Report

of the

Detailed Soil Survey

of the

MORDEN EXPERIMENTAL FARM

Morden, Manitoba

by

W. MICHALYNA

with

A Soil Map superimposed on a photo mosaic

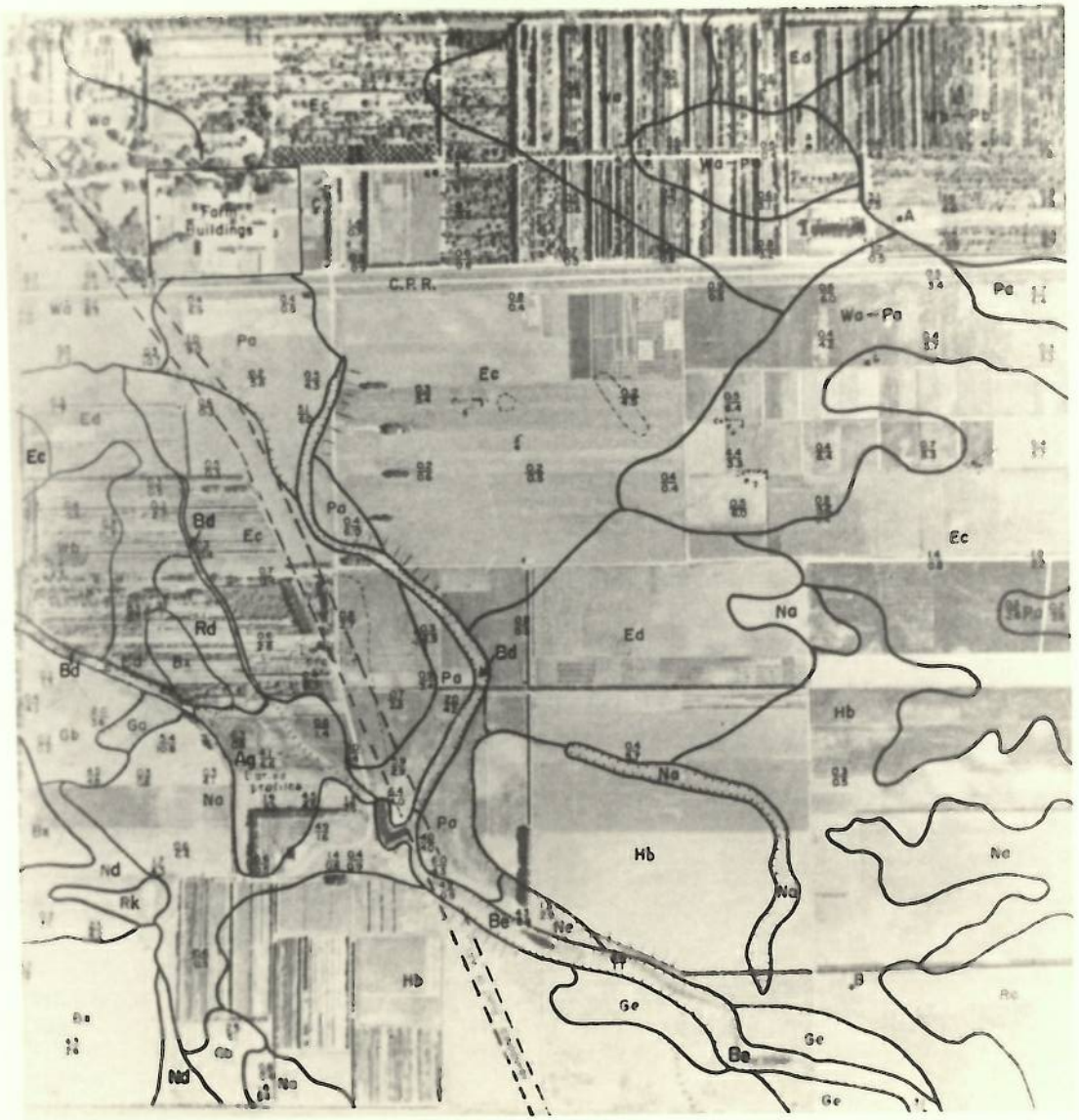
Manitoba Soil Survey

Canada Department of Agriculture, Manitoba Department of Agriculture,

and the University of Manitoba

Key to the Soils and Identification Legend

		Map Symbol
I.	Soils developed on till and modified	
	1) Moderately well drained	
	a) Blumenstein Complex	Bx
II.	Soils developed on moderately coarse textured beach, deltaic and alluvial deposits with less than 14 percent clay (LVFS, FSL and VFSL)	
	1) Moderately well drained	
	a) Hochfeld Series (Orthic Black)	Hb
	2) Imperfectly drained	
	a) Reinland Series (Gleyed Carbonated Rego Black)	Ra
	b) Reinland, overblown phase	Rc
	c) Reinland, till substrate phase	Rk
III.	Soils developed on medium textured and moderately coarse textured (14 to 20 percent clay) deltaic and alluvial deposits (FSL, VFSL, SCL, L and SiL)	
	1) Moderately well drained	
	a) Rosengart Series (Orthic Black)	Rd
	2) Imperfectly drained	
	a) Neuenberg Series (Gleyed Carbonated Rego Black)	Na
	b) Neuenberg, till substrate phase	Nd
	c) Gnadenthal Series (Gleyed Carbonated Rego Black)	Ga
	d) Gnadenthal, sand substrate phase	Gb
	e) Gnadenthal, clay substrate phase	Ge
IV.	Soils developed on moderately fine alluvial and lacustrine deposits (CL, SiCL and SCL)	
	1) Moderately well drained	
	a) Eigenhof Series (Orthic Black)	Ec
	b) Eigenhof, sandy substrate	Ed
	2) Imperfectly drained	
	a) Neuhorst Series (Gleyed Rego Black)	Ne
V.	Soils developed on fine textured alluvial and lacustrine deposits (SiC, SC and C)	
	1) Moderately well drained	
	a) Winkler Series (Orthic Black)	Wa
	b) Winkler, sandy substrate	Wb
	2) Imperfectly drained	
	a) Plum Coulee Series (Gleyed Black)	Pa
	b) Plum Coulee, sandy substrate	Pb
VI.	Soils developed on recent alluvium	
	1) Imperfectly drained soils developed on coarse to moderately fine textured sediments	
	a) Hespler Series (Gleyed Deorcic Regosol)	Hg
	2) Imperfectly drained soils developed on fine textured sediments	
	a) Blumengart Series (Gleyed Deorcic Regosol)	Bd
	3) Poorly drained soils developed on coarse to moderately fine textured sediments	
	a) Blumenort Series (Rego Humic Gleysol)	Bc


Farm Buildings
C.R.R.
Ed
Wa
Wa—Pa
Pa
Ec
Bd
Rd
Na
Hb
Ag
Nd
Rk
Be
Ge

ACKNOWLEDGEMENTS

The Detailed Soil Survey of the Morden Experimental Farm was conducted in 1961 by the Manitoba Soil Survey under the direction of Dr. W.A. Ehrlich and L.E. Pratt. The soils on the Farm were mapped by F.P. Leclaire and D.W. Anderson. The Deep Drilling and Physical analysis were conducted by the P.F.R.A. from Vauxhall under the direction of R.A. Milne. The groundwater data was compiled by F.H. Wilson.

Acknowledgement is also made to Dr. J.W. Morrison who encouraged this work and accommodated the Survey Staff with a laboratory during this period.

SUMMARY

The Morden Experimental Farm is located at the foot of the Manitoba Escarpment on a complex of surface deposits ranging from till and modified till to deltaic sands and alluvial sediments. The elevation on the Farm ranges from 987 feet A.S.L. in the south-west corner to 963 feet A.S.L. in the north-east corner with a general gradient of 15 feet per mile.

The mean annual temperature at Morden is 38°F.; the mean for the summer months May to September is above 50°F. The average length of the frost free period with a minimum of 33°F. is 120 days; the average duration of a killing frost free period with a minimum of 29°F. is 150 days.

Annual precipitation during the 43 year period 1919 to 1961 varied from 10.85 inches (in 1920) to 27.20 inches (1944) with an average of 19.57 inches. The probability of annual precipitation being greater than 18 inches is 2 years in every 3 years. The probability of precipitation during the growing season May to September being greater than 12 inches is 2 years in every 3 years. The 32-year mean evaporation for the month May to September is 22.57 inches.

The soils on the Farm are dominantly Orthic and Rego Blacks. Small areas of Gleyed Deorcic Regosol and Rego Humic Gleysol soil have been mapped. Twelve soil series were mapped on the Farm with the following phases: the till substrate phase, clay substrate phase, sand substrate phase, and overblown phase.

The moderately fine to fine textured soils are of moderate to high fertility. They have a high organic matter, total nitrogen, available phosphorus, and ammonium extractable potassium content. The moderately coarse textured soils are moderate to low in fertility. They have low organic matter, total nitrogen, and potassium content. They have moderately rapid permeability, low moisture retention and are generally non-saline, except in areas bordering the till deposits.

The groundwater on the north half of the Farm may be within four feet of the surface in spring and early summer. The water table on the sandy soils is usually much lower. Secondary water table peaks may occur throughout the summer or fall under conditions of above average rainfall.

Results of salinity measurements of soil extracts show that the salt content varies considerably throughout the Farm. The Hochfeld, Reinland, Neuenberg, Rosengart and Eigenhof Series are non-saline. Throughout the rest of the Farm, conductivities of soil extracts as high as 11.0 mmhos have been recorded. The results from soil tests and well water indicate that salts are present in the subsoils or the Farm, particularly in the north half and the south-west quarter.

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DETAILED SOIL SURVEY

of the

MORDEN EXPERIMENTAL FARM, MORDEN, MANITOBA

LOCATION AND AREA

The Morden Experimental Farm occupies the whole of Section 4, Township 3, Range 5, West of the Principle Meridian. It is located directly east of the Town of Morden on the No. 3 Highway.

