ALBERTA INSTITUTE OF PEDOLOGY
BULLETIN B-72-1

RESEARCH COUNCIL OF ALBERTA
REPORT 72-7

SOIL SURVEY FOR URBAN DEVELOPMENT

EDMONTON, ALBERTA

by

J. D. Lindsay and M. D. Scheelar
Soils Division

Research Council of Alberta
11315 - 87 Avenue
Edmonton, Alberta
1972

CONTENTS

ILLUSTRATIONS

TABLES

SOIL SURVEY FOR URBAN DEVELOPMENT — EDMONTON, ALBERTA

Abstract

As an aid to planning urban development, a detailed soil survey was carried out in 1970 on 260 acres of the Mill Woods subdivision, City of Edmonton. Four soil associations — Ellerslie, Mill Woods, Argyll and Hercules — were distinguished; these are Chernozemic, Solonetzic, Alkaline Solonetz and Humic Gleysol soils, respectively. Ellerslie association soils are a good top soil source and will support plant growth well. Argyll association soils have poor surface drainage, and, being saline, are not well suited to lawn establishment; they also have poor trafficability. The Mill Woods association soils are intermediate between Ellerslie and Argyll associations. Hercules association soils are poorly drained and may be saline; their potential is poor.

A major concern is potential corrosion of concrete structures: highest potential is in Argyll and Hercules soils and least in Ellerslie soils. Precautions can be taken to prevent corrosion.

INTRODUCTION

Recently, 6,000 acres of land were annexed adjacent to the City of Edmonton, Alberta for urban expansion. According to the report of the City Planning Department (1971), this new community, called Mill Woods, will eventually accommodate 120,000 people and will have a development time span of more than 20 years.

Development of the area began in 1970 and to aid in the development plans a high intensity (detailed) soil survey was carried out on 260 acres of the area in that year. The purpose of the survey was to provide information indicating the suitability and/or limitations of the soils for urban development. The role of soil surveys in planning urban development has been documented by Hunter *et al*. (1966) and by Thomas (1966).

A soil map of the area and soil survey interpretation maps of topsoil suitability, potential corrosion hazard, and soil drainage are included in this report. Detailed descriptions of representative soil profiles are recorded in the appendix.

METHODOLOGY

The area to be mapped was carefully surveyed into a grid system in which stakes were established along lines spaced at 250-foot intervals. This step ensured that adequate control was provided for soil mapping and soil sampling procedures. The actual mapping was carried out using large scale (500 feet to 1 inch) aerial photographs.

A truck-mounted coring drill was used for the inspection of the soils of the area. Cores, to a depth of seven feet, were obtained at each of the staked sites in the grid system.

The soils were classified at each survey stake, using the cores, but sampled only at every second stake. Thus samples of the surface and subsoil horizons were obtained at 500-foot intervals throughout the area. This intensity of sampling appeared justified in view of the reported occurrence by Bowser et al. (1962) of soluble salts in the area. In all, a total of about 300 soil samples were obtained for laboratory analyses.

In the laboratory, emphasis was given to the determination of water soluble salts, soil reaction (pH), mechanical analysis, Atterberg limits, total nitrogen, and carbon. Standard methods of analyses as employed in the Soil Survey Laboratory were used for the various determinations.

SOILS

The soils of the area were mapped and classified according to the System of Soil Classification for Canada (Canada Department of Agriculture, 1970).

The soils of that portion of the Mill Woods district mapped are developed on lacustrine clays. Bayrock and Hughes (1962) note that this area is part of Glacial Lake Edmonton which covered much of the Edmonton district during late Pleistocene time. During the course of the soil survey of this area the underlying till was only occasionally encountered at the inspection sites. According to drill records obtained by Hardy and Associates (1971) in the area the stratigraphic sequence of material is variable but consists of about 12 feet of lacustrine clay, over 10 feet of clay loam till overlying bentonitic shales and sandstones of the Edmonton Formation.

Generally the topography of the area is fairly smooth with slopes seldom exceeding two per cent.

