SELECTED PROCEEDINGS

OF THE

ELEVENTH MEETING OF THE

CANADA SOIL SURVEY COMMITTEE

AT THE

UNIVERSITY OF GUELPH

GUELPH, 24-27 FEBRUARY, 1976

EDITED BY

K.W.G. VALENTINE

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FOREWORD

The meeting of the Canada Soil Survey Committee at Guelph in 1976 was primarily concerned with mapping systems. There was a fairly broad consensus that this is a sadly neglected field deserving much thought and some systematization. However, there was initially some doubt about whether any actual progress was made. Subsequent feedback, received especially in the course of correlation tours, revealed that more was achieved than we perceived at the time. For example, there was some healthy re-examination of mapping schemes that had been taken for granted. Therefore, we have considered it appropriate to compile and issue the material generated by the meeting, in anticipation of further attempts to document and systematize the way soils are mapped.

One of the difficulties encountered in compiling this record nearly two years after the fact is in keeping a distinction between what was said at the meeting and what could be said now. A case in point is the procedure involved in using the CanSIS Cartographic File. Difficulties were foreseen in using on the manuscript maps some symbols, such as the virgule, which are used in the computer programs to convey specific (and different) instructions. These difficulties have now arisen and for this reason the current method of using the file as described by Faulkner and Kloosterman has been included as an Appendix, although it was obviously not presented at the meeting.

It is also appropriate to include the Report on Soil Moisture Regimes, a second important topic dealt with at Guelph, since it is also hoped to advance this cause in the near future.

The Reports of the Subcommittees on Landforms and Cryosolic soils have since been adopted for use and are to be found in other sources. Statements to this effect are therefore made here, without including the reports.

We appreciate the effort of Keith Valentine in compiling these proceedings.

J.L. Nowland
J.A. Shields
J.H. Day

Ottawa, December 1977

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REPORT OF SUBCOMMITTEE 17: MAPPING SYSTEMS, UNITS AND LEGENDS

J.L. NOWLAND, J.A. SHIELDS and J.H. DAY

First of all we have attempted to set out the objectives of this committee as follows:

1. To consider the desirability of mapping land rather than mapping only soil. What are the attributes of land to be mapped in our program? What role should be played by vegetation, hydrography and water bodies?

2. To devise if possible a defined classification system for mapping.

3. To select if possible a set of definitions and practices to achieve efficient and common terminology and procedures on a national basis.

With these objectives in mind our report will be separated into four sections; Current Situation and Needs looks at the way some maps have been constructed and identifies topics that need special attention; Mapping Systems: a Review of Responses attempts to put together a picture of your responses to our memos of the last year; Cartographic Constraints and Implications describes the problems related to various types of symbols and A Soil Mapping System offers one possible approach in the form of a flow chart.

CURRENT SITUATION AND NEEDS

We would first like to thank you all for the many responses to the numerous memos sent out by the correlation staff. For the most part the responses were summaries of group discussions. However, there were also some excellent individual efforts. They were all greatly appreciated.

Before going on to discuss your replies to the memos we would like to assess the current situation by making a rather quick summary of some soil maps and legends considered representative of various soil survey groups. A list of those maps and legends is given in Table 1.

The information given on each map legend is summarized in Table 2. The maps and legend summary have been put on display in various parts of the room. It would be appreciated if you would examine them to see if any information has been misinterpreted or overlooked.

Before proceeding further, there are a couple of terms that appear on the summary form (Table 2) which should be defined:

Soil Mapping Individual: a segment of the landscape that is defined during the course of a soil survey; its limits are established to suit the intensity and objectives of the survey.

Soil Mapping Format (Convention) Used: a mapping convenience used for grouping various collections of soil mapping individuals which best reflects their distribution over a given landscape. It is dependent on the scale of mapping, the nature of the mapping individuals and the complexity of terrain and parent materials. Examples include:

(1) Deciles of Soil Series to a maximum of three as on the Red Rose -Washow Bay, Tawatinaw, and Morden-Winkler maps.

(2) Soil Associations and Map Units which occur on the Edson-Hinton and Rosetown maps.

Table 1. List of Legends and Maps Summarized

Province	Map Area	Scale
British Columbia	Nechako-Francois Lake	1:126,720
	Lac la Hache - Clinton	1:125,000
	Nig Creek - Big Arrow	1:125,000
	Halfway	1:125,000
	Tulameen	1:126,720
Alberta	Edson - Hinton	1:126,720
	Lethbridge	1:126,720
	Tawatinaw	1:126,720
	Edmonton (Urban Study)	1:8000
Saskatchewan	Rosetown	1:126,720
Manitoba	Red Rose - Washow Bay	1:126,720
	Kettle Rapids	1:125,000
	Morden-Winkler	1:20,000
Ontario	Waterloo County	1:20,000
	Carleton County (Gloucester and Nepean Townships)	1:25,000
Nova Scotia	Cumberland County	1:63,360
Northwest Territories	Slave River Lowlands	1:63,360

The following conclusions can be drawn from the review of maps and legends in Table 2:

1. The soil mapping individual is generally a subgroup developed on a material of specified genetic origin, texture, calcareous grade and depth to discontinuity.

Table 2 SUMMARY SOIL MAPS AND LEGENDS REVIEWED

Recommended Definitive Elements of Delineated Areas

Map Area (See Table 1)