PHYSICAL FEATURES

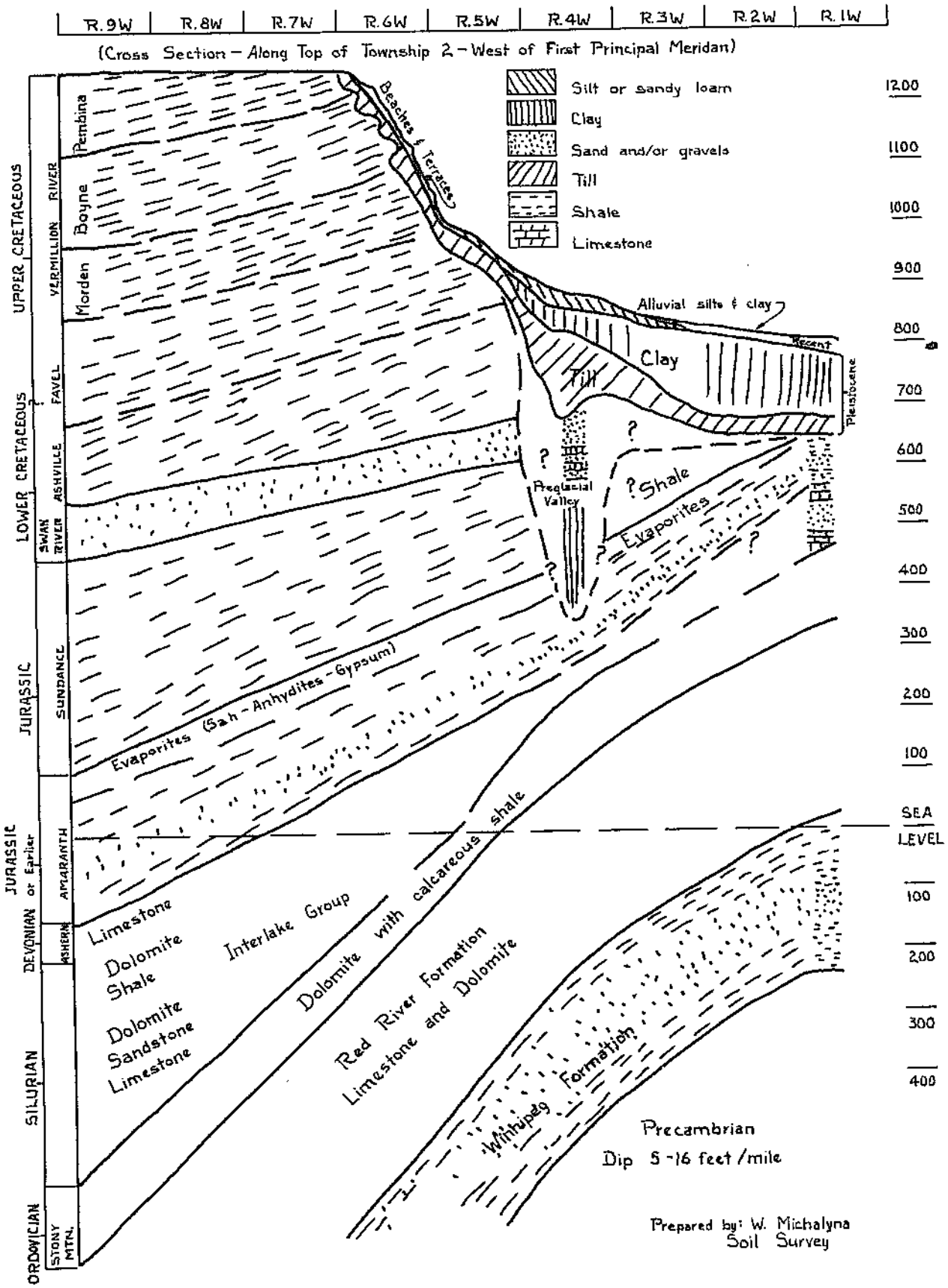
The Farm is located below the 1000 foot contour adjacent to the Manitoba Escarpment. The elevation ranges from 987 feet a.s.l. in the south-west corner to 963 feet a.s.l. in the north-east corner. The slope of the land on the Farm is toward the east with an average fall of 15 feet per mile. West of the Farm, the elevation varies from 1000 feet to more than 1500 feet above sea level in a distance of eight miles.

The surface deposits on which the soils are formed are variable due to the mode of deposition and subsequent erosion. The underlying cretaceous shales (probably of the Morden member of the Vermilion River Formation) were covered with till during the last glacial period. Fig. 1 shows a sketch of the Geological formations of South-Central Manitoba. With the retreat of the ice, the area was inundated with the waters of Lake Agassiz. (The upper level of Lake Agassiz was 1250 feet above sea level). As the water level receded, wave action along the shore line caused the formation of beaches and deltas and modified earlier deposits. The emerged surface was modified by the action of streams from the escarpment.

Where the streams emerged from the escarpment, alluvial plains were formed. The Dead Horse Creek has been one of the main streams contributing

FIGURE 1

SKETCH of GEOLOGICAL FORMATIONS of SOUTH-CENTRAL MANITOBA



to these alluvial deposits. The alluvial sediments are derived from three sources in the escarpment: (1) fine material eroded from the glacial till deposits, (2) clay eroded from shale beds of the Riding Mountain Formation, and (3) silt and clay from the shale beds and calcareous "chalk" of the Vermilion River Formations. The parent materials of the soils on the Farm may be, (1) glacial till and water worked till, (2) beach and deltaic deposits, (3) alluvial and lacustrine deposits.

CLIMATE

The climatic data for Morden as presented in this report have been summarized from "The Report on Land Classification of the Morden-Winkler Area by W.A. Ehrlich et al". (1)

(i) Temperature

The temperature data given in Table 1 shows an annual mean temperature of 38°F with a mean above 50°F for the summer months of May to September, inclusive. The average length of the frost free period (Table 2) with a minimum of 33°F is 120 days; the average duration of a killing frost free period with a minimum of 29°F is 150 days. The range of the frost free period (33°F) is from 92 to 145 days while the range of the killing frost free (29°F) is 93 to 167 days. The probabilities of frosts expressed in years or dates are shown in Table 3.

(ii) Precipitation

Annual precipitation (Table 4) during the 43 year period 1919 to 1961 has varied from 10.85 inches (1920) to 27.20 inches (1944) with an average of 19.5 inches. The probabilities of annual and summer precipitation are presented in Table 5 a, b.

(iii) Evaporation

The mean evaporation at Morden from 1930 to 1962 for the period May to September is 22.57 inches. The evaporation ranges from 16.38 inches (1936) to 38.27 inches (1961). Table 6 shows the Mean, Lowest, and Highest Evaporation for the months May to September during 1930 to 1962.

TABLE 1 - Temperature (°F) Data for 43 Year Period

(1919 to 1961 Inclusive) for Morden

	January	February	March	April	May	June	July	August	September	October	November	December	Yearly Mean
Average Mean	2.9	7.4	20.5	38.7	53.1	62.7	68.9	66.6	56.3	43.8	24.6	10.2	38.5
Average High	37.1	40.3	51.7	74.2	88.3	91.2	95.4	95.4	89.1	78.1	54.9	41.9	
Average Low	-28.4	-24.4	-13.6	10.9	23.4	35.6	44.0	40.5	27.7	15.8	-5.1	-22.6	
Extreme High	57 (1942)	54 (1932)	77 (1946)	90 (1947)	108 (1934)	105 (1933)	111 (1936)	105 (1949)	101 (1931)	89 (1920)	68 (1931) (1949)	64 (1939)	
Extreme Low	-42 (1943)	-35 (1925)	-28 (1939)	-7 (1932)	13 (1958)	28 (1924)	36 (1950)	33 (1950)	17 (1930)	0 (1919)	-23 (1958)	-36 (1933)	
% of years below 25°F	100	100	100	100	58.1	0	0	0	27.9	86.0	100	100	
% of years above 90°F	0	0	0	0	32.5	58.1	81.4	86.0	39.5	0	0	0	

TABLE 2 - Frost and Vegetative Period Data for Morden

(1919 to 1961 inclusive)

Mean date of last frost in spring (33°F)	May 20
Mean date of last "killing frost" in spring (29°F)	May 11
Range of last frosts in spring (33°F)	April 26 (1922) to June 20 (1940)
Range of last killing frosts in spring (29°F)	April 24 (1927) to June 7 (1924)
Mean date of first frost in fall (33°F)	September 21
Mean date of first killing frost in Fall (29°F)	September 28
Range of first frosts in fall (33°F)	September 2 (1946) to October 8 (1931)
Range of first killing frosts in fall (29°F)	September 9 (1924) to November 5 (1931)
Average duration of frost free period (Min. 33°F)	120 days
Average duration of killing frost free period (Min. 29°F)	150 days
Shortest frost free period (Min. 33°F)	92 days (1929)
Shortest killing frost free period (Min. 29°F)	93 days (1924)
Longest frost free period (Min. 33°F)	145 days (1944)
Longest killing frost free period (Min. 29°F)	167 days (1941)
Average duration of vegetative period*	142 days
Shortest vegetative period	116 days (1929)
Longest vegetative period	175 days (1952)

* Vegetative period is considered as the period during which the mean daily temperature is at or above 42°F.

Table 3 - Probabilities of Frost as Indicated

from the

1919 to 1961 Climatic Data

(3a) - Probability of Frost Free Seasons (Min. 33°F)

Equal to or Less than Indicated

	Shortest Period	1 in 10 yrs.	1 in 4 yrs.	1 in 3 yrs.	1 in 2 yrs.	2 in 3 yrs.	9 in 10 yrs.	Longest Period
Days	92	96	109	116	122	130	140	145

(3b) - Probability of Killing Frost Free Seasons (Min. 29°F)

Equal to or Less than Indicated

	Shortest Period	1 in 10 yrs.	1 in 4 yrs.	1 in 3 yrs.	1 in 2 yrs.	2 in 3 yrs.	3 in 4 yrs.	9 in 10 yrs.	Longest Period
Days	93	117	129	134	141	147	150	158	167

(4c) - Probability of Frost Occurring on or After the Date Indicated

	Earliest Frost	7 in 8 yrs.	3 in 4 yrs.	2 in 3 yrs.	1 in 2 yrs.	1 in 3 yrs.	1 in 4 yrs.	1 in 5 yrs.	Latest Frost
Spring	April 26	May 12	May 16	May 17	May 21	May 26	May 29	June 7	June 20
Fall	September 2	Sept 10	Sept 15	Sept 17	Sept 21	Sept 26	Sept 30	Oct. 2	Oct. 8

(3d) - Probability of a Killing Frost (Min. 29°F) Occurring on or After the Date Indicated

	Earliest Killing Frost	7 in 8 yrs.	3 in 4 yrs.	2 in 3 yrs.	1 in 2 yrs.	1 in 3 yrs.	1 in 4 yrs.	1 in 5 yrs.	Latest Killing Frost
Spring	April 24	May 2	May 4	May 7	May 11	May 14	May 16	May 24	June 7
Fall	September 9	Sept 19	Sept 23	Sept 25	Sept 28	Oct. 2	Oct. 5	Oct. 11	Nov. 5

TABLE 4

Mean Monthly Precipitation in Inches at Morden

and the Highest and Lowest Monthly Means

for the years 1919 to 1961 Inclusive.