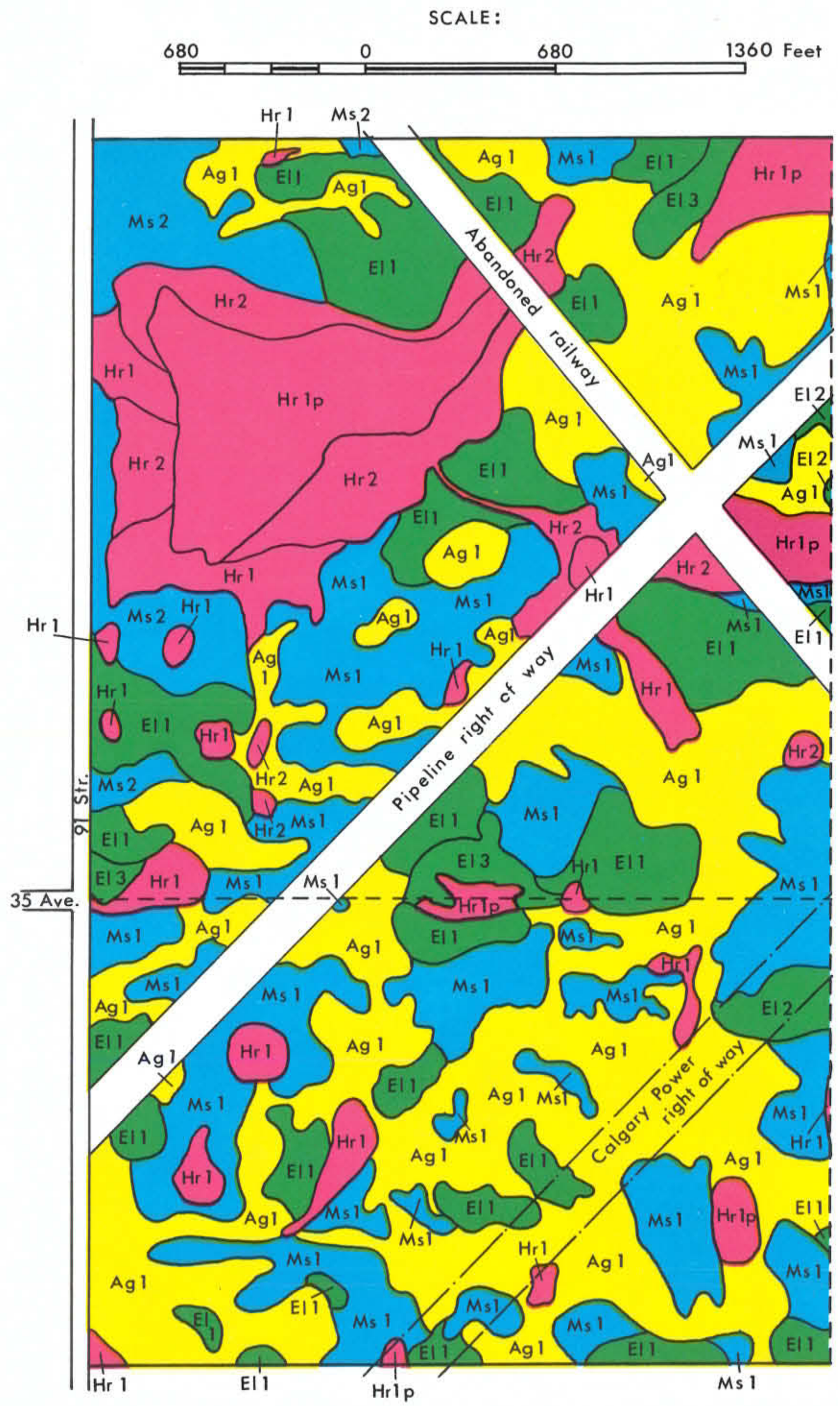
The soils were mapped on a soil association basis. The use of soil associations appeared suited to this study because the fine divisions included in the soil classification system could be recognized, although in many instances their intimate occurrence in the landscape precluded delineation on the soil map. This is not regarded, however, as a shortcoming of the mapping procedure since most of these inseparable units, although significant from a classification standpoint, are not sufficiently different with respect to soil properties to affect their use for urban development.

The make-up of the various soil associations employed in the Mill Woods district is shown in the legend of the soil map (Fig. 1).

The Ellerslie association consists primarily of Chernozemic soils. These soils are characterized by a dark colored, granular and friable Ah horizon (topsoil) of high fertility. The B horizon is fairly friable while the C horizon is calcareous but only weakly saline. Soils of this association are developed on lacustrine silty clay and clay material.

The soils of the Mill Woods association are Solonetzic and usually occur in areas of groundwater discharge where soluble salts have been brought relatively near the surface by groundwater. The Solonetzic soils comprising the Mill Woods association have A horizons that are somewhat thinner than the Chernozemic soils. They have an extremely hard clay pan when dry which becomes a sticky gelatinous mass when wet; this characteristic is more prominent in the Solonetz soils than in the Solods. These soils, however, all have sulfates present in the lower portion of the solum and are developed on lacustrine silty clay and clay.

Figure 1. SOIL MAP MILL WOODS AREA



Soils Legend:

Association	Mapping Unit	% Slope	Surface Soil Texture	Parent Material	Dominant Subgroup	Significant Subgroup
Ellerslie	El 1	0—2	Silt Loam	Lacustrine	Eluviated Black	Orthic Black
	El 2	0—2			Solodic Black	Black Solod
	El 3	0—2			Gleyed Eluviated Black	
Mill Woods	Ms 1	0—2	Loam		Black Solonetz	Black Solod
	Ms 2	0—2			Black Solod	Black Solonetz
Argyll	Ag 1	0—2	Clay Loam		Alkaline Solonetz	
Hercules	Hr 1	0—2	Clay Loam		Orthic Humic Gleysol	
	Hr 2	0—2			Saline Rego Humic Gleysol	

p — peaty phase

The Argyll association is comprised of Alkaline Solonetz soils which are extremely dense and intractable. These impermeable soils have a thin A horizon and sulfates usually occur in both the B and C horizons. The soils of this association pose the greatest number of problems for developers in the Mill Woods area.

The Hercules association includes those soils that are saturated or are under reducing conditions continuously or during some period of the year. They are poorly drained soils which are invariably found in areas of groundwater discharge. Salinity may occur in all horizons of some of these soils.

SOIL INTERPRETATIONS

From the basic soil survey data it is possible to make predictions of performance for the soils of the area based on soil morphology and the associated soil physical and chemical properties. In the Mill Woods area there are probably two main uses for which the soils of the area will be required — lawns and landscaping, and as a construction material.

The data in table 1 provide some indication of the suitability of the surface soil for landscaping. These data represent mean values for soil samples collected at some 116 sites throughout the area.

The soils of the Ellerslie association have the highest potential for landscaping and for supporting plant growth. As a topsoil source it is superior to the other soils in terms of thickness, organic matter content, and total nitrogen content. At the same time the analyses show that the water soluble salt content, as expressed by electrical conductivity and per cent sulfate, is negligible and should not affect plant growth.

