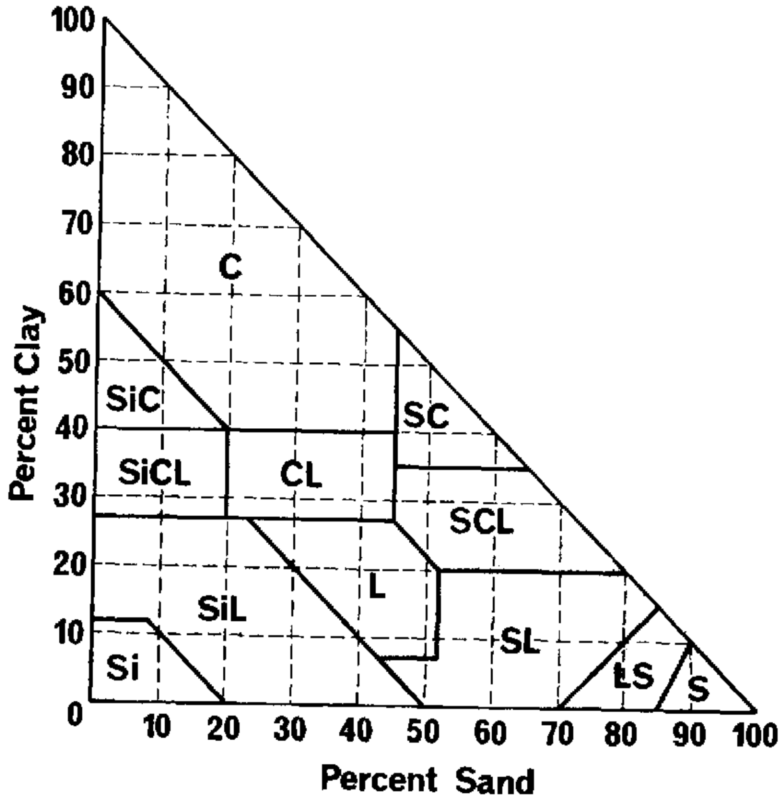
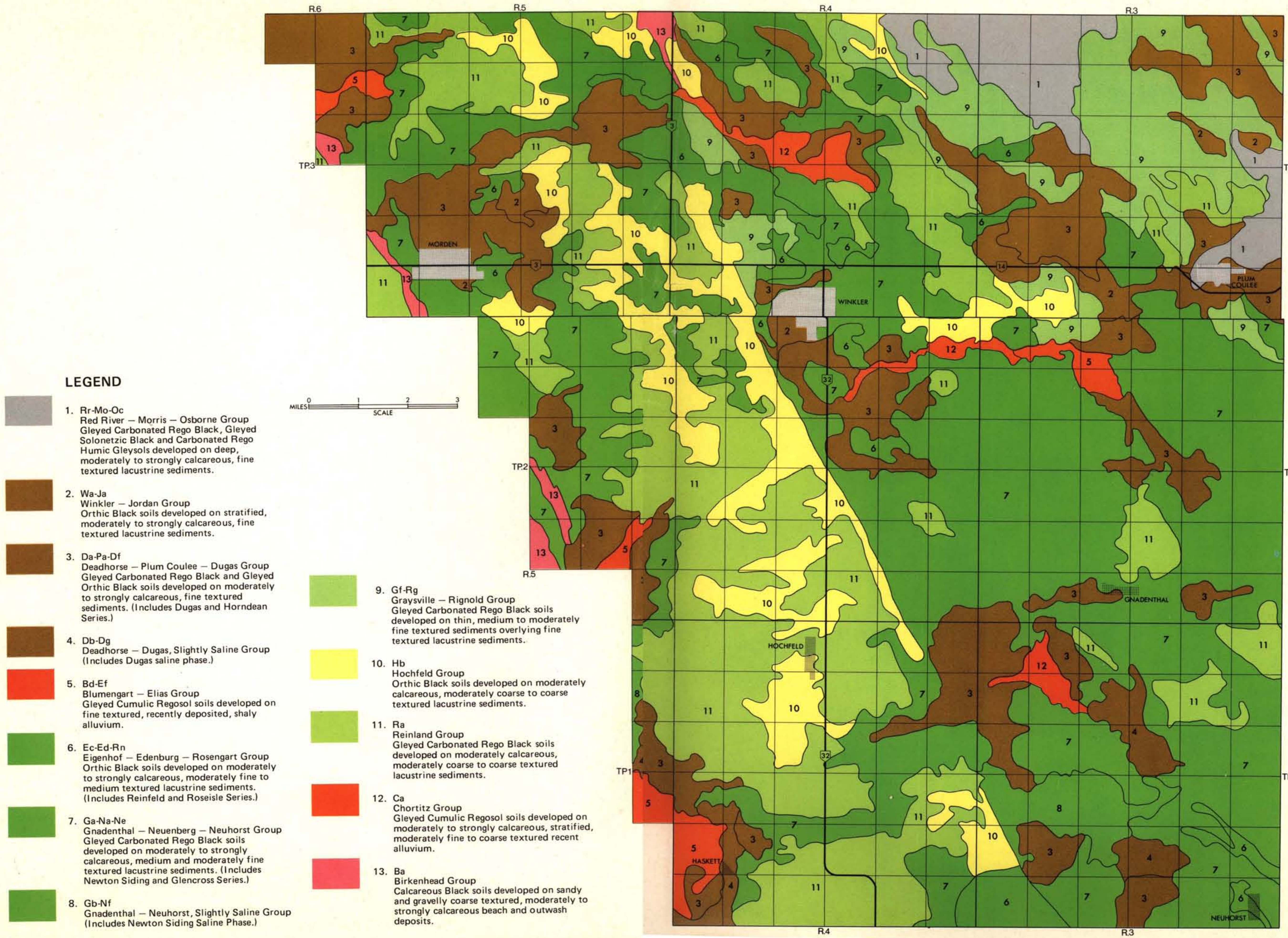


FIGURE 40

Soil textural classes. Percentages of clay and sand in the main textural classes of soils; the remainder of each class is silt.