Element	Nech	Lac	Nig-	Half	Tula	Edson	Tawat	Edmt	Lethb	Roset	RedRo	Kettle	Morden	Water	Carlet	Cumb	Slave
1. Soil Mapping Individual Identified:																	
1.1 Taxonomic level:	S/M (O,G)	S/M	S/M	S/M (O)	S/M (O)	S/M (O,Se)	S/M	S/M	S/M	S/M (O)	S/M	S/M	Se	Se	S/M	Se	S/M (O)
1.2 Climate: Soil Climatic Map:				√											√		
Soil Zone:								√	√	√							
Forest Zone:	√	B										Eco					
1.3 Parent Material:																	
Genetic Origin:	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Degree of Uniformity:										√		√	√				
Lithologic Discontinuity:	√	√					√		√		√	√	√	√	√	√	√
Depth to Bedrock:	√		√	√	√	√			√		√			√	√		
Modification by Bedrock:	√									√					√	√	
Texture:	Cl	Cl	Cl	Cl	Cl	Cl	Cl	Cl	Fam	Cl	Cl	Cl	Cl	Cl	Cl		Cl
Reaction Class:					√	√											
Calcareous Grades:			√	√	√	√				√	√	√	√	√			
1.4 Solum:																	
Texture - surface only:										√			√	√	√		
- weighted mean:	√	√			√		√		√		√		√	√			
Depth -													√				
Depth to discontinuity:	B		B	B			√		√		√		√	√	√		
Horizon - morphological:						Ae											
- chemical:						pH									pH		
2. Non-Soil Mapping Individual Identified:																	
Rock Type:	RO	√			√				RO		RO				RO		RO
Other																	
3. Local Landform																	
Genetic Origin:	M	L	L	L	L				L	M		M			L		
Surface Expression:	M	L	L	L	L				L	M		M			L		
4. Mapping Format (Convention or Approach) Used:																	
Soil Mapping Individual:	SA + MU	SA + MU	MU %	MU	MU	SA + MU	MU %	SA + MU	Se + SU	SA + MU	MU %	SA + MU	Se Sgl	Se Sgl	SA + MU	Se Sgl %	Se %
Non Soil Mapping Individual:	√										√				√	√	√
Slope	M	M	M	L	M	M	L	M		M	L	M	R	M	√	√	
Stoniness														√	√	√	
Misc. Land Type						√	√			√				√	√		√

Explanation of abbreviations

1.1 S/M - Subgroup on material
(O,G) - Order and Great Group were also shown
Se - Soil Series

1.2 B - Biogeoclimatic
Eco - Ecoregions

1.3 Cl - Textural Class
Fam - Family Particle Size Class

1.4 B - Bedrock

2. RO - Rock Outcrop

3. M - On Map
L - On Legend

4. SA+MU - Soil Assoc + Map Units
Se+SU - Dom Series + Soil Unit
MU - Map Unit
Sgl - Single Series
Se+SU - Dom Series + Soil Unit

M - Map
L - Legend
R - Report

2. The solum of the soil mapping individual is characterized by texture and lithology of the materials and by drainage characteristics of the subgroup.

3. It is only seldom that morphological, chemical, or physical properties of the soil mapping individual are more refined than those definitive of the subgroup - this applies to all mapping scales.

4. Climate, other than that inferred by the subgroup, is not usually definitive for the mapping individual.

5. The soil mapping individual was generally referred to as a soil series and occasionally as a mapping unit.

   Comment: To us it was quite distressing to think that of all the options available for series separation below the subgroup, those utilized most frequently have been primarily confined to differences in texture and lithology of the solum and parent material. Other definitive characteristics for series including horizon and solum thickness, color and structure of B horizons, presence of Bm or Bt horizon have generally been ignored.

6. Nonsoil mapping individuals including rock type and water bodies are generally not shown on maps. - Rock outcrops are shown but rarely rock type.

7. Local landforms are generally shown either on the map or indicated in the legend.

8. Soil Mapping Formats (Conventions) varied considerably, they included:

   Single soil series
   Decile soil series (maximum of 3)
   Decile map units
   Soil Association and numeric map units

9. Optional definitive elements such as slope class were generally shown on the map or legend.

10. Vegetation characteristics of delineated areas were described in the legend of several maps, but were not definitive for map area delineations.

11. Water body classification was mentioned only in the text of the Kettle Rapids Report.

12. With regard to the question of whether we are mapping soil or mapping land, the legends reviewed indicated that:

    (a) Delineated map areas range from those consisting of single soil series (Morden-Winkler, Manitoba) to those which virtually encompass all the attributes of land (Kettle Rapids, Manitoba).

    (b) Most areas delineated describe soil geomorphic (or soil landform) elements.

Comment: We correlators wish to encourage the mapping of soil-geomorphic elements, but hesitate to recommend that we attempt to map all the attributes of land at the present time. Land encompasses water quality and productive capacity, neither of which is being mapped by most survey groups.

13. The soil landform mapping model or the taxonomic mapping model? - It is only rarely that survey groups are actually mapping taxonomy (ie. a particular taxonomic category).

    Comment: This is contrary to the impression that one may initially get from glancing at many legends whose 1st or 2nd column heading is labelled Soil Series. - Most of those series are no more than broad subgroups developed on a specified parent material. Surely the series is a bit more refined than that. However, let us not forget that a taxonomic category is a very useful mapping tool. It provides us with a consistent use of soil nomenclature, points out the relationships between categories, and allows for the extrapolation of interpretive data between sites that are within the same category.

From this brief review it would appear that we are in need of the following:

1. A dictionary of terms and definitions used in mapping. This is evident from the different definitions of the term "map unit" shown in Table 3.

2. A framework of a hierarchial mapping system to:

   - Reflect characteristics of soil and landform
   - Provide flexibility to accomodate different mapping scales according to the main objectives of the survey
   - Provide information which is readily interpreted for different kinds of uses.

3. The documentation of the kinds and ranges of properties definitive of the soil mapping individual. These must be compatible with the objective, scale and application of the survey.

4. The documentation of the methods for grouping soil mapping individuals in different mapping formats or a clear description of the construction of the mapping units.

5. Map unit descriptions by written, statistical or pictorial methods should be improved. - The modal concept is important but the range of properties and the nature of the unnamed inclusions are also important.

Other needs include guidelines for:

a. The maximum number of legend boxes (soil names) which should be shown on the legend.

b. The minimum total area requirement for a soil to occur on the map.

c. The standardization of map symbols, if only to agree on the numerator/denominator components.

d. The definition of legend column headings on the map as well as in the report.