The soils of the Argyll association, on the other hand, have fairly serious limitations with respect to the establishment of lawns. It can be seen in table 1 that these soils are characterized by a relatively thin surface horizon in which the organic matter content is low in comparison to the soils of the Ellerslie and Mill Woods soil associations. Also, the electrical conductivity suggests that the surface horizon of the Argyll soils is slightly to moderately saline. It was noted in the field that in areas

Table 1. Mean and Standard Deviation Values for Selected Chemical and Physical Properties of the Surface Layer (topsoil) of the Soil Associations in the Mill Woods Area

Mapping association	Depth (inches)	pH	Organic matter (per cent)	N (per cent)	Elect. cond. (mmhos/cm)	SO_4 (per cent)	Surface texture
Ellerslie 1	7.4±1.8	6.3±0.4	12.2	0.69	0.4±0.1	0.00	Silt loam
Ellerslie 2	9.0	6.2	-	-	0.7	0.01	Silt loam
Ellerslie 3	8.0	6.8	-	-	1.1	0.00	Silt loam
Mill Woods 1	6.3±2.0	6.3±0.5	11.2	0.59	0.6±0.3	0.02±0.07	Loam
Mill Woods 2	8.0±2.0	6.5±0.6	-	-	1.5±1.0	0.02	Loam
Argyll 1	4.0±1.2	6.2±0.4	8.7	0.49	1.5±0.8	0.03±0.04	Clay loam
Hercules 1	7.9±2.8	6.7±0.6	10.9	0.67	2.0±1.7	0.09±0.12	Clay loam
Hercules 2	8.2±3.4	6.9±0.6	-	-	2.0±1.1	0.03±0.06	Clay loam

dominated by these soils, water tended to remain on the surface for relatively long periods following a rain. This feature is undoubtedly a result of the impermeable nature of this Solonetzic soil profile and its inherent low hydraulic conductivity.

The soils of the Mill Woods association have moderate limitations for plant growth. They do not have the extreme undesirable physical and chemical properties of the Argyll association but at the same time the analyses indicate that these soils are somewhat inferior to the Ellerslie soils.

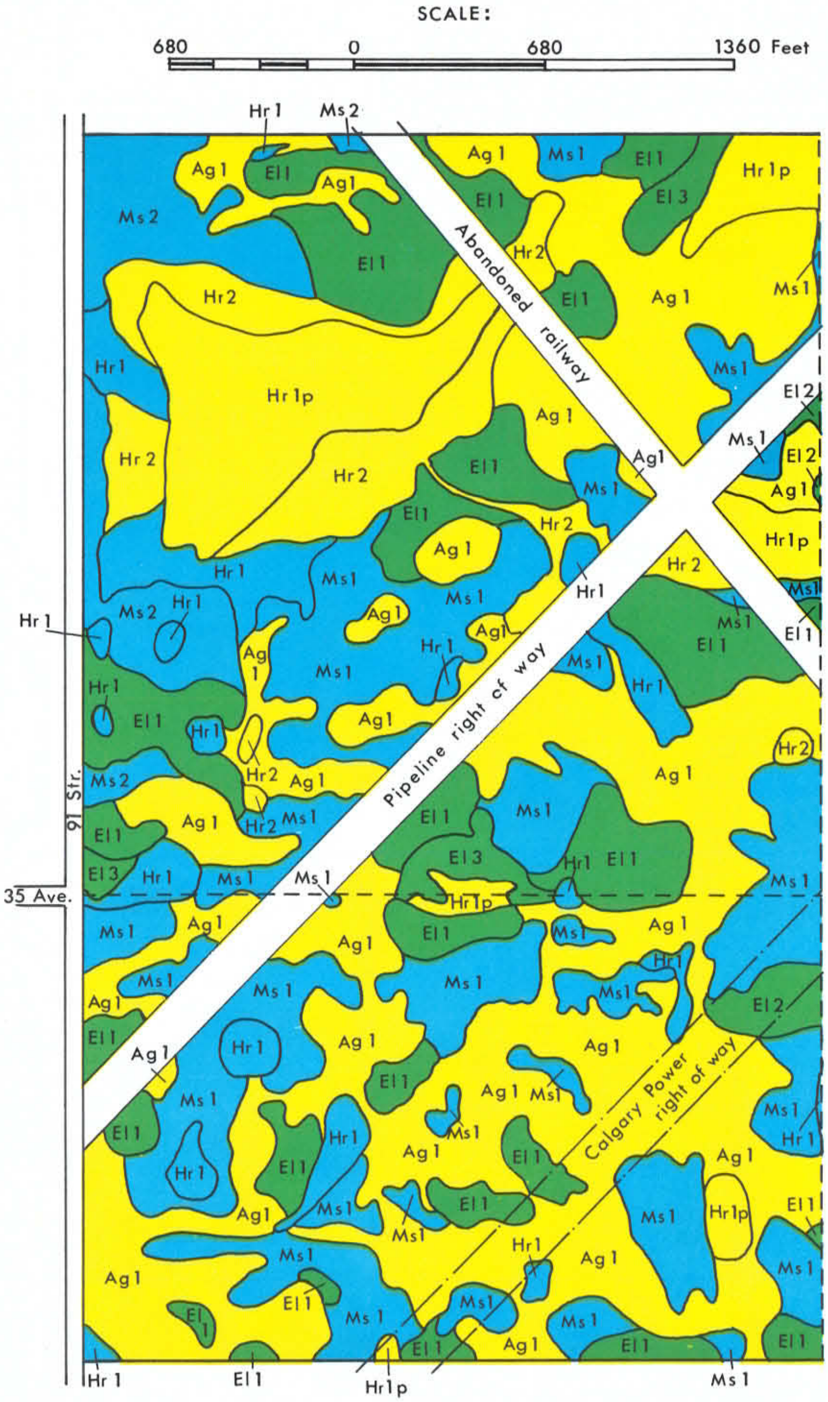
Areas dominated by soils of the Hercules association are poorly drained and have a water table near the surface. Such soils present vegetative rooting problems due to wetness. Also in some of these soils, particularly the Hercules 2 association, salts have been brought near the surface by groundwater discharge and this feature serves to further limit the suitability of these soils for landscaping and lawn establishment.