FIGURE 41
GENERALIZED SOIL MAP OF THE MORDEN-WINKLER AREA



LEGEND

MORDEN-WINKLER AREA

MAP SYMBOL	SOIL NAME	SURFACE TEXTURE	PHASE	DRAINAGE	SUBGROUP
Ba	Birkenhead	Loamy sand		Well	Calcareous Black
Bb	Blumenfeld	Loam		Poor	Carbonated Rego Humic Gleysol
Bd	Blumengart	Clay		Imperfect	Gleyed Cumulic Regosol
Be	Blumenort	Clay		Poor	Carbonated Rego Humic Gleysol
Ca1	Chortitz	Loam		Imperfect	Gleyed Cumulic Regosol
Ca2	Chortitz	Loam	Gently undulating	Imperfect	Gleyed Cumulic Regosol
Da	Deadhorse	Clay		Imperfect	Gleyed Carbonated Rego Black
Db	Deadhorse	Clay	Slightly saline	Imperfect	Gleyed Carbonated Rego Black
Dc	Deadhorse	Clay loam		Imperfect	Gleyed Carbonated Rego Black
Dd	Deadhorse	Clay loam	Slightly saline	Imperfect	Gleyed Carbonated Rego Black
De	Deadhorse	Loam		Imperfect	Gleyed Carbonated Rego Black
Df	Dugas	Clay		Imperfect	Gleyed Carbonated Rego Black
Dg	Dugas	Clay	Slightly saline	Imperfect	Gleyed Carbonated Rego Black
Dh	Dugas	Clay loam		Imperfect	Gleyed Carbonated Rego Black
Dk	Dugas	Loam		Imperfect	Gleyed Carbonated Rego Black
Dl	Dugas	Loam	Slightly saline	Imperfect	Gleyed Carbonated Rego Black
Ec	Eigenhoff	Clay loam		Moderately well	Orthic Black
Ed	Edenburg	Clay loam		Moderately well	Orthic Black
Ef	Elias	Clay		Imperfect	Gleyed Cumulic Regosol
Ga	Gnadenthal	Loam		Imperfect	Gleyed Carbonated Rego Black
Gb	Gnadenthal	Loam	Slightly saline	Imperfect	Gleyed Carbonated Rego Black
Gc	Gnadenthal	Clay loam		Imperfect	Gleyed Carbonated Rego Black
Gd	Gnadenthal	Clay		Imperfect	Gleyed Carbonated Rego Black
Gf	Graysville	Loam		Imperfect	Gleyed Carbonated Rego Black
Gg	Glencross	Loam		Imperfect	Gleyed Carbonated Rego Black
Hb	Hochfeld	Fine sandy loam		Well	Orthic Black
Hc	Hochfeld	Fine sandy loam	Eroded	Well	Orthic Black
Hd	Hochfeld	Fine sandy loam	Overblown	Well	Orthic Black
He	Horndean	Clay		Moderately well	Gleyed Orthic Black
Hf	Horndean	Clay loam		Moderately well	Gleyed Orthic Black
Hh	Horndean	Loam		Moderately well	Gleyed Orthic Black
Hj	Hobson	Fine sandy loam		Well	Orthic Black
Hk	Huddlestone	Loamy fine sand	Moderately to very stony	Well	Orthic Black
Ja	Jordan	Clay		Moderately well	Orthic Black
Jb	Jordan	Clay loam		Moderately well	Orthic Black
Mo	Morris	Clay		Imperfect	Gleyed Solonetzic Black
Na	Neuenberg	Very fine sandy loam		Imperfect to moderately well	Gleyed Carbonated Rego Black
Nb	Neuenberg	Very fine sandy loam		Imperfect	Gleyed Carbonated Rego Black
Nc	Neuenberg	Loam		Imperfect to moderately well	Gleyed Carbonated Rego Black
Ne	Neuhorst	Clay loam		Imperfect	Gleyed Carbonated Rego Black
Nf	Neuhorst	Clay loam	Slightly saline	Imperfect	Gleyed Carbonated Rego Black
Ng	Neuhorst	Loam		Imperfect	Gleyed Carbonated Rego Black
Nh	Neuhorst	Clay		Imperfect	Gleyed Carbonated Rego Black
Nj	Newton Siding	Clay loam		Imperfect	Gleyed Carbonated Rego Black
Nk	Newton Siding	Clay loam	Slightly saline	Imperfect	Gleyed Carbonated Rego Black
Nl	Newton Siding	Clay		Imperfect	Gleyed Carbonated Rego Black
Nm	Newton Siding	Clay	Slightly saline	Imperfect	Gleyed Carbonated Rego Black
Oa	Osterwick	Fine sandy loam		Poor	Carbonated Rego Humic Gleysol
Oc	Osborne	Clay		Poor	Rego Humic Gleysol
Pa	Plum Coulee	Clay		Imperfect	Gleyed Orthic Black
Pb	Plum Coulee	Clay loam		Imperfect	Gleyed Orthic Black
Pc	Plum Coulee	Loam		Imperfect	Gleyed Orthic Black
Ra	Reinland	Fine sandy loam		Imperfect to moderately well	Gleyed Carbonated Rego Black
Rb	Reinland	Fine sandy loam	Eroded	Imperfect to moderately well	Gleyed Carbonated Rego Black
Rc	Reinland	Fine sandy loam	Overblown	Imperfect to moderately well	Gleyed Carbonated Rego Black
Rd	Reinland	Fine sandy loam		Imperfect	Gleyed Carbonated Rego Black
Re	Reinfeld	Loam		Moderately well	Orthic Black
Rg	Rignold	Loam		Imperfect	Gleyed Orthic Black
Rh	Roseisle	Loam		Well to moderately well	Orthic Black
Ri	Roseisle	Loam	Moderately to very stony	Well to moderately well	Orthic Black
Rj	Rosebank	Fine sandy loam		Imperfect	Gleyed Carbonated Rego Black
Rm	Rosengart	Loam		Moderately well	Orthic Black
Rn	Rosengart	Very fine sandy loam		Moderately well	Orthic Black
Rr	Red River	Clay		Imperfect	Gleyed Carbonated Rego Black
Wa	Winkler	Clay		Moderately well	Orthic Black
Wb	Winkler	Clay loam		Moderately well	Orthic Black
Wc	Winkler	Loam		Moderately well	Orthic Black

REFERENCE

Main highway 3
Secondary road 248
Pipeline ....
Railway ....
Bridge ....
Municipal boundary ....
River ....
Gravel pit .... GP