Month	Mean Precipitation	% of Annual	Highest and Year	Lowest and Year
January	0.94	4.8	2.43 (1950)	0.02 (1919)
February	0.80	4.1	2.25 (1948)	0.00 (1919)
March	1.22	6.3	3.70 (1944)	0.05 (1939)
April	1.17	6.0	3.90 (1937)	0.01 (1952)
May	2.11	10.8	6.18 (1933)	0.31 (1951)
June	3.06	15.6	6.52 (1928)	0.44 (1929)
July	2.64	13.5	6.89 (1937)	0.33 (1925)
August	2.27	11.6	7.24 (1947)	0.33 (1961)
September	2.06	10.5	6.69 (1941)	0.02 (1938)
October	1.26	6.4	4.62 (1949)	0.19 (1928)
November	1.16	5.9	3.77 (1958)	0.02 (1939)
December	0.88	4.5	2.68 (1933)	0.03 (1954)
Total	19.57		27.20 (1944)	10.85 (1920)
Apr. to Sept.	13.31	68.0	19.76 (1937)	7.23 (1929)

TABLE 5

Precipitation Probabilities Based on the 43 Year Period 1919-1961.

(5a) Probability of Annual Precipitation (In Inches)

Being Equal to the Range Indicated

Inches	<12	12-15	15-18	18-21	21-24	24-27	>27
Years in 43	1	6	7	11	12	5	1

(5b) Probability of Precipitation (In Inches) of the Growing Season

(April to September Inclusive) Being Equal to the Range Indicated

Inches	<9	9-12	12-15	15-18	>18
Years in 43	5	9	16	12	1

TABLE 6

Mean, Lowest, and Highest Evaporation at Morden

for the Months May to September from 1930 to 1962.

Month	Evaporation in Inches		
	Mean	Lowest	Highest
May	3.88	2.05 (1936)	8.10 (1958)
June	4.39	2.87 (1945)	9.27 (1961)
July	5.20	3.24 (1956)	7.16 (1960)
August	5.27	3.03 (1951)	10.36 (1961)
September	3.78	2.23 (1951)	5.22 (1960)
May to September	22.57	16.38 (1930)	38.27 (1961)

SOILS

A. SOIL MAPPING

The Soils on the Morden Experimental Farm have been described by Ellis and Shafer (2) as members of the Morden Association, Altona Association, and the Blumenstein Complex.

In the summer of 1961, a detailed Soil Survey was conducted in the Morden-Winkler Area to assess the suitability of the soils for irrigation. During this time, a detailed Soil Survey was carried out on the Morden Experimental Farm.

In conducting this survey, traverses in a North-South direction were made every 400 feet apart throughout the section. Soil observations were conducted at intervals of 250 feet along each traverse. Samples for salinity measurements were taken where evidence of salts was noticed. In the orchard, samples for salinity measurements were taken at every observation site. Soil profiles of the different soil types were described and soil samples were taken for analysis.

B. SOIL CLASSIFICATION

The Canadian taxanomic classification of soils has six categories: Order, Great Group, Subgroup, Family, Series and Type (4). The first three categories are for the classification of kinds of profiles. The differentiating criteria are largely morphological features which reflect the effects of climate, vegetation, local moisture relations, and age of the parent material.

The basic unit in the field classification is the soil series. A soil series is a group of soils having horizons similar in differentiating characteristics and arrangement within the profile and developed from a particular kind of parent material. The similarity in profiles reflects similar soil forming factors. When soils having similar profile features vary

in some physical feature of significant agronomic importance, the soils are classified as types or phases. A soil type is a subdivision of a series based on the texture of the surface soil; a phase is a subdivision of a series based on any characteristic or combination of characteristics potentially significant to man's use. Example of phases used are saline phase, eroded phase, stony phase. When non-conforming substrate occurred within the four foot depth, the soil was identified with the series name and nature of the substrate, for example, Reinland, till substrate or Winkler clay, sandy substrate.

The key to the soils on the Morden Experimental Farm and identification legend is given in Table 7.

TABLE 7

Key to the Soils and Identification Legend

	Map Symbol
I. Soils developed on till and modified till.	
1) Moderately well drained	
a) Blumenstein Complex	Bx
II. Soils developed on moderately coarse textured beach, deltaic and alluvial deposits with less than 14 percent clay. (LVFS, FSL and VFSL.)	
1) Moderately well drained	
a) Hochfeld Series (Orthic Black)	Hb
2) Imperfectly drained	
a) Reinland Series (Gleyed Carbonated Rego Black)	Ra
b) Reinland, overblown phase	Rc
c) Reinland, till substrate phase	Rk
III. Soils developed on medium textured and moderately coarse textured (14 to 20 percent clay) deltaic and alluvial deposits. (FSL, VFSL, SCL, L and SiL.)	
1) Moderately well drained	
a) Rosengart Series (Orthic Black)	Rd
2) Imperfectly drained	
a) Neuenberg Series (Gleyed Carbonated Rego Black)	Na
b) Neuenberg, till substrate phase	Nd
c) Gnadenthal Series (Gleyed Carbonated Rego Black)	Ga
d) Gnadenthal, sand substrate phase	Gb
e) Gnadenthal, clay substrate phase	Ge
IV. Soils developed on moderately fine alluvial and lacustrine deposits (CL, SiCL and SCL).	
1) Moderately well drained	
a) Eigenhof Series (Orthic Black)	Ec

TABLE 7 - CONTINUED

	Map Symbol
b) Eigenhof, sandy substrate	Ed
2) Imperfectly drained	
a) Neuhorst Series (Gleyed Rego Black)	Ne
V. Soils developed on fine textured alluvial and lacustrine deposits (SiC, SC, C).	
1) Moderately well drained	
a) Winkler Series (Orthic Black)	Wa
b) Winkler, sandy substrate	Wb
2) Imperfectly drained	
a) Plum Coulee Series (Gleyed Black)	Pa
b) Plum Coulee, sandy substrate	Pb
VI. Soils developed recent alluvium.	
1) Imperfectly drained soils developed on coarse to moderately fine textured sediments.	
a) Hespler Series (Gleyed Deorcic Regosol)	Hg
2) Imperfectly drained soils developed on fine textured sediments.	
a) Blumengart Series (Gleyed Deorcic Regosol)	Bd
3) Poorly drained soils developed on coarse to moderately fine textured sediments.	
a) Blumenort Series (Rego Humic Gleysol)	Bc

C. SOILS DESCRIPTION

I. Soils Developed on Till and Modified Till

Blumenstein Complex

The Blumenstein Complex (Bx) are Orthic Black soils developed on a shallow mantle of moderately coarse textured deltaic deposits over moderately calcareous modified shaly till on glacial lake terrace. The profile consists

of a thin, very dark greyish brown Ah horizon and a dark greyish brown Bm horizon. The cultivated soils are generally non-calcareous at the surface and are quite stony. Gypsum may be present in the C horizon.

A description of a representative soil profile of the Blumenstein Complex is given below:

Ah 0 to 6 inches, very dark greyish brown (10YR3/2 dry) fine sandy loam; weak, fine granular; very friable when moist, soft when dry; neutral to mildly alkaline; non-calcareous; contains small limestone pebbles. Grades through a gradual, irregular boundary into:

Bm 6 to 13 inches, dark greyish brown (10YR4/2 dry) very fine sandy loam; weak, fine granular; very friable when moist, soft when dry; mildly alkaline; non to weakly calcareous; contains shale flakes and small limestone pebbles. Grades through a diffuse, irregular boundary into:

Ck_1 13 to 26 inches, very pale brown (10YR7/3 dry) gravelly and shaly very fine sandy loam; medium, fine granular; very friable when moist, soft when dry; moderately alkaline; moderately calcareous; contains shale flakes and pockets of lime. Grades through a diffuse, irregular boundary into;

Ck_2 26 inches +, pale brown (10YR6/3 dry) loam till; weak, fine granular; friable when moist, slightly hard when dry; moderately alkaline and moderately to strongly calcareous;

Fine sandy loam is the dominant soil type. The shale content in the till ranges from a few flakes (observable in the profile) to a higher proportion. Gypsum accumulations are frequently encountered in the C horizon. Salinity tests indicate that some local areas are saline at the surface, however, the highest concentration of soluble salts occur at a depth of 3 feet.

TABLE 8

Analysis of Blumenstein Fine Sandy Loam

Horizon	Depth (In.)	% Sand	% Silt	% Clay	Moisture Retention 1/3 atmos	pH	Cond mmhos/cm	% $CaCO_3$ equiv	% Org C	% Total N	Avail P PPM	Exch Cap me/100 gm	Exchangeable Cations me/100 gm Soil Ca	Mg	K	Na
Ah	0- 6	76.30	13.30	9.80	13.35	7.21	0.19	0.09	2.02	0.17	4.20	17.25	12.70	3.60	0.21	0.46
Bm	6-13	82.61	6.57	10.82	9.56	7.32	4.39	0.27	0.59	.06	1.27	10.33	*0.55	*0.61	---	*0.26
Ck_1	13-26	75.98	10.05	13.97	17.97	7.96		17.72	0.71	.07						
Ck_2	26+	61.19	20.54	18.27	19.32	7.70		16.44	0.44	.04			*0.77	*1.05	---	*0.50

* Soluble Salts - m.e./100 gm. Soil

II. Soils Developed on Moderately Coarse Textured Beach, Deltaic and Alluvial Deposits with Less than 14 Percent Clay.

Hochfeld Series

The Hochfeld Series is a moderately well drained Orthic Black soil developed on moderately calcareous, moderately coarse textured beach, deltaic and alluvial deposits. These deposits are sometimes stratified and are underlain by lacustrine clay (commonly within 15 feet of the surface) or till (on SW corner of the farm). The profile consists of a thick dark grey Ah horizon, 5 to 12 inches thick, with a dark greyish brown Bm horizon.

A description of a representative soil profile of the Hochfeld light very fine sandy loam (clay content less than 14 percent) is given below:

Ap 0 to 5 inches, dark grey (10YR4/1 dry) light very fine sandy loam; weak, fine granular; very friable when moist, soft when dry; neutral to slightly acid. Grades through an abrupt, smooth boundary into;

Ah 5 to 10 inches, dark grey (10YR4/1 dry) light very fine sandy loam; weak, fine granular; very friable when moist, soft when dry; mildly alkaline to slightly acid. Grades through a clear, wavy boundary into;

Bm 10 to 20 inches, greyish brown (10YR5/2 dry) loamy very fine sand; weak, fine granular; very friable when moist, soft when dry; neutral; non-calcareous. Grades through a gradual, wavy boundary into;

Ck_1 20 to 34 inches, light brownish grey (10YR6/2 dry)) loamy fine sand; single grained; very friable when moist, loose when dry; moderately alkaline; weakly calcareous; weakly iron stained. Grades through a gradual irregular boundary into;

$Ckgj_2$ 34 inches +, light brownish grey (2.5y6/2 dry) fine sand; single grained; loose when moist, loose when dry; moderately alkaline; moderately calcareous, and weakly iron stained.