The Solonetzic soils, particularly the Argyll association, will present problems with respect to compaction and trafficability. These relatively fine textured soils have low permeability and are likely to puddle and compact under excessive traffic at high moisture contents. Schoolyards and playgrounds will be particularly susceptible to this type of problem. The maintenance of a vegetative cover in such areas may prove difficult unless precautions are taken to remove surface water and improve soil structure through the addition of organic matter.

In the Mill Woods area considerable care must be taken in preparing the land for landscaping. Since subsoil salinity is characteristic of the Argyll, Mill Woods, and Hercules soil associations, every precaution must be taken to ensure that the subsoil material is not left at the surface following construction. Ideally, the surface soil from the Ellerslie soil association should be used where possible for the establishment of lawns. An interpretive soil map showing the suitability of the surface soils of the Mill Woods area for landscaping purposes is shown in figure 2.

From engineering and construction standpoints the soils in this area present a number of problems with regard to urban development. One major concern

Figure 2. SOIL SUITABILITY FOR TOPSOIL



Legend:

Excellent

Fairly Good to Good

Poor

is the potential corrosion of concrete structures and underground conduits because of subsoil salinity. Some of the subsoil chemical properties of the various soil associations are shown in table 2.

The mean sulfate content in the subsoil ranges from 0.07 per cent in the Ellerslie association to 0.46 per cent in the Argyll association. Corresponding mean electrical conductivity measurements for these soils are 1.9 and 7.9 mmhos/cm, respectively.

The principle soluble salt in the soils of the Mill Woods area is sodium sulfate, with magnesium sulfate also occurring to a significant extent. Pawluk and Bayrock (1969) and Swenson (1971) have also reported the dominance of these two salts in some of the soils of the Canadian prairies. The mechanism of the destructive reaction of the sulfate ion on concrete is well documented by Swenson (1971). Briefly, it can be stated that the products of the reaction, calcium sulfoaluminate hydrate (ettringite) and calcium sulfate hydrate (gypsum), have a much higher volume than the solid reactants, which results in stresses bringing about a breakdown in the concrete.

The Concrete Manual of the United States Bureau of Reclamation (1966) recognizes the following concrete corrosion categories:

Negligible attack: < 0.10% sulfate in soil
Mild but positive attack: 0.10 to 0.20% sulfate in soil
Considerable attack: 0.20 to 0.50% sulfate in soil
Severe attack: > 0.50% sulfate in soil.

Using the above standards as guidelines, the potential corrosion hazard associated with the soil mapping associations in the Mill Woods area ranges from negligible to mild in the Ellerslie association, mild to considerable in the Mill Woods, and considerable to severe in the Argyll association. The poorly drained Hercules association also represents a considerable to severe corrosion hazard.

Swenson (1971) has outlined in some detail the precautions that should be taken where concrete structures are to be placed in a sulfate soil environment. He

Table 2. Mean and Standard Deviation Values for Selected Chemical Properties of the Subsoil (C horizon) of the Soil Associations in the Mill Woods Area

Mapping association	pH	Elect. cond. (mmhos/cm)	SO_4 (per cent)	m.eq. per litre		
				Na	Mg	Ca
Ellerslie	7.6±.1	1.9±1.1	.07±.06	9.3± 7.5	4.7± 4.0	9.4±7.1
Mill Woods 1	7.6±.2	4.9±1.8	.25±.11	37.1±24.0	19.6±13.0	24.2±8.0
Mill Woods 2	7.7±.1	3.9± .8	.21±.10	20.5±13.0	16.6± 8.7	24.0±4.3
Argyll	7.8±.2	7.9±2.2	.46±.20	80.9±36.0	27.3±10.0	20.3±4.2
Hercules 1	7.4±.4	3.0±1.4	.11±.10	25.5±11.6	8.4± 4.6	14.7±6.1
Hercules 2	7.7±.2	5.8±2.4	.29±.20	56.4±25.0	21.3±14.0	17.5±3.9

suggests that preventive measures should include the following: use of sulfate-resisting cement, a low water-cement ratio, high cement content, air-entrainment, waterproof coatings, drainage features, and special attention to reinforcing cover.

An interpretive soil survey map showing the various areas of potential concrete corrosion in the Mill Woods area is shown in figure 3.