Rural Municipality of Stanley

United States of America

SCALE 1:20,000

Miles 0 ¼ ½ 1 Miles

Tp1 R3 Sec1-18

West of Principal Meridian

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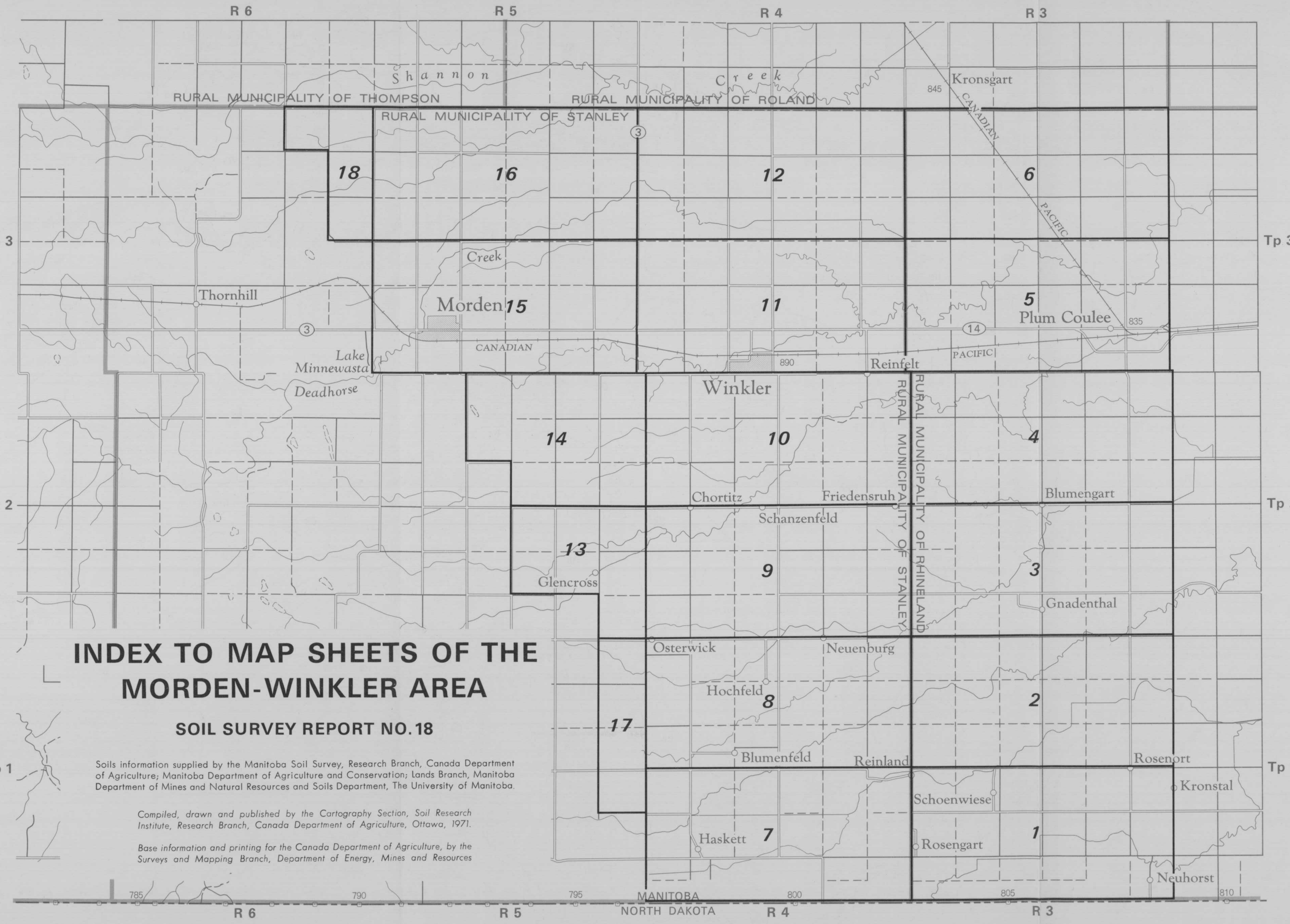

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Base information and printing for the Canada Department of Agriculture, by the Surveys and Mapping Branch, Department of Energy, Mines and Resources