Table 3. Definitions of the term "Map Unit" as used on different soil maps

Scale	Map Area	Definition
1:126 720	Halfway (B.C.)	Combination of two or more kinds of soil which occur together with the same degree of regularity
	Nig Creek (B.C.)	Subgroup on a defined parent material
	Nechako (B.C.)	Subdivision of a Soil Association
	Tulameen (B.C.)	Catena Soil Series Soil Complex Note: The Map Unit was then divided into subunits on the basis of proportions and kinds of other soils present.
	Tawatinaw (Alta)	Soil Series
	Edson-Hinton (Alta)	Subdivision of a Soil Association
	Rosetown (Sask)	Subdivision of a Soil Association
	Red Rose (Man)	Soil Series Grouping of two or more Soil Series Soil Complex
1:63 360	Cumberland (N.S.)	Soil Series
1:20 000	Waterloo (Ont)	Area shown on the map Soil Series Soil Type Soil Phase
1:8 000	Edmonton (Urban Area)	Subdivision of Soil Association

MAPPING SYSTEMS: A REVIEW OF RESPONSES

We would now like to attempt a resumé of the responses to the various memos that were sent out over the past year. An edited version of the principal questionnaire (Day - mapping systems - 4th April 1975) is reproduced in Appendix I to make this discussion intelligible.

1. Defining Some Terms

In the above discussion it was pointed out that we need some definitions of terms to make sure that we all are talking about the same things. The exchanges to date have revealed a fair amount of cross-purpose discussion because of a lack of agreement on what specific terms mean. Essentially two schools of thought have surfaced. The first list of terms and definitions was generated by Day and was supported and amplified by McKeague. The second list emanates from the concept and utilization of the soil association as submitted by Ellis and from the framework of mapping systems submitted by Dumanski and Marshall. A full copy of The Concept and Utilization of the Soil Association in Saskatchewan submitted by Ellis is included as Appendix II as it represents a clear statement of the philosophical basis upon which soil surveys have been conducted in Saskatchewan for years.

For the purpose of subsequent discussion the following definitions are proposed:

Mapping Individual or Component

A segment of landscape that is defined during the course of a soil survey; its limits are established to suit the intensity and objectives of the survey.

Consider the following examples, at different scales.

1:25,000 - Often the individual is a phase of a soil series, or soil type, especially when parent materials and landforms are fairly homogeneous. When parent materials or landforms are mixed or highly variable, the individual used may be described in terms of the order or great group level for the soils, with generalized statements of the landform. Land types may also be defined.

1:50,000-1:125,000 - The individual often employed is

1. Subgroup on specific parent material.
2. Soil series more or less widely defined by profile morphology and parent material uniformity. Phases of series may also be used.
3. Nonsoils.
4. Land type, eg. sloping valley walls, scarps.

1:250,000+ - The individuals or components usually will be more generally identified with respect to profile type, parent material and landform, examples:

1. Soil association
2. Landform, parent material, and Great soil group

3. Nonsoil
4. Land type, eg. floodplain, scree, talus, steep slopes, scarp.

When the scale and objectives of the survey have been established, a decision must be reached as to those characteristics that should be differentiating.

1. Recommended differentiating components for soil: taxonomy, parent material, climate (inferred from vegetation or measured); nonsoil: rock type.
2. Recommended differentiating components for landform are those adopted by C.S.S.C.
3. Optional differentiating accessory components for:
   Soil: Stoniness, erosion, topography.
   Nonsoil: Rock hardness, topography.
4. Nondifferentiating characteristics - vegetation
   - water body classification.

Map delineation

A single bounded area on a soil map having a unique set of differentiating characteristics that conform to the scale and objectives of the survey eg. ABC is different from BCD

$$\frac{ABC}{d} \text{ is different from } \frac{ABC}{g}$$

The soil components of map delineations are commonly composed of either a phase of a series, a series, or an association. The nonsoil components may be landform, stoniness, erosion, topography, rockiness, surface texture, peaty surface or any one of these. A single occurrence of a map unit phase is a map delineation and therefore a mapping unit is the aggregation of all delineations bearing the same component symbol and possibly a variety of accessory symbols.

Mapping Unit

A combination of certain defined ranges of related soil, nonsoil and miscellaneous landtype components (ie. mapping individuals) chosen by a surveyor for its ability to differentiate significant and usually repetitive portions of the soil-geomorphic continum from other portions.

The mapping unit is represented as being of four kinds - simple, combination, undifferentiated group and aggregated combination. The aggregated combination is no more than a combination of combinations that are usually recognized individually on the same map; denoted as complexes by some people, and simply as combinations by others.

2. Relationship of mapping units to soil taxonomy and survey intensity (Day memo, April 4, topics A and H)

"A hierarchical mapping scheme" has been proposed (Dumanski-Marshall) designed to define "naturally occurring, scientifically sound units that relate directly to the landscape, the scale of survey and the probable interpretations that will be made". In this system soil individuals representing the taxonomic component (and perhaps nonsoil individuals) are distributed in soil associations according to parent material similarities and repetitive patterns within defined climates, and further aggregated by geomorphic units (the landform component). With or without reference to the landform component, certain kinds of mapping unit can be identified.

(i) map unit phases of soil series, families, subgroups, etc.

(ii) complex - a pattern of soil individuals that cannot be disaggregated at the scale of the survey.

(iii) Association (as used in the United States of America) - a geographical mixture of two or more distinctive kinds of soil, or of areas of soil and nonsoil, in which the principal components could be separated in a detailed soil survey.

(iv) undifferentiated group - two or more potential mapping units combined into one because there is little or no practical advantage in making the separation.

Alternatively, it has been suggested that soil mapping individuals may be conveniently grouped according to different soil mapping formats (or approaches) which best reflect their distribution over a given landscape (Dumanski, Feb. 2/76). For example, the soil association as defined by Ellis is one kind of mapping format. The association may be subdivided into different mapping units according to the relative distribution of dominant and subdominant mapping individuals. Other soil mapping formats include decile grouping of mapping individuals (be they soil series or whatever) or the soil-landform format referred to by Dumanski.

There is an apparent paradox that whereas a large map scale permits most use of taxonomic separations in constructing mapping unit (so much so that some map units may be taxonomically pure), some diagnostic horizons (Bf, Bt, and Bm) are often not very important considerations in defining mapping units (Wang). There is an opposing view that some horizons may be very important at large scale in terms of plant growth, especially forest regeneration eg. type of A horizon, presence of turbic surface layers (Beke). Referring to similar scale mapping, using subgroup and great group levels in the taxonomic component, one response suggested that overemphasis of zonality results in neglect of important nonzonal soils.