TABLE 9

Analysis of Hochfeld Light Very Fine Sandy Loam

Horizon	Depth (In.)	% Sand	% Silt	% Clay	Moisture Retention 1/3 Atmos	pH	Cond. mmhos/cm	% $CaCO_3$ equiv	% Org C	% Total N	Avail P PPM	ExchaCap me/100 gm	Exchangeable Cations me/100 gm Soil Ca	Mg	K	Na
Ap	0- 5	80.26	6.44	13.30	14.20	6.66	0.35	-	1.94	0.17	9.11	15.97	12.60	3.00	0.28	0.33
Ah	5-10	80.10	6.63	13.26	14.66	6.80	0.36	-	2.01	0.17	7.57	16.72	13.60	2.55	0.37	0.15
Bm	10-20	84.57	5.49	9.94	10.77	7.53	0.22	-	1.10	0.08	4.89	13.11	10.45	2.70	0.18	0.16
Ck_1	20-34	87.26	4.21	8.54	7.93	8.00	0.23	3.23	0.32	0.04						
$Ckgj_2$	34+	90.46	3.42	6.12	6.16	8.25	0.21	9.51	0.19	0.02		16.95	14.70	2.40	0.11	0.13

TABLE 10

Physical and Chemical Results on Hochfeld Light Very Fine Sandy Loam

(Well B)

Depth	Texture	Sat. %	pH	Cond. mmhos/cm	Soluble Salts m.e./l cations Na	Ca+Mg	S.A.R.	Dist H.C.* IN./HR.
0-1'	VFSL	43.8	7.1	1.1	1.4	10.4	0.6	4.20
1-2'	VFSL	42.5	7.4	0.7	1.2	7.1	0.6	4.30
2-3'	VFSL	45.0	7.7	0.5	0.8	4.4	0.5	1.34
3-5'	LFS	37.5	8.0	0.5	1.4	3.8	1.0	2.90
5-7'	VFSL	33.8	7.9	0.3	0.7	3.6	0.5	2.50
7-10'	VFSL	(No sample)						
10-12'	LFS	37.5	7.8	0.7	2.3	5.6	1.4	1.80

* Disturbed hydraulic conductivity.

The B horizon of the Hochfeld Series may be weakly calcareous. These soils are susceptible to wind erosion. Local areas of the Hochfeld eroded or overblown phase may occur. These soils have a low moisture holding capacity and rapid permeability.

Reinland Series

The Reinland Series (Ra) is an imperfectly to moderately well drained, Gleyed Carbonated Rego Black soil developed on weakly to moderately calcareous, moderately coarse beach, deltaic and alluvial deposits. These deposits are usually stratified and are underlain by lacustrine clay or till (on West side of farm) usually within 15 feet of the surface. On the south-east corner of the Farm, the Reinland overblown phase (Rc) has been mapped. The Reinland till substrate phase (Rk) has been mapped on the west side of the Farm. The till occurs about 24 to 36 inches below the surface.

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

Ahk_1 0 to 14 inches, dark grey (10YR4/1 dry) loamy very fine sand; weak, fine granular; very friable when moist, soft when dry; mildly to moderately alkaline; weakly calcareous. Grades through an abrupt, smooth boundary into:

Ahk_2 14 to 20 inches, dark grey (10YR4/1 dry) loamy very fine sand; weak, fine granular; very friable when moist, soft when dry; moderately alkaline and weakly calcareous. Grades through a gradual smooth boundary into:

ACk 20 to 26 inches, dark greyish brown (10YR4/2 dry) loamy very fine sand; weak, fine granular; very friable when moist, soft when dry; moderately alkaline, and weakly to moderately calcareous. Grades through a diffuse, irregular boundary into:

$Ckg\overline{j}_1$ 26 to 38 inches, light brownish grey (10YR6/2 dry) loamy very fine sand; weak, fine granular; very friable when moist, soft when dry; moderately alkaline; moderately calcareous and weakly iron stained. Grades through a diffuse, irregular boundary into:

$Ckg\overline{j}_2$ 38+ inches, very pale brown,(10YR7/4 dry) loamy very fine sand; weak, fine granular; very friable when moist, loose when dry; moderately alkaline; moderately calcareous, and weakly iron stained.

In areas where some erosion has occurred, the depth of the overblown material generally ranges from 4 to 15 inches. This condition occurs near farm buildings and grassed field boundaries. The texture of the wind deposits is mostly loamy very fine sand and very fine sand. These soils are susceptible to wind erosion if proper management is not followed. They have moderately rapid permeability and low moisture retention. There is no

TABLE 11

Analysis of Reinland Loamy Very Fine Sand

Horizon	Depth (In.)	% Sand	% Silt	% Clay	Moisture Retention 1/3 Atm	pH	Cond. mmhos/cm	$CaCO_3$ equiv	% Org C	% Total N	Avail P PPM	Exch Cap me/100 gm	Exchangeable Cations me/100 gm Soil Ca	Mg	K	Na
Abk_1	0-20	82.82	7.94	9.24	12.56	7.70	0.45	0.96	1.99	0.20	13.23	18.20	16.05	3.35	0.16	0.11
ACk	20-26	83.17	7.77	9.06	11.81	7.85	0.57	2.50	1.16	0.12	1.50	19.42	16.45	3.85	0.11	0.15
$Ckg\overline{jj}_1$	26-28	80.86	7.76	11.38	13.31	8.00	0.88	10.85	0.60	0.06						
$Ckgj_2$	28+	80.92	10.51	8.57	12.86	8.25	0.38	15.42	0.27	0.03						

appreciable salt accumulation in the profile, but occasionally gypsum accumulation may be present in the C horizon.

III. Soils Developed on Medium Textured and Moderately Coarse Textured (14-20 percent clay) deltaic, and alluvial deposits (FSL, VFSL, SCL, L, SiL).

Rosengart Series

The Rosengart Series consists of moderately well drained Orthic Black soils developed on weakly to moderately calcareous, moderately coarse textured (clay is 14 to 20 percent) deltaic and alluvial deposits. The deposits are normally stratified and are underlain by lacustrine clay, commonly within 10 to 15 feet of the surface. The profile consists of a moderately thick (8 to 12 inches) dark grey Ah horizon and a thin dark greyish brown Bm horizon.

A description of a representative soil profile of the Rosengart very fine sandy loam is given below:

Ap 0 to 6 inches, very dark grey (10YR3/1 dry) very fine sandy loam, weak, fine granular; very friable when moist, soft when dry; mildly alkaline to neutral. Grades through an abrupt, smooth boundary into:

Ah 6 to 11 inches, very dark grey (10YR3/1 dry) heavy very fine sandy loam; weak, fine granular; very friable when moist, soft when dry; mildly alkaline. Grades through a clear, wavy boundary into:

Bm 11 to 15 inches, dark greyish brown (10YR4/2 dry) very fine sandy loam; weak, fine granular; very friable when moist, soft when dry; mildly alkaline; weakly to non-calcareous. Grades through a clear, irregular boundary into:

BC 15 to 22 inches, greyish brown (10YR5/2 dry) heavy very fine sandy loam; weak, fine granular; very friable when moist; soft when dry; moderately alkaline; and weakly calcareous. Grades through a clear, irregular boundary into:

TABLE 12

Analysis of Rosengart very Fine Sandy Loam

Horizon	Depth (In.)	% Sand	% Silt	% Clay	Moisture Retention 1/3 Atmos	pH	Cond. mmhos/cm	% $CaCO_3$ Equiv	% Org C	% Total N	Avail P PPM	ExchaCap me/100 gm	Ca	Mg	K	Na
Ap	0- 6	77.46	8.33	14.21	20.08	7.57	0.40	0.0	2.33	0.19	5.37	20.55	15.20	5.50	0.11	0.15
Ah	6-11	75.44	9.15	15.41	18.84	7.70	0.30	0.0	1.83	0.14	3.73	20.05	16.10	4.25	0.18	0.21
Bm	11-15	71.93	8.92	19.15	17.98	7.70	0.78	0.27	1.03	0.10	2.82	20.00	14.95	5.55	0.26	0.33
BC	15-22	74.47	9.69	15.84	16.65	7.78	1.83	0.25	0.53	0.05	2.15					
$Ckg\overline{j}_1$	22-30	72.41	8.63	18.86	15.94	7.87	1.50	12.42	0.50	0.05						
$Ckg\overline{j}_2$	30+	82.07	7.81	10.10	12.38	7.82	2.10	11.37	0.22	0.02		9.87	—	3.47	0.06	0.23

$Ck\overline{gj}_1$ 22 to 30 inches, very pale brown (10YR7/2 dry) heavy very fine sandy loam; weak, fine granular; very friable when moist, soft when dry; moderately alkaline; moderately calcareous; and weakly iron stained.

$Ck\overline{gj}_2$ 30+ inches, light brownish grey (10YR6/2 dry) loamy very fine sand; single grained; loose when moist, loose when dry; moderately alkaline; moderately calcareous and weakly iron stained.

The Rosengart very fine sandy loam (clay content between 14-20 percent) has been established in the Morden-Winkler Map Sheet as an intermediate series between the Hochfeld light fine sandy loam and light very fine sandy loam) and the Reinfeld (loam to sandy clay loam) series. The soils generally become a little coarser textured with depth, the C horizon being loamy fine sand or fine sand. There may be a carbonate enrichment in the upper C horizon in some profiles. Occasionally gypsum crystals may be noted in the C horizon, but the salt content is usually low. They are moderately permeable and have a moderate moisture retention capacity.

Neuenberg Series

The Neuenberg Series (Na) is an imperfectly to moderately well drained Gleyed Carbonated Rego Black soil developed on moderately calcareous, moderately coarse textured deposits with a clay content of 14 to 20 percent. These deposits are usually stratified and are underlain by lacustrine clay within 10 to 12 feet of the surface or underlain by till within 3 to 4 feet of the surface (on west side of the Farm). The profile consists of a moderately thick, weakly calcareous, dark grey Ah horizon grading into a mottled, light brownish grey C horizon. The mottles are brownish yellow in color.

A description of a representative soil profile of the Neuenberg heavy very fine sandy loam is given below;

Apk 0 to 6 inches, very dark grey (10YR3/1 dry) heavy very fine sandy loam; weak, fine granular; very friable when moist, soft when dry; mildly alkaline and weakly calcareous. Grades through an abrupt, smooth boundary into:

Ahk 6 to 12 inches, very dark grey (10YR3/1 dry) heavy very fine sandy loam; weak, fine granular; very friable when moist, soft when dry; mildly alkaline and weakly calcareous. Grades through a clear, smooth boundary into:

ACkg$\overline{j}$ 12 to 24 inches, grey (10YR5/1 dry) heavy very fine sandy loam; weak, fine granular; very friable when moist, soft when dry; moderately alkaline; moderately calcareous, and weakly iron stained. Grades through a gradual, smooth boundary into:

Ckg$\overline{j}_1$ 24 to 30 inches, pale brown (10YR6/3 dry) heavy fine sandy loam, pseudo weak, fine granular, very friable when moist, soft when dry; moderately alkaline; moderately calcareous; iron stained. Grades through a gradual wavy boundary into:

Ckg$\overline{j}_2$ 30+ inches, light yellowish brown (2.5Y6/4 dry) loamy very fine sand; single grained; loose when moist, soft when dry; moderately alkaline; moderately calcareous; iron stained.