SCALE 1:20,000

Miles 0 ¼ ½ 1 Miles

Tp1 R3 Sec 19-36

West of Principal Meridian

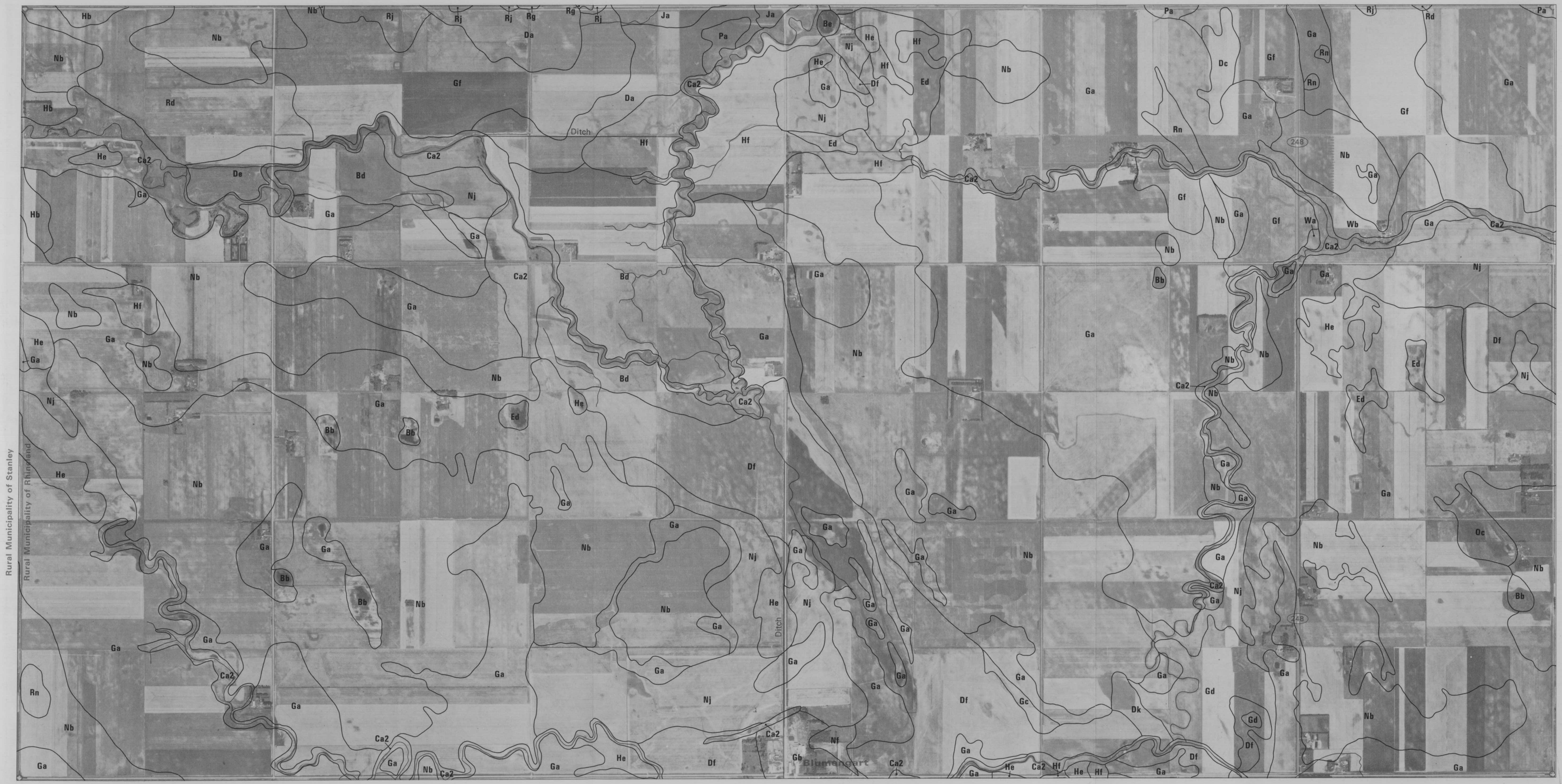
Rural Municipality of Stanley

SCALE 1:20,000

Miles 0 ¼ ½ 1 Miles

Tp2 R3 Sec1-18

West of Principal Meridian



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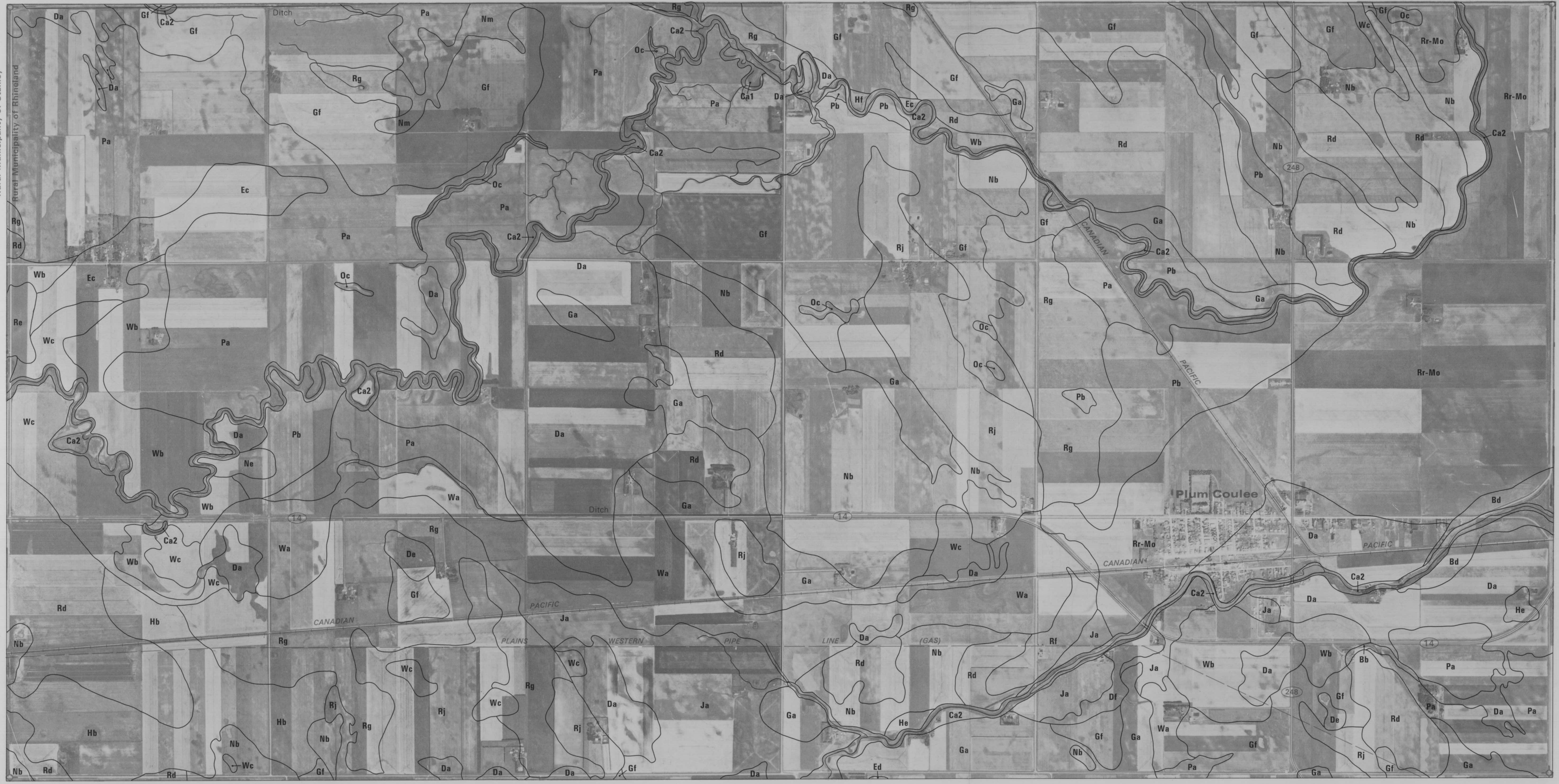

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West of Principal Meridian

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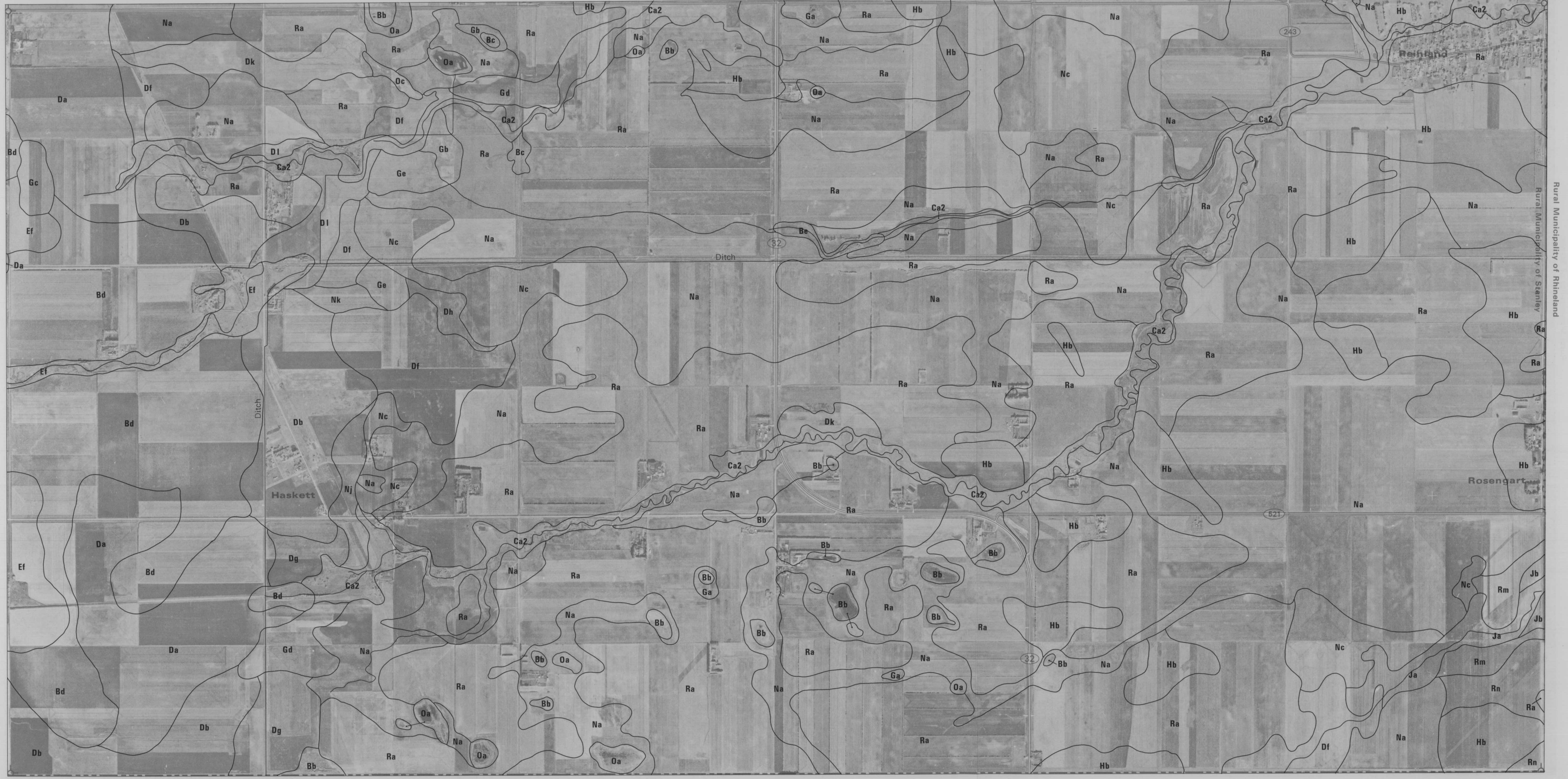
West of Principal Meridian