In the eastern provinces (Ontario eastwards) the traditional approach to detailed and reconnaissance mapping at scale of 1:63,360 and larger has used the series, phase or type as the taxonomic component. The dominance of the taxonomic component spawned mapping units that could be termed "pure and oversimplified" as opposed to "honesty with vagueness", but in reality the "series" were what Pettapiece described as field-determined units with a wider range of characteristics than the taxonomic concept sensu strictu. In reality they were mostly complexes carrying the name of the dominant series, dominant here signifying a range of 40 to 80%, but rarely specified exactly.

The text of the report has been a special element in understanding the constituents of the mapping units, to the point of being an expanded legend for the map. Recently there has been a trend to defining mapping units in terms of dominant and significant polypedons (eg. N.S.) with family particle-size class separations.

In contrast, a common practice in the west has been to relate taxonomy to mapping units through the soil association. The latter has been defined (Ellis) as a group of mapping individuals related by their development on the same parent material under essentially similar climatic conditions. The proportions of different mapping individuals occurring over a particular landform is portrayed by a mapping unit. Within a soil association different landforms give rise to different proportions of mapping individuals and consequently different mapping units.

The difference between the two practices of relating taxonomy to mapping units may have arisen from differences between East and West in the observable clarity of climatic influence, the degree of heterogeneity of materials over short distances, and the clarity and regularity of landform patterns.

One point made was that disturbance reduces the significance of the taxonomic component of mapping units, especially if natural forms of disturbances such as tree throw ("arbroturbism", Nowland) are not incorporated in the taxonomy.

There was not too much argument with the orders of survey intensity, (Day, June 16) but it was suggested that any confusion over the word "order" could be avoided by a change to survey intensity level (SIL). A majority would seem to agree with the taxonomic levels appropriate to SIL as shown in Table 4. It should be borne in mind that intensity implies the detail of work as well as scale. This is why Table 4 shows intensity expressed as thousands of acres per man per year and Table 7 below tackles it another way as inspection and sampling density.

Table 4. Levels of Taxonomy associated with various map scales

Survey Intensity Level (SIL)	Scale	Soil Taxonomy	Biophysical level of Integration (Belair)	'000acres/ man/year
1	Less than 1:12 000	Series, type, phases	ecological phase	<50
2	1:12 000-1:31 680	Series, phases	ecol. type	50-100
3	1:31 680-1:125 000	Series, family, subgroup	ecol. system	100-250
4	1:125 000-1:300 000	Family, subgroup, great group	ecol. district	250-500
5	1:300 000-1:1 million	Great group, order	ecol. region	500

Leskiw and Pettapiece (Alberta Institute of Pedology - Soil Survey) have presented some refinements on the topics of survey intensity levels, hectares represented by areas on maps of different scales, and inspection and sampling densities. They are represented below with explanatory comments.

Table 5. Survey Intensity Levels (SIL)

SIL Code	Name	Scale
1	Very detailed	larger than 1:10 000
2	Detailed	1:10 000 1:25 000
3	Semidetailed	1:25 000 1:100 000
4	Reconnaissance	1:100 000 1:250 000
5	Exploratory	1:250 000 1:1 000 000
6	Synthesis	smaller than 1:1 000 000

Table 6. Map scale and detail of investigation

Hectares (acres) represented by various sized areas on maps of different scales

map area	Map scale (relative factor)						
	1:10 000	1:20 000	1:30 000	1:50 000	1:100 000	1:250 000	1:500 000
1 cm^2*	1 (2.5)	4 (10)	9 (22)	25 (62)	100 (250)	625 (1550)	2500 (6200)
5 cm^2	5	20	45	125	500	3 125	12 500
10 cm^2	10	40	90	250	1 000	6 250	25 000
100 cm^2	100	400	900	2 500	10 000	62 500	250 000

*1 cm^2 is considered to be the smallest area which can be shown on a map (from cartographic considerations)

The size of the smallest area to be recognized dictates the scale of presentation. If, for example, one wished to map units as small as 4 ha (10 acres) then he would have to go to a scale at least as large as 1:20 000. If the smallest area needed was 60 ha (160 acres) then 1:50 000 would be the logical scale to use.

Table 7. Inspection and sampling density (based on map area)

Code	Name	Inspection/cm^2	Code	Sample/cm^2
a	Very frequent	<1	i	<10
b*	Frequent	1-10	ii	10-100
c	Moderately frequent	10-100	iii	100-1000
d	Infrequent (sparse)	>100	iv	>1000

b* (ii) frequency is recommended. At a mapping scale of 1:20 000 this translates to an investigation every 4-40 ha (10-100 acres).

Responses generally indicated few problems in the construction of legends and symbols that could be related specifically to scale. This may substantiate the view that such problems are more directly related to the mapping model used, whether "taxonomy" or "landscape" (Dumanski). However, this begs the question to some degree, since published evidence exists to show that there are as many simple symbols and concise intelligible legends coming out of "taxonomic" models as there are complex symbols and legends under "landscape" models. This would be less true if, as suggested earlier, some of the report text under the taxonomic model was to serve as an extended legend.

Actually many taxonomic approaches probably carry a strong landscape element that are never explicitly stated. This carries through from the strong climatic element at the subgroup level in the taxonomy, the strong relationships between parent materials and landform, and the almost intuitive placement of delineations on topographic breaks. In other words, for many mappers it has been not so much a matter of taxonomic versus landscape model, but how well they used a landscape model that was common instinct.

In conclusion, whereas taxonomy is solely for the recording, ordering and transmission of basic soil pedon characteristics, mapping units attempt to display the spatial relationships between sets of significant combinations of the characteristics and between them and other environmental factors.

3. Representation of mapping units on the map and in the legend (Topic B)

Responses were fairly evenly divided between simple symbols with expanded legends and complex symbols with shorter legends.