The Neuenberg heavy very fine sandy loam is the only type mapped, but small included areas of the Reinland Series may occur. The cultivated soils usually contain lime carbonate in the surface horizon. Accumulations of gypsum crystals are sometimes found in the C horizon, and the soils occasionally have a soluble salt content greater than 4 mmhos.

The Neuenberg till substrate has also been mapped on the Farm. The characteristics are similar to the described profile. The Neuenberg Series has moderate to moderately rapid permeability and moderate water retention capacity.

Gnadenthal Series

The Gnadenthal Series (Ga) is an imperfectly to moderately well drained Gleyed Carbonated Rego Black soil developed on medium textured, weakly to moderately calcareous, deltaic and alluvial deposits. These deposits are usually stratified and may be underlain by moderately coarse or fine textured sediments. The profile consists of a very dark grey to dark grey Ah horizon over a light brownish grey, mottled C horizon. The cultivated soils contain free lime in the surface horizon and usually have a lime carbonate accumulation in the upper C horizon.

A description of a representative soil profile of the Gnadenthal Series is given below:

Apk 0 to 6 inches, very dark grey (10YR3/1 dry) very fine sandy clay loam; weak, fine granular; friable when moist, slightly hard when dry; mildly alkaline; and weakly calcareous. Grades through an abrupt, smooth boundary into:

Ahk 6 to 12 inches, very dark grey (10YR3/1 dry) very fine sandy clay loam; weak, fine granular; friable when moist, slightly hard when dry; moderately alkaline and weakly calcareous. Grades through a clear, irregular boundary into:

AC̄kgj 12 to 24 inches, light brownish grey (2.5Y6/2 dry) very fine sandy clay loam; weak, fine granular; friable when moist, cemented with lime when dry; moderately alkaline; moderately calcareous; weakly iron stained. Grades through a gradual, irregular boundary into:

IIC̄ksgj 24+ inches, light yellowish brown (2.5Y6/4 dry) very fine sandy loam; weak, fine granular, very friable when moist; slightly hard when dry; moderately alkaline; moderately calcareous; mottled and gypsiferous.

TABLE 13

Analysis of Gnadenthal Very Fine Sandy Clay Loam, Sandy Substrate Phase

Horizon	Depth (In.)	% Sand	% Silt	% Clay	Moisture Retention 1/3 Atmos	pH	Cond. mmhos/cm	% $CaCO_3$ Equiv	% Org C	% Total N	Avail P PPM	Exch Ca, me/100 gm	*Water Soluble Cations me/100 gm Soil Ca	Mg	K	Na
Apk	0- 6	64.45	14.19	21.36	27.06	7.90	3.17	4.12	2.84	.262	5.85	25.90				
Ahk	6-12	60.66	17.89	21.45	26.50	8.10	7.75	6.30	2.22	.20	4.56	20.72	6.75	4.05	nil	4.20
ACkgj	12-24	52.41	13.93	33.66	24.32	8.02	10.54	20.13	0.91	0.09	1.93	17.81	5.36	5.65	nil	4.31
IICksgj	24+	71.62	9.79	18.58	17.60	8.30	8.23	12.80	0.28	0.03						

* Based on 25 gms of soil leached with 250 mls of water.

The Gnadenthal Series occupies a very small area on the Farm. The Gnadenthal sand substrate phase has a fine sand to loamy sand substrate within 36 inches of the surface. Where the Gnadenthal loam, clay substrate phase has been mapped, the clay substrate usually occurs within 36 inches of the surface. Even though no saline phases have been mapped, there are local areas that have a conductivity greater than 4 mmhos/cm within the top two feet. Accumulation of gypsum is common in the C horizon. They have a moderate moisture retention capacity and moderate permeability.

IV. Soils Developed on Moderately Fine Textured Alluvial and Lacustrine Deposits.

Eigenhof Series

The Eigenhof Series is a moderately well drained Orthic Black soil developed on moderately calcareous, moderately fine textured alluvial and lacustrine deposits. These deposits are stratified and may be underlain by sandy sediments within 3 to 5 feet of the surface. The profile consists of a very dark grey Ah horizon 8 to 12 inches thick, a dark greyish brown B horizon 8 to 14 inches thick and light brownish grey C horizon. An accumulation of lime carbonate may be present in the upper C horizon. The C horizon is usually iron stained and gypsiferous.

A description of a representative soil profile of the Eigenhof clay loam is given below:

Ap 0 to 6 inches, very dark grey (10YR3/1 dry) clay loam; moderate, fine granular; firm when moist, hard when dry; neutral. Grades through an abrupt, smooth boundary into:

Ah 6 to 10 inches, very dark grey (10YR3/1 dry) clay loam; moderate, fine granular; firm when moist, hard when dry; neutral. Grades through a gradual, wavy boundary into:

TABLE 14

Analysis of Eigenhof Clay Loam

Horizon	Depth (In.)	% Sand	% Silt	% Clay	Moisture Retention 1/3 Atmos	pH	Cond. mmhos/cm	% $CaCO_3$ Equiv	% Org C	% Total N	Avail P PPM	Exch Cap me/100 gm	Exchangeable Cations me/100 gm Soil Ca	Mg	K	Na
Ap	0- 6	20.76	39.57	39.67	36.74	6.47	0.83	-	4.33	0.40	21.58	32.75	27.60	2.60	1.20	0.56
Ah	6-10	21.08	39.10	39.82	36.17	6.62	0.38	-	4.52	0.38	23.23	35.00	28.80	5.60	1.41	0.35
BA	10-13	19.62	39.82	40.56	34.16	6.75	0.33	-	3.43	0.31	21.10					
Bm	13-18	17.70	39.35	42.96	33.88	7.27	0.50	0.27	1.84	0.18	10.44	33.71	25.25	7.60	0.83	0.33
BCk	18-26	11.12	45.08	43.80	32.25	7.64	2.24	16.99	1.10	0.10	5.61					
													Soluble Salts me/100 gm			
$Ckgj_1$	26-34	21.25	39.12	39.64	32.45	7.85	5.72	13.55	0.59	0.06		21.63	*7.84	*6.48	*—	*2.40
$Ckgj_2$	34+	33.30	36.19	30.50	34.49	7.65	2.97	8.30	0.46	0.04						

* Refers to Soluble salts (25 gm of soil leached with 250 mls. of water) m.e./100 gm soil.

TABLE 15

Analysis of Deep Drilling Samples on Eigenhof Clay Loam

Depth Ft.	Texture	Sat %	pH	Cond. mmhos/cm	Soluble Salts meg/litre cations Na	Ca & Mg	SAR	Gyp Cont. T/of	Gyp Reg T/of	Dist HC* in/hr.
0- 1	CL	62.5	7.1	2.7	3.8	26.7	1.0	---	2.1	1.18
1- 2	CL	62.5	7.1	2.6	1.5	32.5	0.4	---	1.7	0.32
2- 3	light C	66.3	7.6	1.5	1.1	16.0	0.4	---	1.0	0.19
3- 4	light C	68.8	7.7	2.2	2.0	26.6	0.5	---	1.4	0.13
4- 5	VFSCL	65.0	7.6	3.2	2.0	41.4	0.4	71.5	0	.30
5- 7	VFSCL	67.5	7.6	3.3	2.3	43.8	0.5	83.6	0	.22
7- 9	VFSCL	62.5	7.8	3.8	3.8	51.9	0.7	88.8	0	.17
9-10	SC	65.0	7.8	3.8	4.3	53.9	0.8	78.6	0	.18

* Disturbed Hydraulic Conductivity.

AB 10 to 13 inches, very dark greyish brown (10YR3/2 dry) light clay; strong medium granular; firm when moist, hard when dry; neutral. Grades through a gradual, wavy boundary into:

Bm 13 to 18 inches, dark greyish brown (10YR4/2 dry) light clay; strong, coarse granular; firm when moist, hard when dry; mildly alkaline. Grades through a gradual, irregular boundary into:

BCk 18 to 26 inches, greyish brown (10YR5/2 dry) light silty clay; strong, medium granular; very firm when moist, very hard when dry; moderately alkaline; and moderately calcareous with lime carbonate concretions. Grades through a diffuse, irregular boundary into:

$Ckg\overline{J}_1$ 26 to 34 inches, pale brown (10YR6/3 dry) clay loam; moderate, fine granular; firm when moist, hard when dry; moderately alkaline; moderately calcareous; weakly iron stained; with concretions of gypsum. Grades through a diffuse, irregular boundary into:

$Ckg\overline{J}_2$ 34+ inches, light brownish grey (2.5Y6/2 dry) clay loam; moderate fine granular; firm when moist, hard when dry; moderately alkaline; and moderately calcareous; iron stained; with concretions of gypsum.

The surface texture in the areas mapped as the Eigenhof clay loam range from a heavy loam to a light clay. The Eigenhof sand substrate phase (Ed) has sandy sediments within 3 to 5 feet of the surface. The Eigenhof till substrate phase has till or modified till within 3 to 5 feet of the surface. The soil has moderately slow permeability and a high moisture retention capacity.

Neuhorst Series

The Neuhorst Series (Ne) consists of imperfectly drained Gleyed Rego Black soils developed on moderately calcareous, moderately fine textured alluvial and lacustrine deposits. These deposits are usually stratified.

The profile is characterized by a thick very dark grey Ah horizon, a greyish brown ACkg horizon (8 to 12 inches thick) which is moderately calcareous, moderately alkaline; and weakly mottled. The Cgj horizon is pale brown, moderately calcareous, mottled and usually gypsiferous. A small area has been mapped on the Experimental Farm.

V. Soils Developed on Fine Textured Alluvial and Lacustrine Deposits.

Winkler Series

The Winkler Series (Wa) is a moderately well drained Orthic Black soil developed on moderately calcareous, fine textured alluvial and lacustrine deposits. These deposits may be stratified and underlain by sandy sediments at 4 to 6 feet from the surface. The profile consists of a moderately thick (6 to 12 inches) very dark grey Ah horizon and a well structured dark greyish brown Bm horizon. The lower portion of the Bm and the C horizon may be weakly iron stained. There may be an accumulation of gypsum in the C horizon. The profile is similar in characteristics to the Eigenhof with the exception that the Winkler has a clay content over 40 percent, while the Eigenhof has a clay content between 27 to 40 percent.