United States of America

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West of Principal Meridian

SCALE 1:20,000

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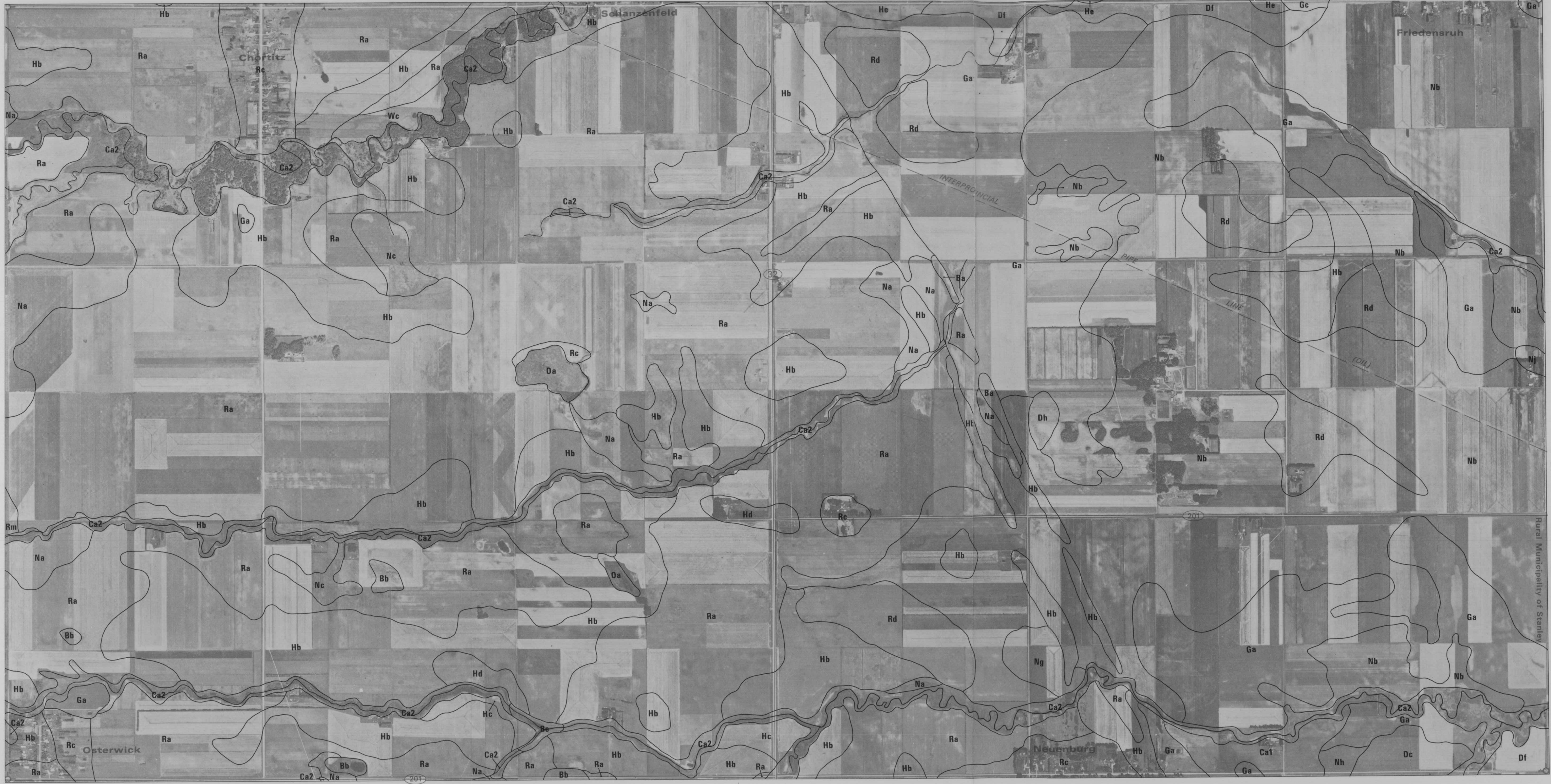
Tp1 R4 Sec19-36