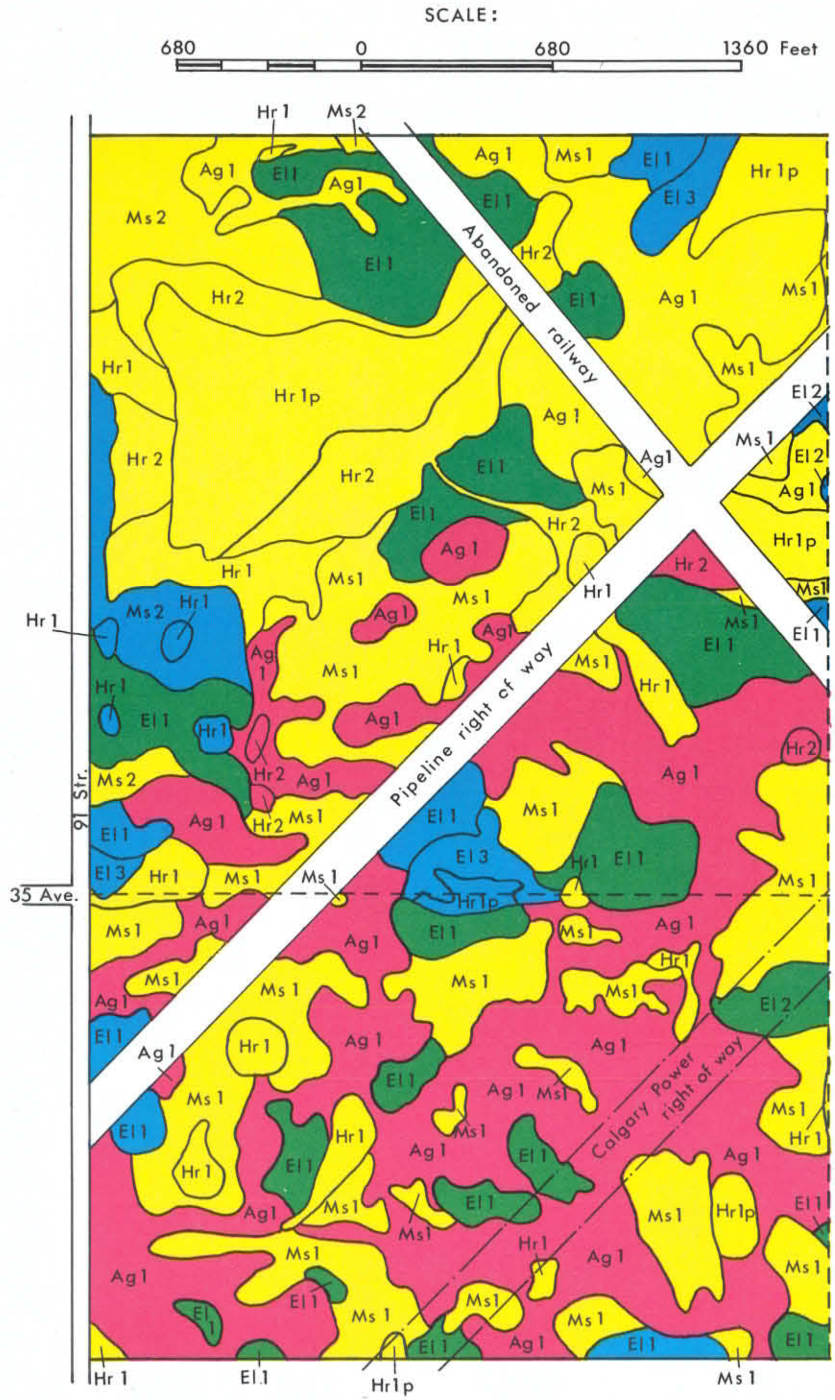
Physical properties of the soil are of special interest to engineers because they affect design, construction, and maintenance of structures. In the Mill Woods area a number of sites were sampled specifically for engineering tests. The results of the analyses are shown in table 3.

Because the western portion of the Mill Woods area is fairly uniformly mantled to a depth of at least seven feet with lacustrine clay, the soil associations differ very little insofar as the engineering data are concerned. There does appear to be, however, some stratification in the material in that the clay content varies to some extent with depth. Generally, all the soils of the area are characterized by a high content of plastic clays and are classified as A 7-6 in the AASHO system and CH in the Unified system. Such material has a high shrink-swell potential and at certain moisture contents may deform quickly under load.

The activity number indicates potential volume changes when the moisture content of the material is altered. In this area the activity number ranges from 0.5 to 0.9, indicating moderately active clays. They do not, however, approach the value of 1.25 suggested by Means and Parcher (1964) as indicative of highly active clays. The activity values obtained for the soils of the Mill Woods area are similar to those reported by Pawluk and Bayrock (1969) for the tills of Alberta.

The areas of poorly drained soils (the Hercules soil association) are of similar texture to the other soils in the area but they are wetter. These areas have water tables near the surface and may present problems in bearing strength and drainage for structures. A map showing the various soil drainage classes characteristic of the Mill Woods area is shown in figure 4.

Figure 3. POTENTIAL CONCRETE CORROSION HAZARD



Legend:

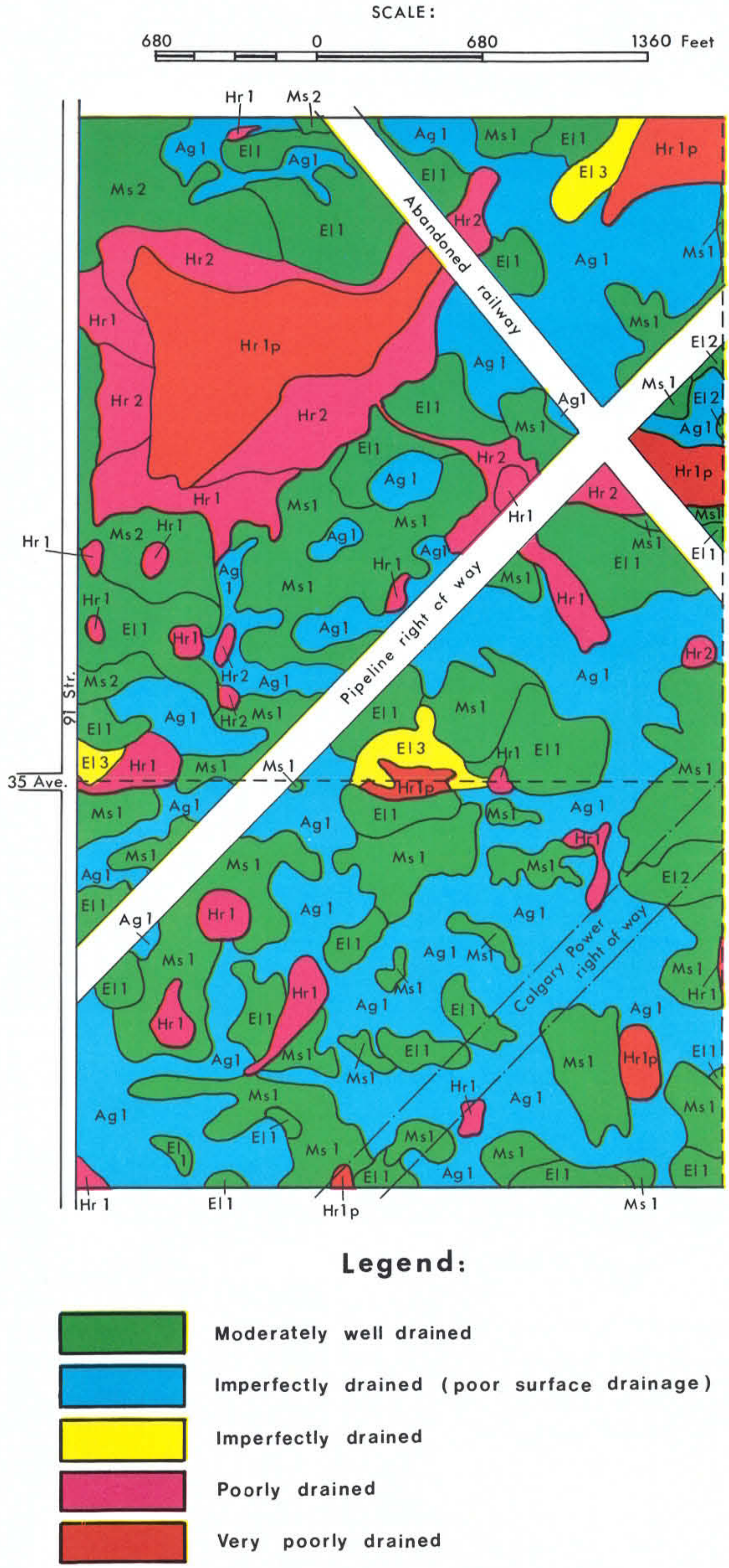
Limitation	Percent Sulfate
Negligible	< 0.10
Positive	0.10 to 0.20
Considerable	0.20 to 0.50
Severe	> 0.50

Table 3. Engineering Test Data for the Subsoil of Representative Soil Profiles of the Mapping Associations from the Mill Woods Area

Mapping associations	Depth from surface (inches)	1 in	3/4 in	Grain-size analyses: Per cent passing sieve 5/8 in	No. 4	No. 10	No. 40	No. 200	Per cent smaller than .05 mm	.005 mm	.002 mm	.001 mm
Ellerslie	20-40	100	100	100	100	100	96	68	69	48	38	34
	40-60	98	98	98	98	97	97	86	83	66	43	38
Mill Woods	20-40	100	100	100	100	100	99	94	93	79	61	51
	60-90	100	100	100	100	100	100	96	95	78	52	41
Argyll	35-55	100	100	100	100	100	98	88	87	74	65	62
	65-90	100	100	100	100	100	96	74	72	54	40	33

Mapping associations	Depth from surface (inches)	Liquid limit (per cent)	Plasticity index	Activity No.	Textural classification: AASHO	Unified	USDA
Ellerslie	20-40	43	21	0.6	A 7-6	CL	SiC
	40-60	53	26	0.5	A 7-6	CH	SiC
Mill Woods	20-40	66	37	0.6	A 7-6	CH	SiC-HC
	60-90	60	33	0.6	A 7-6	CH	SiC-HC
Argyll	35-55	64	39	0.6	A 7-6	CH	SiC-HC
	65-90	61	34	0.9	A 7-6	CH	SiC

Figure 4. SOIL DRAINAGE CLASSES



According to the City of Edmonton Planning Department (1971) the information provided by this detailed soil survey has been used extensively in planning the Mill Woods area. It has aided in the formulation of construction practices particularly in regard to specifications for the type of concrete to be used in the area. Central Mortgage and Housing Corportion, the principal lending agency in the area, has accepted the recommendation of the city planners and will require that such concrete be used for residential construction.

Utility departments of the city have also used the data to ensure that alkali resistant cement is used where necessary and that adequate measures are taken to provide protection for concrete structures, pipes and underground conduit in areas of saline soils.

New home owners will benefit from the soils information in that recommendations can be made with regard to the preparation of the soils for lawns and gardens. A knowledge of the soils is useful in determining the amount and type of fertilizer required, methods of seed bed preparation, and the possible need for other soil amendments.

Requests for detailed or high intensity soil surveys are rapidly increasing. Such surveys can be used for planning a wide assortment of facilities ranging from homes and industrial plants to schools and playgrounds. The cost-benefit ratio of such surveys has been estimated at 1 to 100 by Klingebiel (1966) and can be even greater with very expensive land development such as in the case of the Mill Woods district of Edmonton.

It should be mentioned, however, that information obtained during high intensity soil survey is not meant to eliminate the need for deep borings for specific purposes. The erection of high-rise towers and large buildings will require on-site investigation; the soil survey, however, helps in determining where the deep borings should be made and where the buildings should be sited.

ACKNOWLEDGMENTS

The authors acknowledge the assistance received from many members of the Alberta Institute of Pedology and the Research Council of Alberta. Special recognition is due the laboratory staff of Messrs. W. McKean and A. Schwarzer and Mrs. K. Harker.

REFERENCES CITED

Bayrock, L. A. and G. M. Hughes (1962): Surficial geology of the Edmonton district, Alberta; Res. Coun. Alberta Prelim. Rept. 62-6, 40 pages.