The relation of complexity of symbols and legends to scale is confused. On the one hand high intensity surveys may encounter the greater problem due to their level of detail, but this could be offset by the larger number of relatively homogeneous soil individuals delineated. In lower intensity surveys, complexity resulting from the greater range of variables in the mapping unit components more than offsets any trend to simplicity stemming from generalization.

Map symbol conventions could stand some national standardization; the traditional elements appear in many different permutations. One suggestion was for soil elements in the numerator and nonsoil in the denominator. Others might be soil over landform or connotative over nonconnotative.

A discussion of the cartographic implications of using simple or complex symbols is included below under the heading of "Cartographic Constraints and Implications".

4. Incorporation of geomorphological units into symbols and legend (Topic C)

Common practice ranges from mere use of material composition to landform being the dominant element. Slope, material, surface expression and genetic origin are the geomorphological elements quite commonly used, but a systematic treatment based on more or less formal classification of local landforms is not widely established as yet.

Where it is in use, the geomorphological component in mapping units has spawned some extremely large symbols and opinion on their acceptability is divided. Complete integration of geomorphology is possible without need for expression in symbols, provided the mapping units are framed by geomorphological units in the legend. This seems to be quite difficult to achieve in areas where the landscape lacks distinct patterns or has its subtleties concealed by dense forest.

At small scales the landform component of mapping units frequently engenders exactly the same problems associated with the soil taxonomic component ie. variability over short distances and the need for complex groupings and symbols. Where landform for some reason cannot be adequately represented either in the legend alone, or in a cluttered symbol, dual maps may be the only solution. One objection to this is the expense; another was "possible conflict and confusion between surficial geology maps and geomorphology" (Sudom).

Explicit integration of geomorphology is most advanced in the West and least in the East. In most eastern situations, incorporation in the legend but not the symbol is preferred for SIL's 1 to 3. At SIL 4, symbolization is preferred.

Some favoured the block diagram as the main vehicle for landform characterization.

5. Incorporation of climate and vegetation in the mapping unit (Topic D)

Most responses indicated a desire that vegetation should be descriptive rather than definitive for mapping units and several advocated block diagrams as the best means of illustration.

It is recognized that macroclimate exercises a rather strong definitive role through the great group and subgroup levels of the taxonomic component in the mapping unit, and pedoclimate through the family level. Dumanski and Marshall placed macroclimate as a primary separator in their suggested hierarchical mapping system, but not to be used for detailed separations. Nobody discussed the role of significant contrasting mesoclimates such as those that would need to be identified in the land evaluation program. Things like frost-pockets and coastal-strip influence have often been discussed in the interpretive sections of soil reports; it might be productive to incorporate such factors in the mapping unit differentiae ie. at the inventory as well as the interpretive stages of the survey process.

Incorporation of macroclimate and vegetation as definitive components of mapping units appears more useful at smaller scales (SIL 4 and 5).

6. Incorporation of stoniness, topography, and erosion into symbols and legend (Topic E)

There seems to be little controversy on the handling of these factors as nonsoil phases of series at larger scales (SIL 1 and 2); they are represented in several different symbol layouts in different surveys. There was little said about smaller scale surveys.

According to some possible definitions of mapping units these features help to define the unit, but by the definition to be proposed they define subdivisions of mapping units called map unit phases.

There is probably quite a bit of flexibility as to whether traditional slope classes be merged with or superseded by general landform characterization in the legend or symbol. This would also be true for stoniness which could be incorporated in the mapping unit or association definitions in the legend as opposed to symbolization. Stoniness ranges expressed only in the legend would presumably cover a range and would result in a loss of some site-specific information.

There were no suggestions for changes in class limits or definitions for stoniness or slope, although some improved criteria for stoniness might well deserve attention.

No feelings were expressed on the adequacy or inadequacy of our existing treatment of actual erosion or potential hazard. This is also fair game for improvement in view of the extent of the process in both our arid and humid climates, and in view of the general downplaying of its significance during the CLI capability exercise. There is a deficiency to be made up here.

In general, slope and stoniness appear in the denominator of the map symbol, and erosion in the numerator. It would be easier on the user if a measure of national uniformity were achieved.

7. Method of handling complex distributions
(Topic F)

"Honesty with vagueness" won hands down over the oversimplified-false-purity-with-explanatory-text approach that characterized many surveys in the past. Few voiced concern over the vagueness implicit in associations of dominants, subdominants and inclusions, perhaps because it is unavoidable at the speed we cover the ground. But do we need cut-off guidelines for the third association in a complex or for the column of "inclusions" that clutter the legend? Here again use of diagrams might be encouraged to aid the user establish the probable location of soil individuals, assuming the basic inventory map is to be available to the user.

8. Relative interpretability of different types of mapping unit
(Topic G)

This question elicited a weak response, possibly a question of ask a stupid question... Or because the different types of mapping unit had not been defined.

Some favoured the interpretation of the whole mapping units on the basis of the dominant member, while others could not accept this and preferred the apportioning of interpretive ratings according to proportional representation of mapping individuals. Ontario recognizes real problems here and is studying the matter.

Several people support multiple interpretive maps regardless of the type of mapping unit and the expense, and very few expressed satisfaction with interpretive tables in the text being the sole means of communication. A note of caution was voiced against multiple-use interpretive maps because of the confusion they can cause. This topic is discussed further in "Cartographic constraints and implications" below.

9. Relationship between symbol and legend complexity and the expertise of the user
(Topic J)

An almost unanswerable question since few people could be quite sure how complex is complex, and what is costs. The question possibly arose at a time of frustration with the effect of the landform classification on map symbols. British Columbia remains adamant that "anyone can break down complex symbols if he has adequate legends" (and doesn't break down first?). Belair from the Quebec biophysical viewpoint is in agreement with this position since he does not expect any user to take a soil map and interpret it.

A majority of respondents dislike complex symbols because of the real problems of comprehension they create. After all, other pedologists are also users, and even some of them find the symbols hard to cope with.

The increased frequency of errors during compilation and the costly slowdown in compilation are real problems. So too is the obliteration of base map information, especially in inhabited areas where it is important. These points are discussed more fully below under the heading "Cartographic constraints and conclusions".