West of Principal Meridian



Rural Municipality of Rhineland
Rural Municipality of Stanley

SCALE 1:20,000

Miles 0 ¼ ½ 1 Miles

Tp 2 R4 Sec 1-18

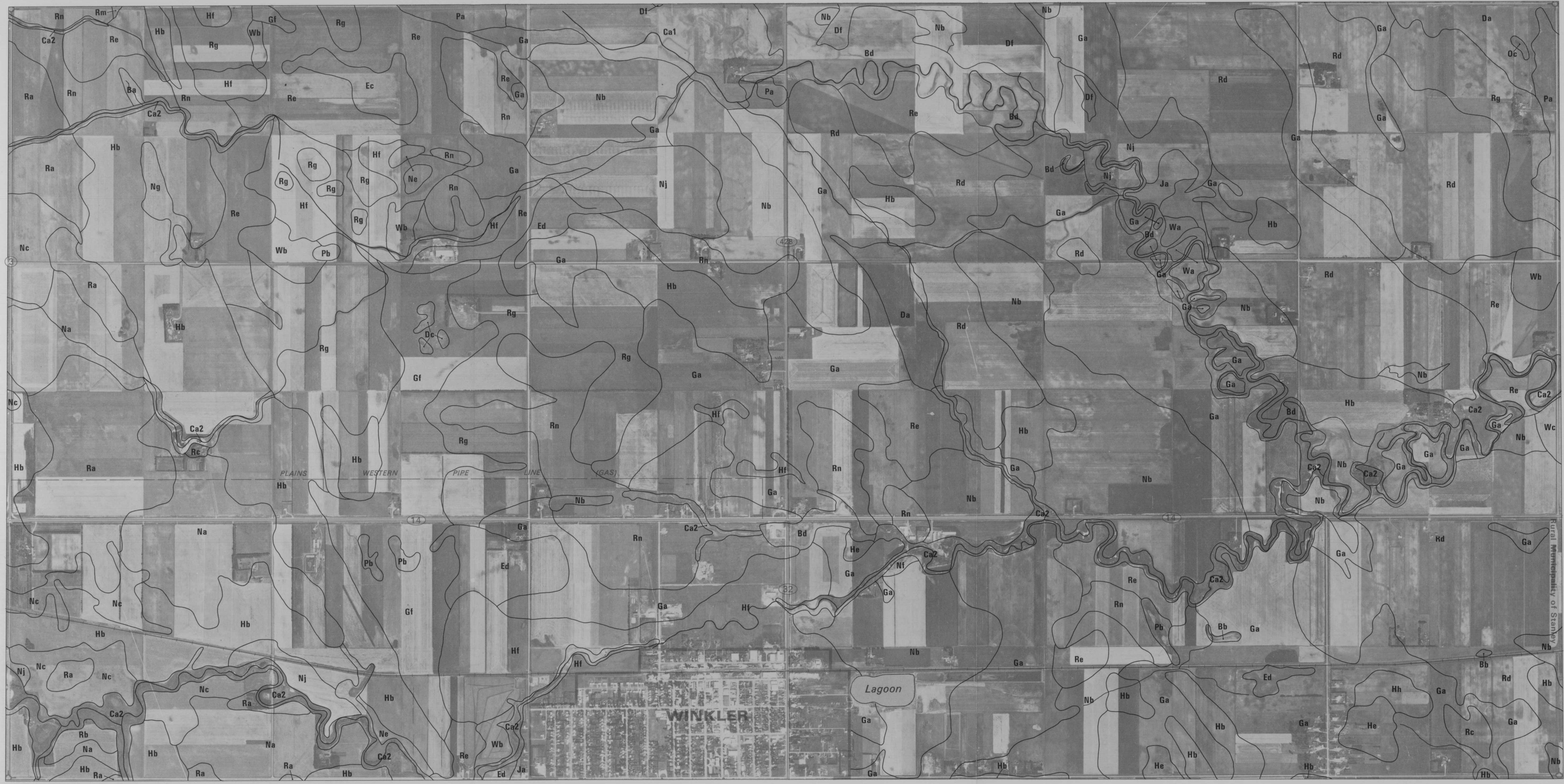
West of Principal Meridian

SCALE 1:20,000

Miles 0 ¼ ½ 1 Miles

Tp2 R4 Sec19-36

West of Principal Meridian



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Tp 3 R4 Sec 1-18

West of Principal Meridian

SCALE 1:20,000

Miles 0 ¼ ½ 1 Miles