Bowser, W. E., A. A. Kjearsgaard, T. W. Peters and R. E. Wells (1962): Soil Survey of Edmonton Sheet (83-H); Alberta Soil Survey Report No. 21, 66 pages.

Canada Department of Agriculture (1970): System of soil classification for Canada; Can. Dept. Agriculture, Queen's Printer for Canada, Ottawa, 249 pages.

City of Edmonton Planning Department (1971): Mill Woods, a development concept report prepared on behalf of the civic administration.

Greif, F. (1972): Personal communication.

Hardy, R. M. and Associates Limited (1971): Edmonton public schools foundation investigation, Grace Martin elementary school, Mill Woods development.

Hunter, W. R., C. W. Tipps and J. R. Coover (1966): Use of soil maps by city officials for operational planning; in Soil Surveys and Land Use Planning, Soil Science Society of America, p. 31-36.

Klingebiel, A. A. (1966): Cost and returns of soil surveys, Soil Conservation, vol. 32, p. 3-6.

Means, R. E. and J. V. Parcher (1964): Physical properties of soils; Charles E. Merrill Books Inc., 464 pages.

Pawluk, S. and L. A. Bayrock (1969): Some characteristics and physical properties of Alberta tills; Res. Coun. Alberta Bull. 26, 72 pages.

Swenson, E. G. (1971): Concrete in sulphate environments; Canadian Building Digest, Division of Building Research, National Research Council of Canada, 4 pages.

Thomas, C. J. (1966): Use of soil surveys by a planning consultant; in Soil Surveys and Land Use Planning, Soil Science Society of America, p. 60-75.

United States Bureau of Reclamation (1966): Concrete Manual; United States Dept. Interior, Bureau of Reclamation, 7th edition, 642 pages.

APPENDIX

SOIL ASSOCIATIONS

Soil associations were used as a basis for soil mapping in the Mill Woods area. In this detailed soil survey the associations consisted of either single soil profiles (series) or in some instances two related soil profiles developed on a particular soil parent material (surficial geological material).

Based on the occurrence of the soil profiles on the landscape each soil association was divided into mapping units (Table 4). For example, the Ellerslie association consists of three mapping units - Ellerslie 1 a combination of Eluviated Black and Orthic Black soil profiles; Ellerslie 2 consists of Solodic Black and Black Solod soils; Ellerslie 3 consists of imperfectly drained Gleyed Eluviated Black soils.

Table 4. Soil Associations in the Mill Woods Area

Soil association	Mapping unit	Parent material	Dominant soil profile	Significant soil profile
Ellerslie	El 1	Lacustrine	Eluviated Black	Orthic Black
	El 2		Solodic Black	Black Solod
	El 3		Gleyed Eluviated Black	
Mill Woods	Ms 1	Lacustrine	Black Solonetz	Black Solod
	Ms 2		Black Solod	Black Solonetz
Argyll	Ag 1	Lacustrine	Alkaline Solonetz	
Hercules	Hr 1	Lacustrine	Orthic Humic Gleysol	
	Hr 2		Saline Rego Humic Gleysol	

The dominant soil profile in a mapping unit usually represents about 60 per cent of the delineated area while the remainder, the significant soil profile, represents about 40 per cent of the area.

The composition of the various soil associations and detailed descriptions of the soil profiles are as follows:

Orthic Black Soil Profile

Horizon	Depth (inches)	Description
Ahp	0-9	Very dark gray (10YR 3/1 m), silt loam; fine granular; friable; clear, smooth boundary; 5 to 15 inches thick.
Bm	9-27	Dark brown (10YR 3/3 m), silty clay; weak, medium subangular blocky; firm; clear, smooth boundary; 12 to 20 inches thick.
BC	27-35	Yellowish brown (10YR 5/4 m), silty clay; weak fine subangular blocky; friable; clear, wavy boundary; 6 to 14 inches thick.
Ck	35+	Brown (10YR 4/3 m), silty clay to heavy clay; amorphous; friable, very plastic; lacustrine deposit.

Eluviated Black Soil Profile

Horizon	Depth (inches)	Description
Ahp	0-8	Very dark gray (10YR 3/1 m), silt loam; fine granular; friable; clear, smooth boundary; 7 to 14 inches thick; some eluviation occurs in lower portion of this horizon.
Ae	8-9	Light brownish gray (10YR 6/2 m), silt loam; weak, fine platy; very friable; clear, smooth boundary; 1 to 3 inches thick.
AB	9-12	Very dark grayish brown (10YR 3/2 m), silty clay; strong, fine subangular blocky; firm; clear, smooth boundary, 3 to 6 inches thick.
Btj	12-26	Very dark grayish brown (10YR 3/2 m), silty clay; moderate, medium subangular blocky; firm; clear, smooth boundary; 10 to 18 inches thick.

Horizon	Depth (inches)	Description
BC	26-34	Dark grayish brown (10YR 4/2m), silty clay; weak, fine subangular blocky; friable; clear, wavy boundary; 5 to 12 inches thick.
Ck	34+	Brown (10YR 4/3m), silty clay to heavy clay; amorphous; friable, very plastic; moderately effervescent; lacustrine deposit.

Solodic Black Soil Profile

Horizon	Depth (inches)	Description
Ahp	0-8	Black (10YR 2/1m), silt loam; fine granular; friable; clear, smooth boundary; 6 to 12 inches thick.
AB	8-14	Very dark grayish brown (10YR 3/2m), silty clay; strong fine subangular blocky; firm; clear, smooth boundary; 3 to 7 inches thick.
Bnjt	14-26	Very dark grayish brown (10YR 3/2m), silty clay; strong, medium subangular blocky; firm; clear, smooth boundary; 10 to 22 inches thick.
BCs	26-38	Dark grayish brown (10YR 4/2m), silty clay; weak, fine subangular blocky; 10 to 16 inches thick.
Csk	38+	Brown (10YR 4/3m), silty clay; amorphous; friable, very plastic; moderately effervescent; very weakly saline; lacustrine deposit.