A description of a representative soil profile of the Winkler Clay is given below:

Ap 0 to 6 inches, very dark grey (10YR3/1 dry) clay; strong, medium granular; firm when moist, hard when dry; neutral to slightly acid. Grades through an abrupt, smooth boundary into:

Ah 6 to 12 inches, very dark grey (10YR3/1 dry) clay; strong, medium granular; firm when moist, hard when dry; neutral to slightly acid. Grades through gradual wavy boundary into:

BA 12 to 15 inches, very dark greyish brown (10YR3/2 dry) clay; strong fine subangular blocky; firm when moist, hard when dry; neutral to slightly acid. Grades through a gradual wavy boundary into:

Bm 15 to 20 inches, dark greyish brown (10YR4/2 dry) clay; strong, fine subangular blocky; firm when moist, hard when dry; neutral. Grades through a gradual, irregular boundary into:

BCk 20 to 34 inches, greyish brown (10YR5/2 dry) clay; strong, coarse granular; firm when moist, hard when dry; moderately alkaline; moderately calcareous and weakly iron stained.

Ckgj 34 to 44 inches, pale brown (10YR6/3 dry) clay to silty clay; strong, fine granular; firm when moist, hard when dry; moderately alkaline; and moderately calcareous; weakly iron stained; and concretions of gypsum. Grades through an abrupt, wavy boundary into:

IICkgj 44 to 54 inches, light brownish grey to light grey (10YR6/2-7/2 dry) clay loam; medium, very fine granular; friable when moist, hard when dry; moderately alkaline; moderately calcareous; iron stained; and gypsiferous.

While the Winkler clay is the most common type, the clay loam type may occur within the mapped area. These are soils with a shallow mantle of clay to loam over the clay. A Winkler, sand substrate has also been mapped in which sandy sediments occur within 3 to 5 feet of the surface. These soils are not saline except where they occur in a complex with the Plum Coulee soils. They are well structured, have moderately slow permeability, and a high moisture retention capacity.

Plum Coulee Series

The Plum Coulee Series consists of imperfectly drained Gleyed Black soils developed on moderately calcareous, fine textured alluvial and lacustrine deposits. The profile has a moderately thick, very dark grey Ah horizon and a very dark greyish brown Bmg horizon with weak mottling.

TABLE 16

Analysis of Winkler Clay

Horizon	Depth (In.)	% Sand	% Silt	% Clay	Moisture Retention 1/3 Atmos	pH	Cond. mmhos/cm	% $CaCO_3$ Equiv	% Org C	% Total N	Avail P PPM	Exch Cap me/100 gm	Exchangeable Cations me/100 gm Soil Ca	Mg	K	Na
Ap	0- 6	17.22	39.96	42.82	43.13	6.70	0.72	0.32	4.15	0.32	17.42	36.13	26.52	6.95	1.10	0.59
Ah	6-12	16.87	36.53	46.60	38.13	6.65	0.69	0.20	3.85	0.34	17.13	35.21	25.15	7.03	1.26	0.64
BA	12-15	13.72	37.56	48.72	35.27	6.56	0.49	0.25	3.04	0.15	10.43					
Bm	15-20	13.83	37.86	48.31	33.95	6.67	0.36	0.45	1.42	0.26	6.58	29.71	23.71	4.60	0.72	0.57
BCk	20-34	12.04	45.13	42.83	--	7.60	0.34	9.71	1.47	0.12	4.89					
													Soluble Salts me/100 gm			
Ckgj	34-44	10.62	42.87	46.51	35.22	7.50	2.91	11.12	0.80	0.07		23.44	*6.44	*2.47	--	*0.78
IICkgj	44-54	34.62	34.91	30.47	34.56	7.50	3.35	10.48	0.65	0.06						

* Soluble salts - m.e./100 gm soil.

A description of a representative soil profile of the Plum Coulee Clay is given below:

Ap 0 to 6 inches, very dark grey (10YR3/1 dry) clay; strong medium blocky; firm when moist, hard when dry; slightly acid. Grades through an abrupt, smooth boundary into:

Ah 6 to 10 inches, very dark grey (10YR3/1 dry) clay; strong, medium blocky; firm when moist, hard when dry, slightly acid. Grades through a clear, wavy boundary into:

Bmg 10 to 17 inches, very dark greyish brown (10YR3/2 dry) clay; weak, medium prismatic with strong, medium blocky micro-structure; firm when moist, hard when dry; neutral, slightly acid. Grades through a gradual, irregular boundary into:

BCkg$\overline{j}$ 17 to 22 inches, dark greyish brown (10YR4/2 dry) clay; strong medium blocky; firm when moist, hard when dry; mildly alkaline, weakly calcareous; weakly iron stained. Grades through a gradual, irregular boundary into:

Ckg$\overline{j}$1 22 to 30 inches, brown (10YR5/3 dry) clay; pseudo strong medium granular; firm when moist, hard when dry; moderately alkaline; moderately calcareous; iron stained; and gypsiferous.

Cksg$\overline{j}$ 30+ inches, pale brown (10YR6/2 dry) clay; pseudo strong, medium granular; firm when moist, hard when dry; moderately alkaline; and moderately calcareous; mottled; and gypsiferous.

On the Farm, this soil has been developed on an alluvial deposit underlain by deltaic sandy sediments at 3 to 6 feet from the surface. If the sandy sediment were encountered within the four foot depth, the soil was mapped as the Plum Coulee, sandy substrate. The depth of the Ah horizon varies in thickness from 6 to 10 inches. The Bmg horizon may be slightly

TABLE 17

Analysis of Plum Coulee Clay

Horizon	Depth (In.)	% Sand	% Silt	% Clay	Moisture Retention 1/3 Atmos	pH	Cond. mmhos/cm	% $CaCO_3$ Equiv	% Org C	% Total N	Avail P PPM	Exch Cap me/100 gm	Exchangeable Cations me/100 gm Soil Ca	Mg	K	Na
Ap	0-6	16.47	38.93	44.60	37.99	6.12	0.67	--	3.68	0.31	19.45	34.51	22.60	10.00	1.20	0.35
Ah	6-10	15.01	39.94	45.05	39.46	6.10	0.73	--	3.68	0.31	19.06	33.35	22.00	10.80	1.11	0.27
Bmg	10-19	5.14	40.14	54.72	39.80	6.83	0.54	--	1.73	0.15	8.08	35.57	23.60	12.01	0.87	0.94
BCkgj	19-22	8.92	37.86	53.22	37.20	7.70	0.70	3.89	1.24	.10	8.08	--	--	--	--	--
													Soluble Salts me/100 gm			
$Ckgj_1$	22-30	7.86	26.09	66.05	35.05	7.80	3.93	11.17	0.83	0.06			*10.77	*5.35	*0.18	*1.21
Cksgj	30+		No Analysis													

* Soluble Salts - meg/100 gms soil.

TABLE 18

Analysis of Deep Drilling Samples from Winkler-Plum Coulee soil area

Depth Inches	Texture	% Sat	pH	Cond. mmhos/cm	Soluble salts m.e./litre-cations Na	Ca & Mg	SAR	ESP	Gyp Content T/ac.	Dist H.C.* Ins./hr.
0-10	light C	66.7	7.1	0.8	1.5	6.4	0.8	2.6	0.6	1.55
10-19	C	86.6	7.4	0.7	1.5	6.6	0.8	2.6	—	0.32
19-28	C	72.5	7.6	0.6	1.6	4.7	1.0	3.3	—	0.23
28-37	C	75.0	7.9	4.7	17.0	53.6	3.3	6.9	21.1	—
37-46	C	82.5	7.9	5.9	24.5	73.8	4.0	9.3	65.8	0.23
46-55	CL	77.5	7.9	6.3	27.5	64.0	4.9	10.4	80.5	0.25
55-67	C	82.5	7.8	5.1	19.5	53.6	3.8	10.1	85.3	0.18

* Disturbed Hydraulic Conductivity.

solonetzic in local areas. Although no saline phase was mapped, there are local saline areas within the designated map areas of Plum Coulee Clay and Plum Coulee, sandy substrate. These soils have slow permeability and high moisture retention capacity.

VI. Soils Developed on Recent Alluvium

The recent alluvial soils are immature soils occurring in creek beds, channels and former oxbows. These soils have little profile development other than very weak surface Ah horizons. The profile may have buried Ah horizons. Three soil series have been mapped on the Farm.

(1) Hespler Series: These are imperfectly drained Gleyed Deorcic Regosol soils developed on coarse to moderately fine textured sediments. They are usually stratified and may have buried Ah horizons present.

(2) Blumengart Series: These are imperfectly drained soils developed on dominantly fine textured sediments. These sediments may be stratified with thin layers of fine sand to clay loam. Buried Ah horizons may be present.

(3) Blumenort Series: These are poorly drained Rego Humic Gleysol soils developed on dominantly fine textured sediments that are usually stratified and may contain thin layers of coarse to moderately fine textured sediments or buried the Ah horizon. These soils may be inundated during the spring and following heavy rains.

FERTILITY OF THE SOILS

The soils on the Farm may be grouped into three general categories: low, medium and high fertility on the basis of profile characteristics and nutrient status of the soil at time of sampling. This may vary from plot area to plot area depending on past management, cultural practice and amount of erosion.

The soils considered with low fertility on the farm are the Blumenstein Complex. The Available Phosphorus is low and the Ammonium acetate extractable potash is quite low. The organic matter content is 3.4 percent.

The soils considered to be of medium fertility on the Farm are the Hochfeld, Reinland, Neuenberg, Rosengart and the Gnadenthal Series. Most of the soils have more than 3.5 percent organic matter, and available phosphorus at time of sampling was about 5 ppm. The analysis for a few of the profiles indicates that phosphate may be low and that potassium is quite low in the sandy soils.

The soils considered to be of high fertility on the Farm are Eigenhof, Neuhorst, Winkler, Plum Coulee, and the imperfectly drained alluvial soils. The potassium content is high to very high, the available phosphate content is high and the organic matter is moderate to high.

In the general grouping mentioned above, levels of salinity were not indicated and will be discussed elsewhere.

The criteria for rating of the soils on the basis of high, medium and low was based on fertility work conducted at the Soils Department and Soil Testing Laboratory of the University of Manitoba. The ratings are shown in Table 19.

TABLE 19

Phosphorus and Potassium Ratings for the Assessment of the Fertility of the Soil (1965)

Phosphorus Rating	Avail P PPM	Potassium Rating	Potassium Level ppm	Potassium Level m.e./100 gm
Very Low	0- 5	Very Low	0-44	0.11
Low	6- 8	Low	45-84	0.11-0.21
Medium	9-12	Medium	85-128	0.21-0.33
High	13-18	High	129-168	0.33-0.43
Very High	18+	Very High	169+	0.43+

For experimental areas, particularly fertility studies, it would be necessary to sample the soils within the plots and analyze the soil for the various elements as required.