Tp3 R4 Sec 19-36
West of Principal Meridian

SCALE 1:20,000

Miles 0 ¼ ½ 1 Miles

Rural Municipality of Stanley

Tp2 R5 Sec 1,10-15

West of Principal Meridian

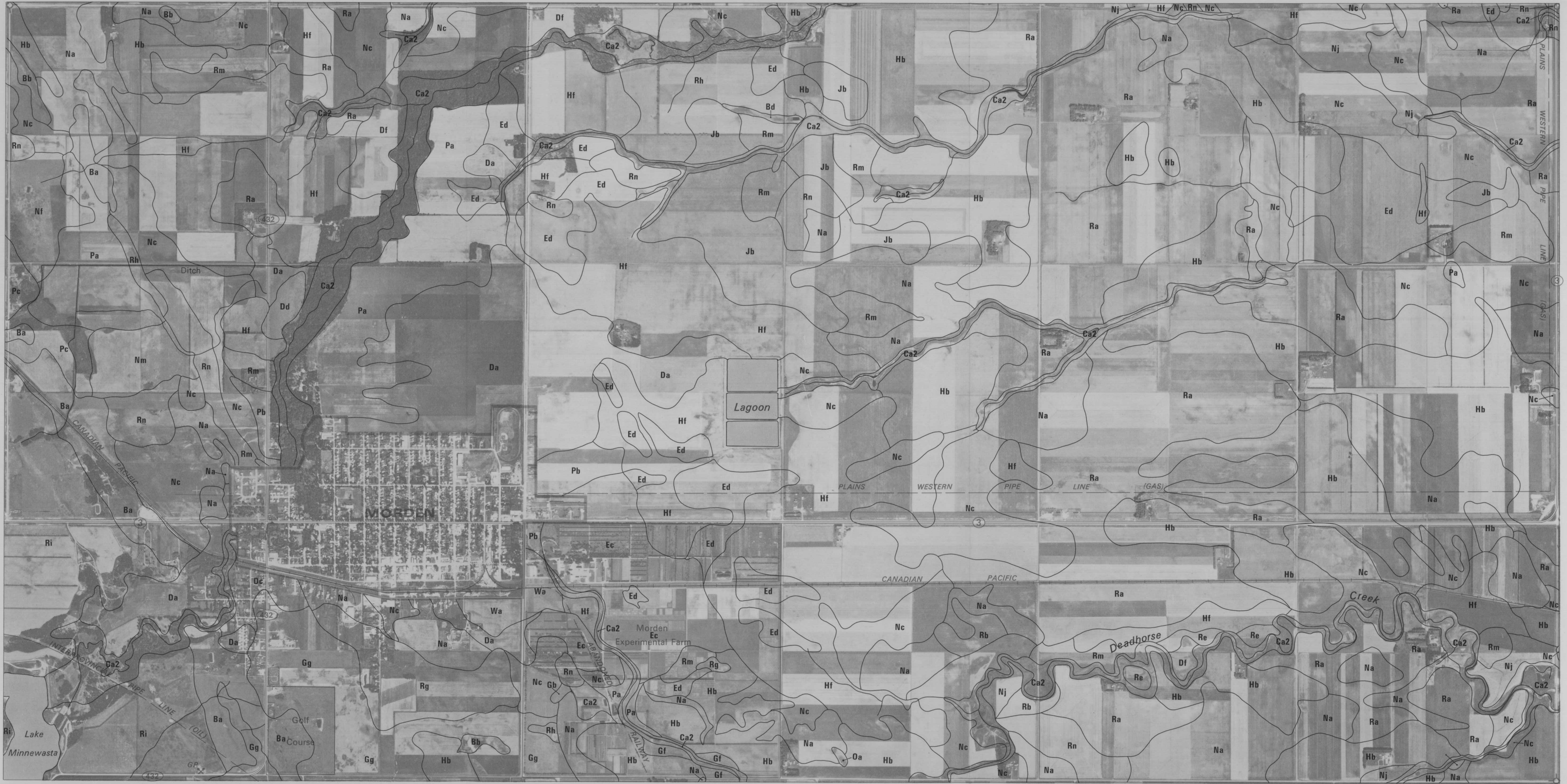
SCALE 1:20,000

Miles 0 ¼ ½ 1 Miles

Rural Municipality of Stanley

Tp2 R5 Sec 22-28, 33-36

West of Principal Meridian



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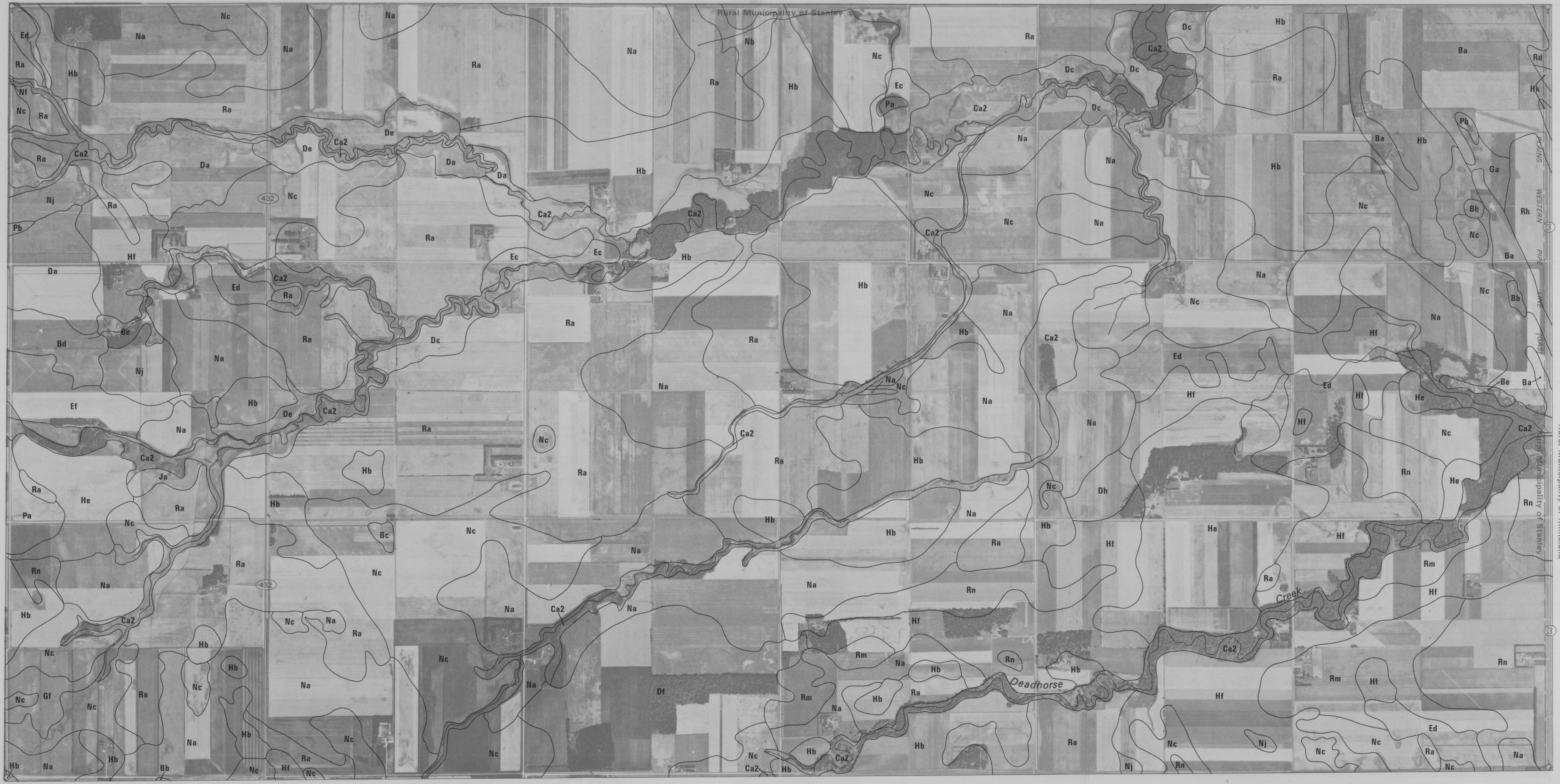
Rural Municipality of Stanley