Gleyed Eluviated Black Soil Profile

Horizon	Depth (inches)	Description
Ahp	0-7	Very dark gray (10YR 3/1m), silty loam; fine granular; friable; clear, smooth boundary; 6 to 12 inches thick.
Ae	7-9	Light brownish gray (10YR 6/2m), silt loam; weak, fine platy; very friable; clear, smooth boundary; 1 to 3 inches thick.

Horizon	Depth (inches)	Description
ABgj	9-11	Very dark grayish brown (10YR 3/2m), silty clay; strong, fine subangular blocky; firm; clear, smooth boundary; few, medium, faint mottles; 1 to 4 inches thick.
Btgj	11-23	Dark grayish brown (10YR 4/2m), silty clay; moderate, medium subangular blocky; firm; clear, smooth boundary; common, medium, distinct mottles; 10 to 18 inches thick.
BCgj	23-37	Very dark grayish brown (10YR 3/2m), silty clay; weak, fine subangular blocky; friable; clear, wavy boundary; common, medium, distinct mottles; 12 to 18 inches thick.
Ckgj	37+	Brown (10YR 4/3m), silty clay to heavy clay; amorphous; friable; moderately effervescent; common, medium, distinct mottles; lacustrine deposit.

Black Solod Soil Profile

Horizon	Depth (inches)	Description
Ahp	0-8	Black (10YR 2/1 m), silt loam; fine granular; friable; clear, smooth boundary; 6 to 10 inches thick.
Ae	8-10	Light brownish gray (10YR 6/2m), silt loam; weak, medium platy; very friable; clear, smooth boundary; 1 to 3 inches thick.
AB	10-13	Dark grayish brown (10YR 4/2m), silty clay loam; strong, medium subangular blocky; firm; clear, smooth boundary; 1 to 4 inches thick.
Bnt	13-23	Very dark grayish brown (10YR 3/2m), silty clay; compound, weak, medium columnar and strong, medium subangular blocky; very firm; clear, wavy boundary; 10 to 16 inches thick.
Csk	23+	Dark grayish brown (10YR 4/2m), silty clay; amorphous; friable, very plastic; moderately effervescent; moderately saline; lacustrine deposit.

Black Solonetz Soil Profile

Horizon	Depth (inches)	Description
Ahp	0–8	Black (10YR 2/1 m), loam; fine granular; friable; clear, smooth boundary; 6 to 10 inches thick.
Bnt	8–22	Very dark brown (10YR 2/2m), silty clay; strong, medium round top columnar; very firm; clear, wavy boundary; organic staining on ped surfaces; 10 to 18 inches thick.
Csa	22–40	Very dark gray (10YR 3/1 m), silty clay; amorphous; friable; moderately saline; clear, wavy boundary; 14 to 24 inches thick.
Csk	40+	Very dark grayish brown (10YR 3/2m), silty clay; amorphous; friable; moderately saline; moderately effervescent; lacustrine deposit.

Alkaline Solonetz Soil Profile

Horizon	Depth (inches)	Description
ABp	0–3	Black (10YR 2/1 m), clay loam; compound, weak, fine columnar to moderate, medium subangular blocky; firm; clear, wavy boundary; 2 to 5 inches thick.
Bn	3–15	Very dark grayish brown (10YR 3/2m), silty clay to clay; strong, medium round top columnar, organic stained; very firm; dense; clear, smooth boundary; 8 to 15 inches thick.
Csa	15–29	Very dark gray (10YR 3/1 m), silty clay; amorphous; firm; clear, wavy boundary; moderately to strongly saline; 10 to 18 inches thick.
Csk	29+	Very dark grayish brown (10YR 3/1 m), silty clay; amorphous; firm; clear, wavy boundary; moderately to strongly saline; lacustrine deposit.

Orthic Humic Gleysol Soil Profile

Horizon	Depth (inches)	Description
Ah	0-6	Black (10YR 2/1 m), silty clay loam; compound, weak, fine subangular blocky and moderate, coarse granular; friable; abrupt, smooth boundary; 5 to 10 inches thick.
Bg	6-20	Very dark grayish brown (10YR 3/2 m), silty clay; moderate, medium subangular blocky; plastic; common, medium; distinct strong brown (7.5YR 5/6 m) mottles; clear, smooth boundary; 8 to 18 inches thick.
Ckg	20+	Dark grayish brown (10YR 4/2 m), silty clay; amorphous; many, medium, distinct strong brown mottles (7.5YR 5/6 m); plastic; moderately effervescent; lacustrine deposit.

Saline Rego Humic Gleysol Soil Profile

Horizon	Depth (inches)	Description
Ahp	0-8	Black (10YR 2/1 m), clay loam; weak, medium granular; friable; abrupt, smooth boundary; 4 to 10 inches thick.
Csakg	8-24	Very dark gray (10YR 3/1 m), silty clay; common, medium, distinct strong brown (7.5 YR 5/6 m) mottles; amorphous; plastic; moderately to strongly saline; moderately effervescent; 10 to 22 inches thick.
Cskg	24+	Dark brown (10YR 3/3 m), silty clay; many, medium, distinct strong brown mottles (7.5YR 5/6 m); moderately saline; moderately effervescent; lacustrine deposit.

Peaty phase - A peaty surface layer occurs at the surface of some of the Gleysolic soils in the area. Where this layer is greater than 6 inches but less than 18 inches in thickness, it has been designated as a peaty phase of the particular soil.