GROUNDWATER AND SALINITY STUDIES

Groundwater studies have been carried out on three locations on the Farm; a) the centre of the NE quarter (Well A), b) the centre of the SE quarter (Well B), and c) the centre of the NW quarter (Well C). The results from 1960 to 1964, plotted in Fig. 2, show the groundwater level in feet below the surface. In Well A, the groundwater level during the spring and early summer of each year is within four feet of the surface. In 1962, the water level was within two feet of the surface in July. During the time May to August, the conductivity of the water ranged from 2.4 to 6.1 mmhos/cm. The graphs show that secondary high water peaks may occur throughout the summer or fall if above average precipitation occurs. A similar rise occurred in September, 1964.

The water levels in Wells B and C were much lower, usually below six feet except for the month of June in 1962. In Well C, the water level was between five to six feet during the months of May, June and July of 1963. The conductivity of the water ranged from 4.3 to 6.0 mmhos/cm in Well C. The conductivity of the water in Well B was less than 0.7 mmhos/cm.

The salinity of the water in Well A and B indicates that the subsoils are saline. Analysis of the subsoils for Well A (Table 20) show that the soil within two feet of the surface had a conductivity of 9.0 mmhos/cm. The subsoil to a depth of 12 feet had an average of about 4.5 mmhos/cm.

Salinity results for Well C (Table 21) show that the conductivity of soil within two feet of the surface is 1.0 mmhos/cm. Below three feet, the conductivity ranged from 2.5 to 6.0 mmhos/cm.

Salinity results for Well B (Table 10) on the sandy deposits are low with a conductivity at the surface of 1.1 mmhos/cm to 0.3 mmhos/cm at five to seven feet.

Deep drilling results on the medium to fine textured deposits (generally north half of the farm) show that the subsoils are moderately saline with conductivity from 3.5 to 6.5 mmhos/cm.

It is difficult to explain the conductivity results of Well A to the conductivity results of the water in the dugout in the NE quarter. The conductivity of the water (Table 22) in the dugout does not exceed 0.31 mmhos/cm during the summer months while the conductivity of the water in Well A ranges from 2.4 to 6.1 mmhos/cm. The dugout is situated less than 200 feet from Well A. It is conceivable that there would be a dilution effect in the spring due to snowmelt and runoff, but the conductivity does not change much during the summer months.

FIGURE 2

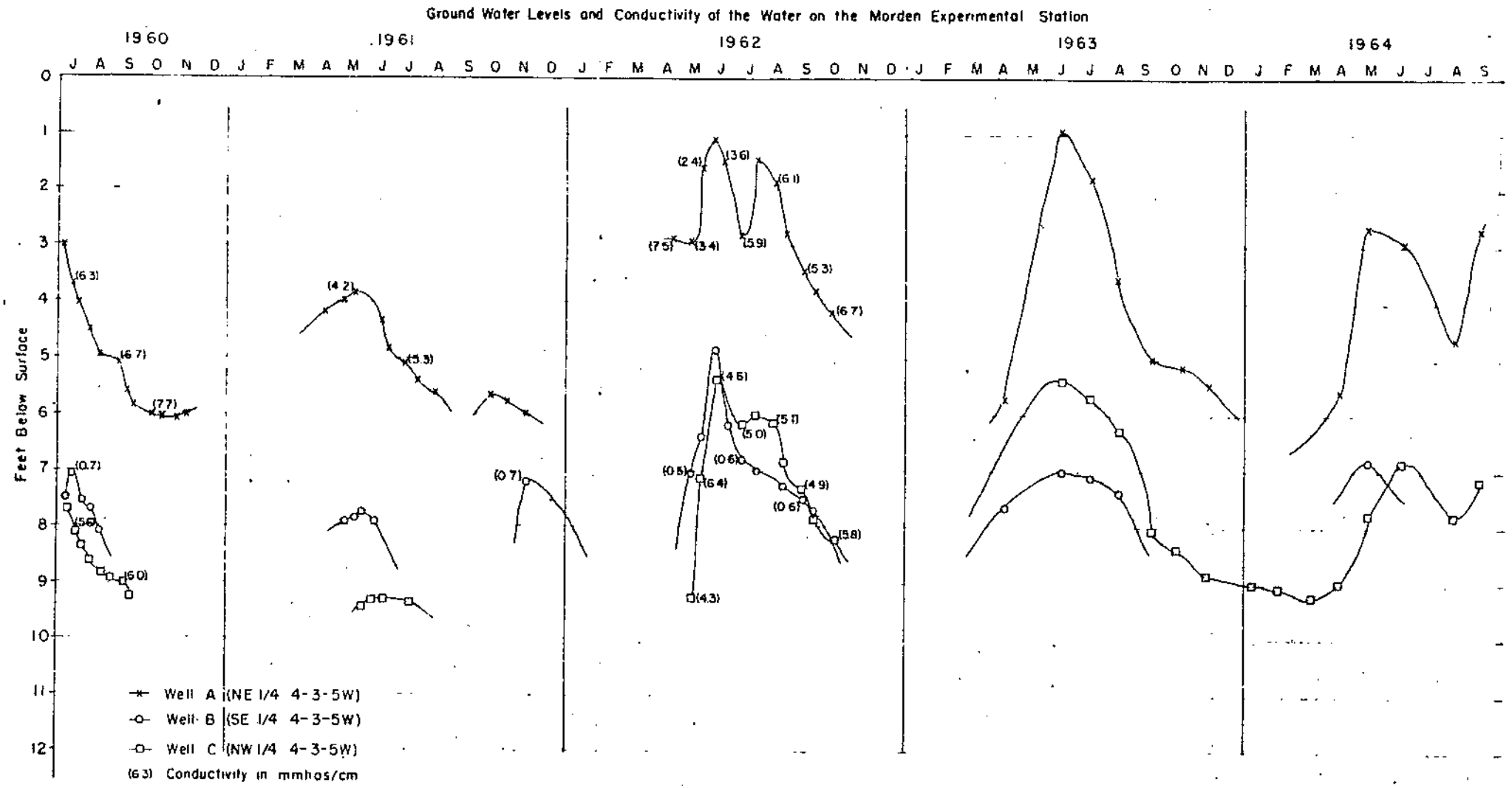

Ground Water Levels and Conductivity of the Water on the Morden Experimental Station
1960
1961
1962
1963
1964
J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
Feet Below Surface
0
1
2
3
4
5
6
7
8
9
10
11
12
(6.3)
(6.7)
(7.7)
(0.7)
(5.6)
(6.0)
(4.2)
(5.3)
(0.7)
(2.4)
(3.6)
(6.1)
(7.5)
(3.4)
(5.9)
(5.3)
(6.7)
(4.6)
(5.1)
(5.0)
(0.5)
(0.6)
(6.4)
(4.9)
(0.6)
(5.8)
(4.3)
Well A (NE 1/4 4-3-5W)
Well B (SE 1/4 4-3-5W)
Well C (NW 1/4 4-3-5W)
(63) Conductivity in mmhos/cm

TABLE 20

Analysis of Deep Drilling Samples from Well A - NE quarter

Depth Feet	Texture	Sat %	pH	Cond. mmhos/cm	Soluble salts m.e./l. cations		SAR	Dist. H.C.* Ins/hr.
					Na	Ca & Mg		
0- 1	C	53.8	6.6	8.9	49.3	58.2	9.1	0.37
1- 2	C	70.0	7.3	9.0	23.0	37.5	5.3	0.81
2- 3	VFSL	50.0	7.7	5.8	27.5	61.0	5.0	0.37
3- 4	VFSL	36.3	7.5	4.8	29.0	37.7	6.7	0.76
4- 5	FSL	37.5	7.5	4.4	28.0	34.0	6.8	0.58
5- 7	FSL	40.0	7.5	4.2	26.5	31.9	6.6	0.79
7- 8	FSL	No Sample						
8-10	LFS	40.0	7.5	4.3	26.3	31.2	6.7	2.30
10-12	LFS	37.5	7.5	4.0	24.8	30.5	6.4	2.30

* Disturbed Hydraulic Conductivity

TABLE 21

Analysis of Deep Drilling Samples from Well C - NW quarter

Depth Feet	Texture	Sat %	pH	Cond. mmhos/cm	Soluble salts m.e./l. cations		SAR	Dist. H.C.* Ins/hr.
					Na	Ca & Mg		
0- 1	CL	58.5	7.1	1.0	2.2	7.7	1.1	1.20
1- 2	VFSCL	62.5	7.5	0.6	1.0	5.4	0.6	0.68
2- 3	CL	66.5	7.3	2.5	3.0	22.9	0.9	0.18
3- 4	CL	61.3	7.2	3.4	5.0	35.9	1.2	0.09
4- 6	VFSCL	65.0	7.4	4.1	10.5	64.0	1.9	0.54
6- 8	VFSCL	62.5	6.9	5.8	21.5	71.6	3.6	0.34
8- 9	MS	56.3	7.4	6.0	21.0	74.4	3.4	0.49
9-10	MS	No Sample						
10-11	FSCL	58.5	7.3	3.6	9.5	43.7	2.0	0.35
11-12	LS	No Sample						

* Disturbed Hydraulic Conductivity.

The salinity of the water in the two dugouts in the SW quarter ranged from 0.30 to 1.67 mmhos/cm with the lowest conductivity occurring in early spring, gradually becoming more saline through the summer months (Table 22).

TABLE 22

Conductivity of Water from Dugouts on the Farm in 1962

Dugout Location	Conductivity of Water (1962)					
	May 10	May 28	July 5	July 19	Aug. 10	Sept. 7
NE quarter	0.15	0.21	0.20	0.20	0.31	0.28
SW quarter E side of Road	0.30	0.89	0.88	1.00	1.05	0.81
SW quarter W side of Road	0.30	1.04	1.46	1.67	1.14	0.96

In determining the quality of water for irrigation purposes, the total concentration of soluble salts and the relative proportion of sodium to other cation must be known. Water with a conductivity less than 0.25 mmhos/cm is considered as good quality for irrigation and has low salinity hazard.. Water with a higher conductivity (0.25 to 0.75 mmhos/cm) is considered of medium salinity hazard. Sensitive crops may be adversely affected by the use of irrigation waters having conductivity values in the range 0.25 to 0.75 mmhoc/cm.

Results of salinity measurements of soil extracts show that the salt content varies considerably throughout the Farm. The Hochfeld, Reinland, Neuenberg, Rosengart, and Eigenhof series are non saline. Throughout the rest of the area, the salinity of the soil is quite variable; the surface is generally low, and the subsoil generally moderately saline. With reference to the soils map, the conductivity of the soil in mmhos/cm is shown at the place of sampling as two

figures $\frac{1.3}{12.9}$. The top figure indicates the conductivity of the surface 6 to 9 inches, the lower figure indicates the salinity of the subsoil at the 3 foot depth. The value should be interpreted for the crop grown and its tolerance to different salt concentration. A general relationship between the salt concentration in the soil extract and its effects on plant growth is shown in Table 23 (3).