Tp3 R5 Sec1-18

West of Principal Meridian

Rural Municipality of Thompson Rural Municipality of Roland



Rural Municipality of Rhineland

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Tp3 R5 Sec19-36

West of Principal Meridian

SCALE 1:20,000

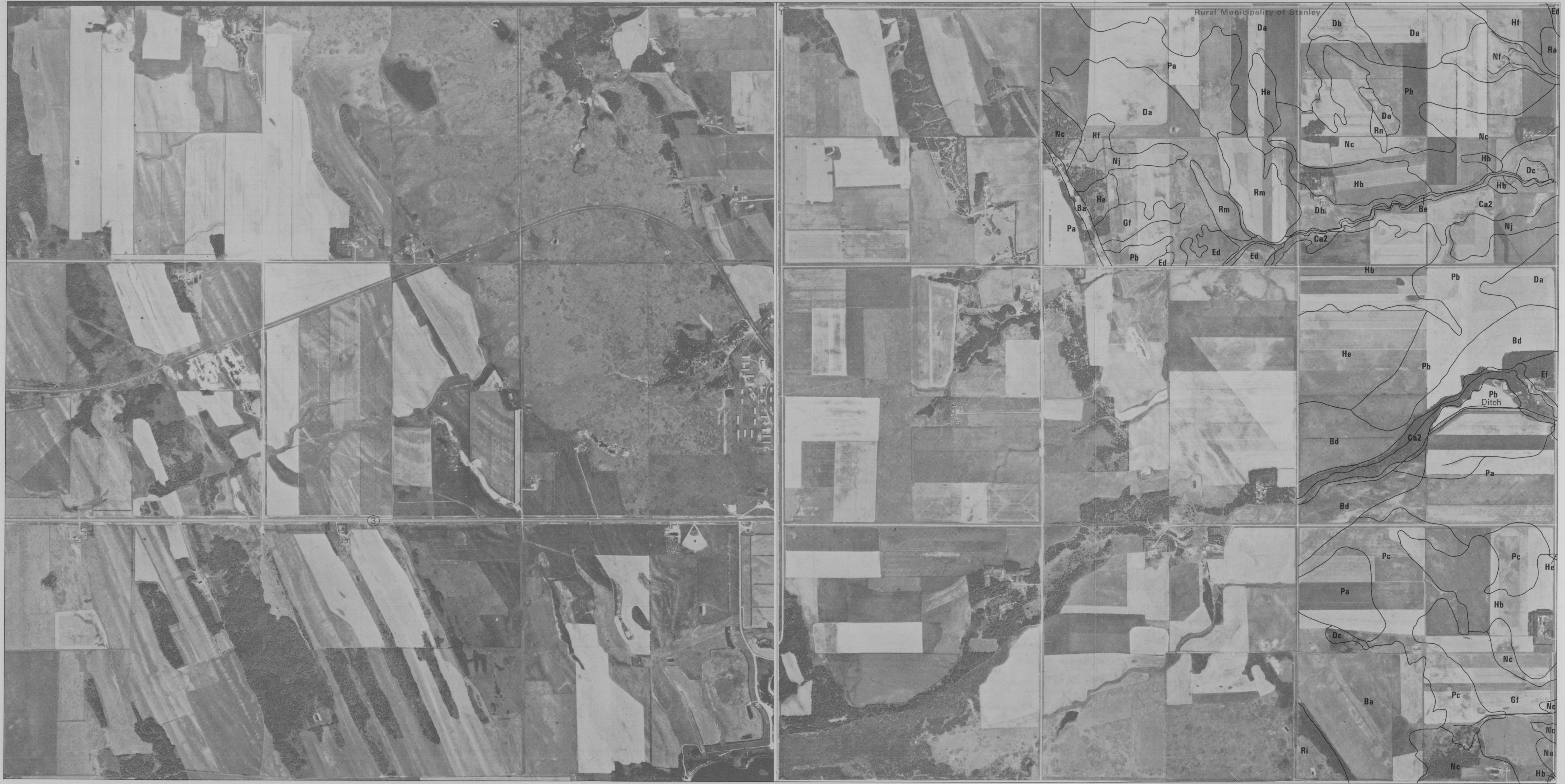
Miles 0 ¼ ½ 1 Miles

Rural Municipality of Stanley

Tp1 R5 Sec13,24,25,36

West of Principal Meridian

Rural Municipality of Thompson



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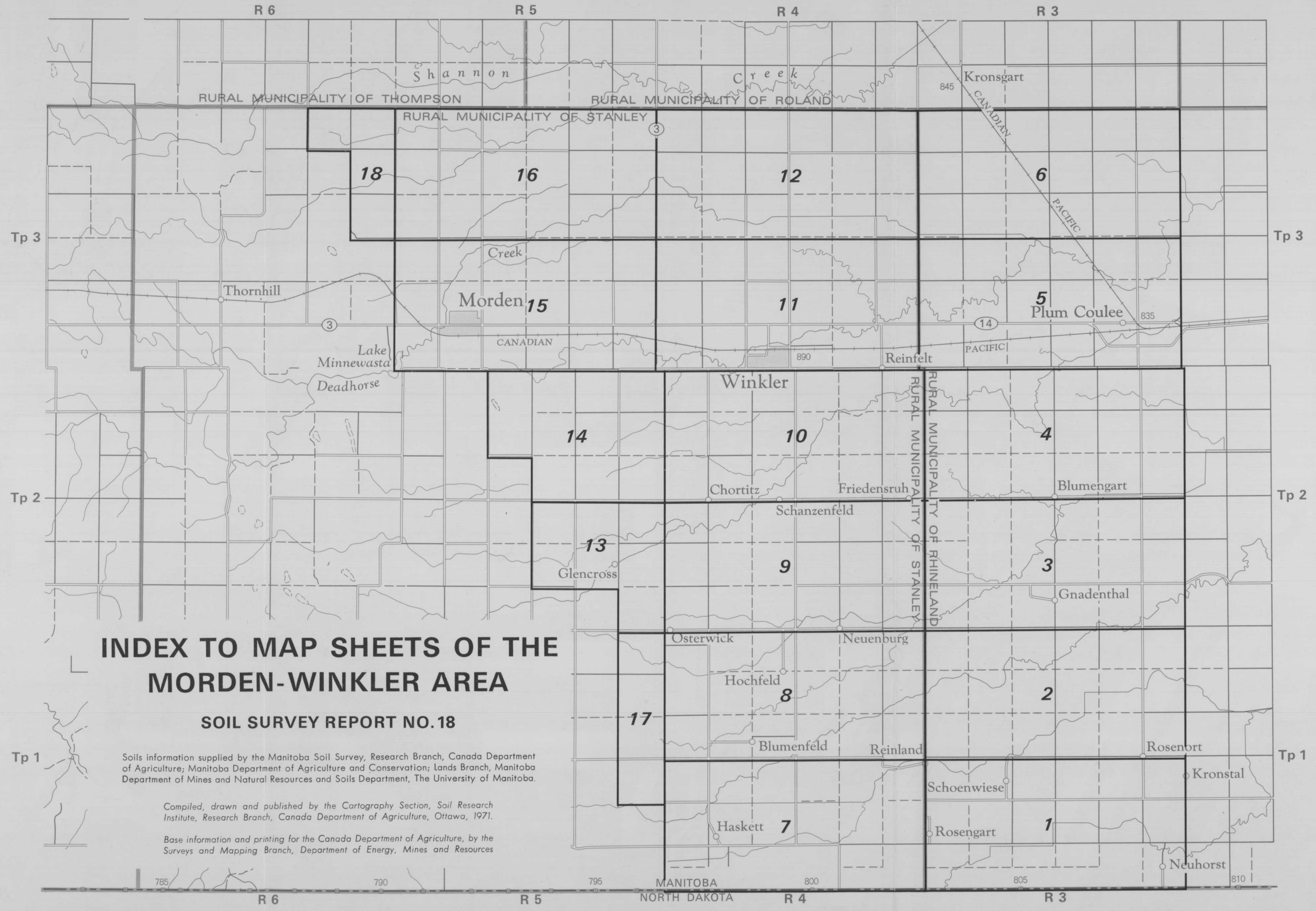
Tp 3 R6 Sec 24,25,35,36

West of Principal Meridian



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