10. Do you seek to characterize "land" or "soil"?
(Topic K)

The landscape model can provide a more satisfying and complete synthesis of information and probably reduces the soil taxonomic component to its proper perspective, a "basic building block" (Dumanski). It may facilitate interpretations and land evaluation, and help avoid problems such as complex symbols. A majority of respondents embraced it, even without having any concrete proposal to chew on during the exchange of memos.

However, a significant number of pedologists have stated that they map soil rather than land. A few among them appear to have a concept of soil that is almost as broad as the concepts of land held by others. Many treat land elements descriptively rather than in the definition of mapping units.

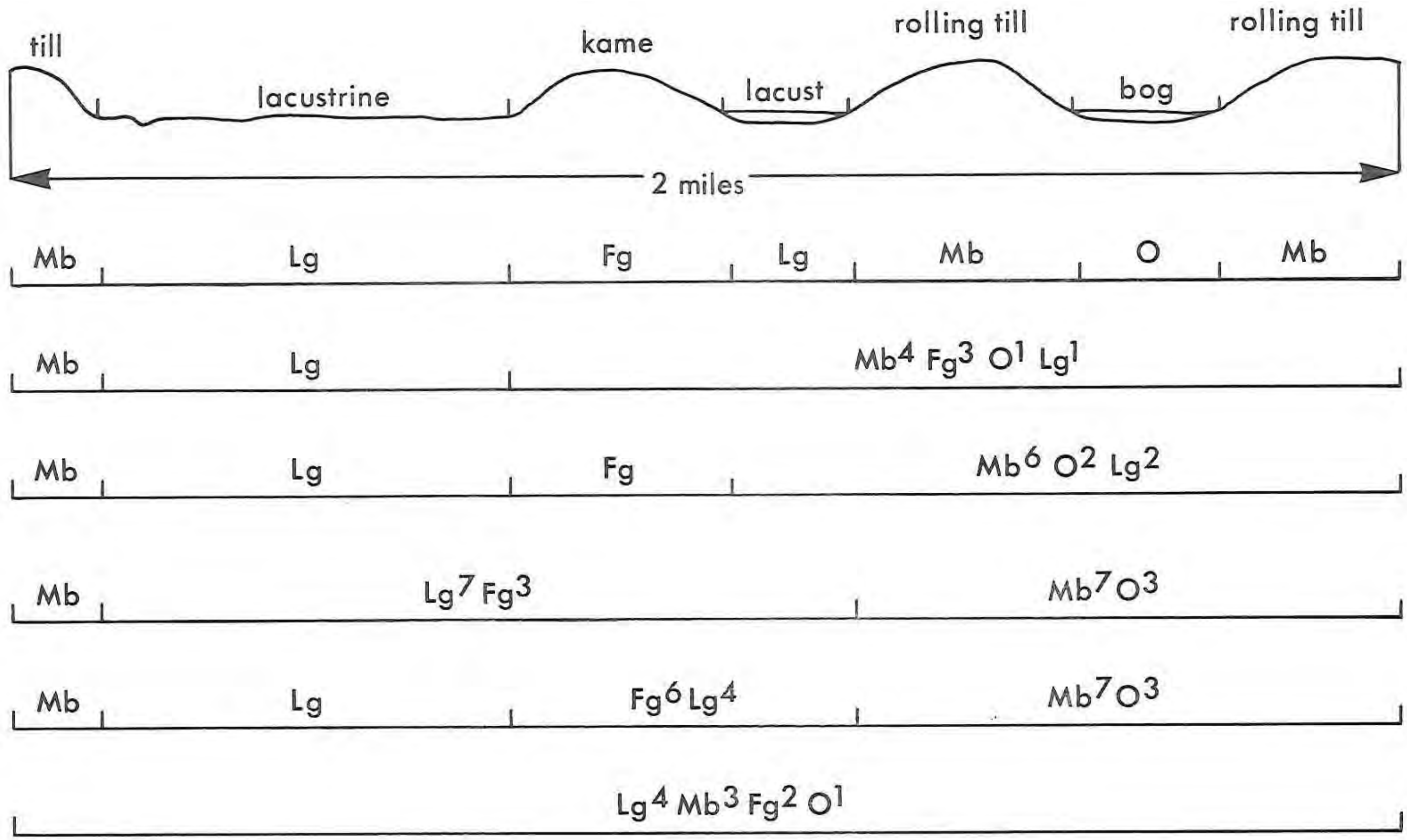
There is just about a concensus among respondents that low intensity surveys require a landscape approach, and some would reduce the significance of the soil taxonomic component in mapping units to negligible proportions.

One wonders if there is a problem in the landscape approach for those working in areas of subdued complex landforms that are patternless, or well camouflaged by forest. The geomorphic boundaries are frequently not self-evident, and the units themselves incorporate a number of classes from the landform classification scheme. The decisions as to which units should be complexed and delineated are not easy and the result may be very arbitrary soil geomorphic units. This is illustrated in the six options shown in Figure 1. The choice is strongly influenced by intensity of the survey and scale.

Landscapes that do not readily resolve themselves into neat units and easily perceived patterns could conceivably end up in a mess of dominant, subdominant and included landform classes. The advantages of this might be questioned, and a pragmatic mapper would probably simplify his symbols and omit some landform detail. Such complex landscapes confront the mapper in many parts of Canada.

Until perhaps five years ago we mapped the climate and landform by implication rather than directly as is now the growing custom. It remains to decide whether or not we will systematize the mapping of some of the other attributes of land.

Our position is that the national system of landform classification should be used as the framework within which soils should be mapped at all scales. It therefore may be concluded that vegetation, hydrology, man's activity and all other attributes of land should not be used as definitive characteristics.



Which is your choice for mapping at 1:125,000?

FIGURE 1 An example of options for mapping complex geomorphic landscapes

Only the soil-geomorphic aspects will be definitive. This in no way downgrades the importance of climate in mapping, because we believe it is adequately incorporated in the soil taxonomic system.

The other unmapped land attributes may be used descriptively to characterize mapping units.