TABLE 23

The Relationship Between the Salt Concentration in the Soil Extract and its Effect on Plant Growth

Cond. mmhos/cm	Plant Response
0-2	Salinity effects negligible
2-4,	Yield of sensitive crops may be restricted
4-8	Yield of many crops restricted
8-16	Only a few tolerant crops yield satisfactorily

Fruit crops such as apple, plum and strawberries have a low salt tolerance. Vegetable crops such as green beans, celery, radish, may suffer a 50-percent decrease in yield on a soil with a conductivity of 3 to 4 mmhos as compared to yield on a non saline soil (3). A 50-percent decrease in yield of cucumber, squash, peas, onion, carrots, potatoes, sweet corn, lettuce, cauliflower, Bell pepper. cabbage, broccoli and tomato may result on scils with a conductivity between 4 to 10 mmhos/cm. In this sequence, the cucumber is the least tolerant and the tomato the most tolerant.

The results from the soil tests and well water indicate that salts are present in the subsoils on the Farm, particularly in the North half and the SW

quarter. With the rise in the water table during the late spring and early summer, it is to be expected that the concentration of soluble salts will rise in the soil. If the water table remains within 3 to 4 feet of the surface, the soils above the water table will become moist and, along with capillary action and high evaporation rates, salts may be brought nearer to the surface.

Table 24, "Land Classification Standards for Irrigation Suitability", has been included to show the criteria used for rating of the soils into irrigation suitability units. Should supplemental irrigation be used on the farm, it would be necessary to, (a) determine the quality of the water prior to application, (b) to determine the level of salinity to the three foot depth present on the experimental area or plot, and (c) to assess the water and soil quality in relation to the variety of crop grown.

TABLE 24

LAND CLASSIFICATION STANDARDS FOR IRRIGATION SUITABILITY - PEMBINA RIVER STUDY - MANITOBA

Land Characteristics	Symbols Sub-class Defic.	Class 1 - Very Good	Class 2 - Good	Class 3 - Fair	Class 4 - Unsuitable
SOILS	S				
Texture		Fine sandy loams to clay loams	Loamy fine sand to light clay	Sand to permeable clay	Gravel to clay
very coarse textured	v				
very fine textured	h				
Water holding capacity					
low available moisture capacity	q	40 to 60 saturation % >6" storage in 4 feet <4"/hr. hydraulic cond.	35 to 65 saturation % 5" storage in 4 feet <5"/hr. hydraulic cond.	25 to 75 saturation % >3" storage in 4 feet <7"/hr. hydraulic cond.	<25 or >75 saturation % <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		<1% and >0.1% in general gradient	<3% in general gradient	<5% in general gradient	>5% in general gradient
excess gradient	g				
Irrigation pattern		400' minimum run	300' minimum run	150' minimum run	<150' run
deficient field size or shape	j	10 acres minimum size if regular 20 acres " size if irregular	5 acres minimum size if regular 8 acres " size if irregular	5 acres minimum size	<5 acres size
Surface (levelling requirement)	u	Light - 0 to 200 cubic yards excavation per acre.	Medium - 200 to 350 cu.yards excavation per acre.	Heavy - 350 to 500 cu.yards excavation per acre.	Excessive - more than 500 cu.yards 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	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
high water table restricted outlet					

GLOSSARY

A - horizon. A mineral horizon or horizon formed at or near the surface in the surface in the zone of maximum removal of materials in solution and suspension and/or maximum in situ accumulation of organic matter.

B - horizon. A mineral horizon or horizons characterized by one or more of the following:

(1) an enrichment (enclusive of dolomite or salts more soluble in water) in silicate clay, iron, aluminum, and/or illuvial organic matter (Bt, Bf, Bh, Bfh).

(2) a prismatic or columnar structure which exhibits pronounced coatings or stainings and characterized by the presence of significant amounts of exchangeable sodium and/or magnesium (Bn).

(3) An alteration by hydrolysis or oxidation to give a change in color and/or structure that does not meet the requirements of (1) and (2) above (Bm).

C - horizon. A mineral horizon or horizons comparatively unaffected by the pedological process operative in A and B, excepting:

(1) the process of gleying, and (2) the accumulation of dolomite and salts more soluble in water (Cca, Cg and C).

Lower Case Suffixes

Ca - A horizon with secondary carbonate enrichment when the concretion of lime exceeds that present in the unenriched parent material.

g - A horizon characterized by reduction and gray colors; often mottled (gley).

h - A horizon enriched with organic matter.

j - A horizon whose characteristics are weakly expressed. It must be used with some other suffix.

k - Presence of carbonate as indicated by visible effervescence with dilute HCl (kalk).

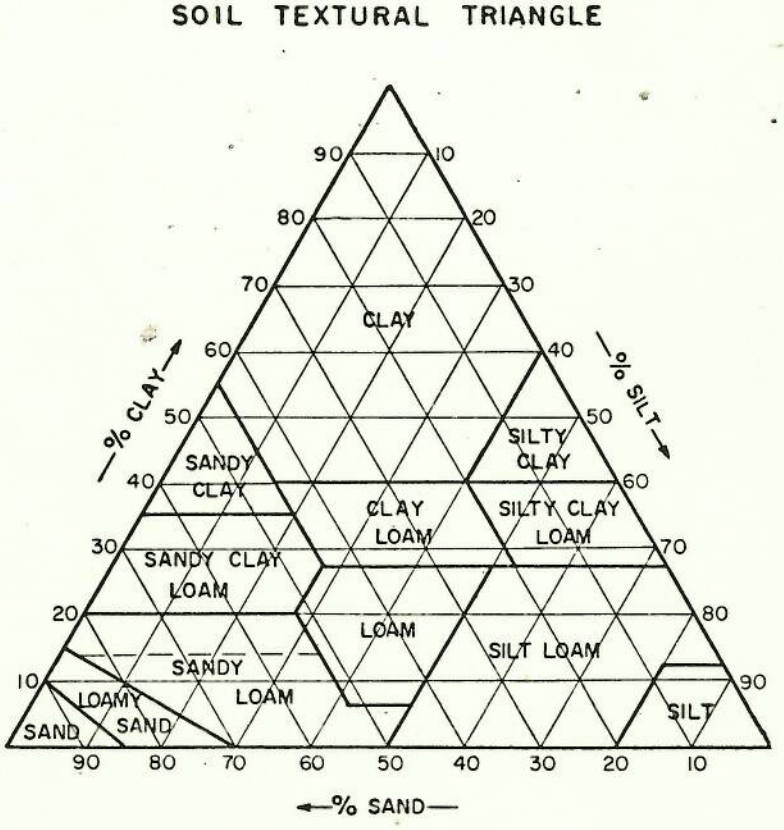
m - A horizon slightly altered by hydrolysis, oxidation and/or solution to give a change in color and/or structure (mellowed).

p - A layer disturbed by man's activities, i.e. by cultivation and/or pasturing. To be used only with A.

sa - A horizon with secondary enrichment of salts more soluble than carbonates where the concentration of salts exceeds that presented in the unenriched parent material.

s - A horizon with salts including gypsum which may be detected as crystals or veins, or as surface crusts of salt crystals, or by distressed crop growth, or presence of salt tolerant plants.

Soil Textural Triangle



Texture - refers to the proportion of the various soil separates sand, silt, and clay making up the soil mass.

An outline of the general terms in five classes in relation to the basic soil textured class names is as follows:

Coarse-textured soils - sands
loamy sand

Moderately coarse soils - loamy fine sand
loamy very fine sand
fine sandy loam (below 14% clay)

Medium textured soils - fine sandy loam (14-20% clay)
sandy clay loam (light)
loam
silt loam
silt

Moderately fine textured soils - silty clay loam
clay loam
sandy clay loam (heavy)

Fine textured soils - silty clay
clay
sandy clay

Surface Deposits

Till or Glacial Till - an unstratified, unconsolidated, heterogeneous mixture of clay, silt, sand, gravel and sometimes boulders deposited directly by the ice with little transportation by water.

Beach Deposits - deposits of gravel and sands marking the beach lines of former glacial lakes.

Alluvial Deposits - deposits formed by streams and may occur either as flood plain deposition or alluvial fans.

Lacustrine Deposits - clays, silts, and sand, laid down in glacial lakes.

Calcium Carbonate Equivalent - the percent carbonates (calcite, dolomite, etc.) in the soil expressed as calcium carbonate.

Terms used to express the carbonate content of the soil:

Weakly calcareous - 2 to 5 percent Calcium Carbonate Equivalent.

Moderately calcareous - 6 to 15 percent.

Strongly calcareous - 15 to 25 percent.

Very strongly calcareous - 26 to 40 percent.

Extremely calcareous - greater than 40 percent.

Electrical Conductivity - the reciprocal of the electrical resistivity. The resistivity is the resistance in ohms of a conductor which is one cm. long and has a cross sectional area of 1 cm^2. It is expressed in reciprocal ohms per centimeter or mhos per centimeter (or millimhos per centimeter).

Hydraulic Conductivity - refers to the effective flow velocity or discharge velocity of water in soil at unit hydraulic gradient. It is an approximation of the permeability of the soil and is expressed in inches per hour.

Overblown - refers to a superficial wind deposit great enough to influence management, but not great enough to destroy the essential characteristics of the soil.

Saturation Percentage - the moisture percentage of a saturated soil paste expressed on a dry weight basis.

Method of Analysis

pH and Conductivity: As outlined in Saline and Alkali Soils Handbook 60.

Mechanical Analysis: Method of making mechanical analysis of soils by Kilmer, V.J. and Alexander, L.T. 1949. Soil Science 68, 15-24.

Carbon Analysis: A wet combustion method adapted from methods of Adams (J. Ind. Eng. Chem. Anal. Ed. 6:227. 1934) and Waynick (J. Ind. Eng. Chem. 11:634-636. 1919).

Total Nitrogen: Determined by method in chemical Methods of Soils Analysis - Ottawa 1958.

$NaHCO_3$ Extractable Phosphorus - Olsen's Method as outlined in Chemical Method of Soil Analysis - Ottawa 1958.

Cation Exchange Capacity - As outlined in Chemical Methods of Soils Analysis - Ottawa 1958.

Calcium and Magnesium - Modification of Cheng, K.L. and Bray, R.H. Soil Science 72, 449, 1951 and Lott, P.F. and Cheng, K.L. Chemist Analysis, Vol. 46, No. 2. 1957.

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(3) Saline and Alkali Soils Agriculture Handbook, No. 60, United States Department of Agriculture.

(4) Report of the Sixth Meeting of the National Soil Survey Committee of Canada, Laval University, Quebec. 1965. National Soil Survey Committee.