11. Philosophy
    (Topic L)

Expressions of philosophy were not plentiful, but a few building blocks may be starting to take shape that could lead to a "body of philosophical principles and general conceptions" underlying soil survey. Among them are statements on the relationship of mapping and soil taxonomy, the landscape model and the hierarchical mapping system. These are discussed elsewhere.

CARTOGRAPHIC CONSTRAINTS AND IMPLICATIONS

The memorandum of Day, Kloosterman and Roberts (edited and reproduced in Appendix III) dated May 75 elicited only one response. This was rather disappointing but maybe too few understood the questions and their importance.

Part A of that questionnaire referred to the 60 byte memory capacity made up of 12 packages with four characters each, plus twelve separators.

When the questionnaire was circulated Ed Brandon had almost finished the program to remove the 12 package limit and to retain the 60 byte memory capacity. Within this constraint there is now no limitation to the CanSIS system, neither is there any limitation on the amount of prose-style description that can be accomodated in the legend. Two examples of the way long symbols can be handled are shown in Figures 2 and 3.

The 60 byte memory includes all symbol elements plus separators.

Part B of questionnaire. The maps in cartography at present have fairly simple landform terms and symbols. But the last report of the landform committee has generated a system that has the potential for much more complicated symbols. It can describe complex or combined landforms and materials, and their erosional modifiers, and has virgules and colons that inform the user of the proportions of each component. Three possible types of landform symbol are shown in Figure 4. They are taken from reports of Lord, Boydell and Acton. In each case we have added an imaginary map unit symbol to the denominator, as is usually done.

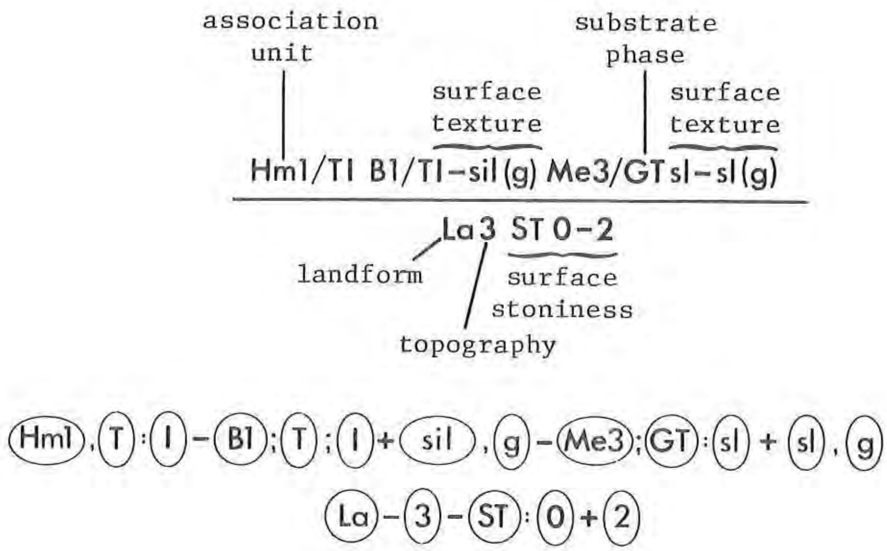
The major point we want to make here is that the Gradicon digitizing table in use has a keyboard similar to a typewriter with additional buttons or special signs. The signs are used to code instructions on where to place superscripts, colons, hyphens, subscripts, etc. that you might wish to use in these landform and soil symbols. But the number of choices is small and the commands have to be written by a programmer.

Most of our draftsmen are not skilled typists and do the hunt and peck routine while the monster chatters back through the teletype. One error, the bell rings and the kiss-off button (X OFF) flashes red.

This is the element of the problem on our minds when we asked about accuracy and acceptable error rates. Those who replied expected top accuracy. But complicated symbols require more time and care to enter.

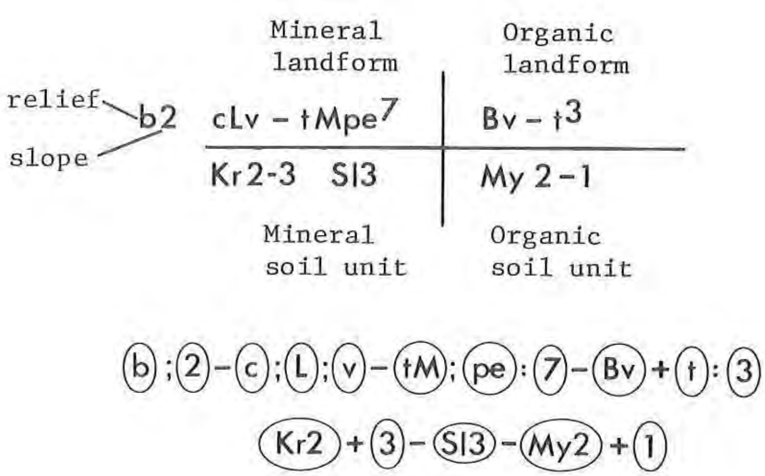
Part C of the questionnaire discussed the capability of the CanSIS map data system to accept additional categories of information, eg. vegetation and hydrology. It is possible, but the four symbol data files must have common polygons.

As an example let us use the Prince Albert National Park pilot project. We received a soil map, a vegetation map with symbols and line segments additional to those on the soil map, and a forest type map with symbols and line segments additional to the preceding two.



18 packages
47 bytes

FIGURE 2: Coding of long symbol for a soil-geomorphic unit.



16 packages
40 bytes

FIGURE 3: Coding of symbol for mineral and organic landforms

$$\frac{Ac^{8}\ Bu^{2}}{gm\ Mb\ //Mv-E=Ef}$$

Lord
Fort St. John

$$\frac{A^{5}\ B^{3}\ C^{2}}{Ss\ Mb5Rh3Cv\ b-d}$$

Boydell

$$\frac{A^{6} : B^{4}}{\frac{tG^{a}e}{G^{a}e}\ I-P^{a} : \frac{tG^{a}e}{G^{a}e}\ I-P^{a}}$$

Acton

FIGURE 4: Various types of landform symbol (denominator)

Hm1;T:l-B1;T;l+sil,g-Me3;GT:sl+sil,g/M-Mv-3-st:3
*PT:Vi:Gb:C * PT?7-SW!;?:

69 bytes
for 3 categories of
information

FIGURE 5: A possible symbol giving soil, vegetation and forest type data for a polygon from the Prince Albert National Park pilot project.

It is possible to add a few line segments to expand the soil polygon set, but it is very cumbersome if many segments are to be added. At the present time it is preferable to digitize the three complete maps separately and to treat the legends separately, because you must by now realize that 60 byte memory capacity is limiting. One of the possible discrete polygons coded with the three categories of information is shown in Figure 5. As you can see it requires more bytes than the total capacity: 69.

In the last part of the question asked it was stated that alternative types of symbols must be considered. The reasons are

1. ability to comprehend the information
2. legibility of map
3. cartographic cost

Three main choices are available to us, assuming that we wish to cover four categories of information, for example soils, landform, vegetation, and hydrology. The choices are

1. All inclusive, all comprehensive symbols arrayed in 4 point style.

(soil) Hml/TℓBl/Tℓ-sil(g)Me3/GTsl-sil(g)	(vegetation) Pt^{7}Swi^3
mMv2 St3 El R3 (landform)	Psc Vi Wsa 5 (hydrology)

This choice would quickly exceed the 60 byte capacity, more bytes create a higher error rate, require more programming and therefore increased time, cause minimum legibility of map base and map units, and require very simple legends. The polygons become increasingly smaller as more categories of information are added, but they are probably the easiest for a pedologist (author principally) to correlate.

2. Semi-connotative symbol

Hml-Me3 105	Pt 9
Mv2 7	PsWsa5

Here the generalized element of each category connotes only a limited amount of data and the numeric element leads into a portion of the semi-extended legend to provide extra details.

This method is considered preferable to choice 1 because the symbols are smaller with lower error rate and require less cartographic time, although they require nearly as much programmer time. The symbols are less connotative than choice 1 but more legible.

3. Totally nonconnotative symbols

S1051	V 91
L 76	H 52

This choice is preferable to the others because the cartographic error rate and the programmer input are both minimized and the legibility is superior. The legend must be all inclusive, but would not be longer than for either choices 1 or 2 for the description of the mapping individuals. However it would have to be more complex in order to describe each map unit. For example S1051 would refer to a part of the soil legend, H52 to part of the hydrology legend.

Summary

1. Based on our own prejudices and lack of experience, we prefer choice 2 with choice 3 close behind it.

2. We wish to stress that virgules, colons, semicolons, and dashes are used as separators in coding the map symbols. They must not be used at all in the map symbol itself.

3. We plead on behalf of draftsmen and programmers, to say nothing of the users of maps, for the highest possible degree of uniformity in the symbols. Pity the poor draftsmen and programmer.

4. Legends should be organized in tabular form, ordered internally by alphabetical or numerical sequence. Legends should be as connotative as possible, eg. use words (6 to 9% slopes) not classes (class 4 slopes).

5. If more than one category of information is displayed create a separate legend for each.

Interpretations in relation to scale and kinds of map units

Responses to topic G of the memo from Day dated 4th April 1975 covered the entire range from rating only the dominant soil component, to giving an average rating for all components in the map unit. There are real problems in this area that we suspect will be discovered once we undertake to prepare single purpose interpretive and rating maps.

Much of our current philosophy on ratings is drawn from the U.S. Guide for interpreting engineering uses of soils. We find these guidelines quite inclusive, and very satisfactory for rating mapping individuals, when the mapping individuals equates with the taxonomic soil series or phases of series. After all, the guidelines were developed as part of the standard progressive survey at 1:25,000 in the United States.

But the problem, briefly stated, is how to rate a map delineation when it includes dissimilar soil individuals, and phases based on differences in topography, stoniness etc. This kind of map delineation is commonly used at smaller scales (1:100,000-1:250,000), but can also be used at larger scales to depict inseparable contrasting mapping individuals. In either case we think it is quite unacceptable to give an average rating (eg. slight limitation plus severe limitation averages to moderate limitations) because it is unreal.

It may be slightly better to state the rating of the dominant component, but surely for some uses the subdominant component may be critical. Imagine a septic filter field on deep well-drained loam with sporadic subdominant rock outcrops. Or again, imagine rating the mass movement hazard of a morainal blanket with slopes covering the range from 30 to 50%.

We think one must express the probability of finding a certain limitation for use in the map unit. Our various systems of recording dominance of mapping individuals within the map unit do indeed record a probability, and therefore it is very logical in our view to report the interpretive ratings in the same way one reports the composition of the mapping unit.

eg. SV7 G3 70 percent well drained and 30 percent poorly drained clayey lacustrine soils

for septic field the rating would be

M7S V3 70 percent moderately severe and 30 percent very severe limitation due to slow conductivity or high water table.

This approach applies both to soil maps on which ratings of soil map units are given in tabular form and to single-purpose interpretive maps.

The pedologist must rate each soil individual. The computer print-out of symbols will be of great help in this operation. Once completed, the computer and plotter together will draw the interpretive map.

The computer will not likely impose any foreseeable constraint on the interpretive symbols; they are based on the 80 character card

ie. 20 for symbol plus 60 for interp rating
or 60 for symbol plus 20 for interp rating.

Editor's note: A description of the procedure for "Retrieving Interpretive Maps from the CanSIS Cartographic File" is included as Appendix IV to bring this discussion up to date (December 1977).

A SOIL MAPPING SYSTEM

McKeague in reviewing the history of soil classification points out the need for a system of classifying and naming soil mapping units in addition to a taxonomic system. Thirty or more years ago terms like "Soil Zone", "Soil Subzone", "Azonal", "Intrazonal", etc. were used to this end. Within the last five years another set of terms "Land Region", "Land District", "Land Type" etc. have been developed by some biophysical mappers. We conclude that a hierarchical classification has merit because it aims to give the soil-geomorphic pattern "predictive capacity which ultimately translates itself into a more rapid and better survey". It provides for the "definition of naturally occurring scientifically sound units that relate directly to the landscape, the scale of survey and the probable interpretations".

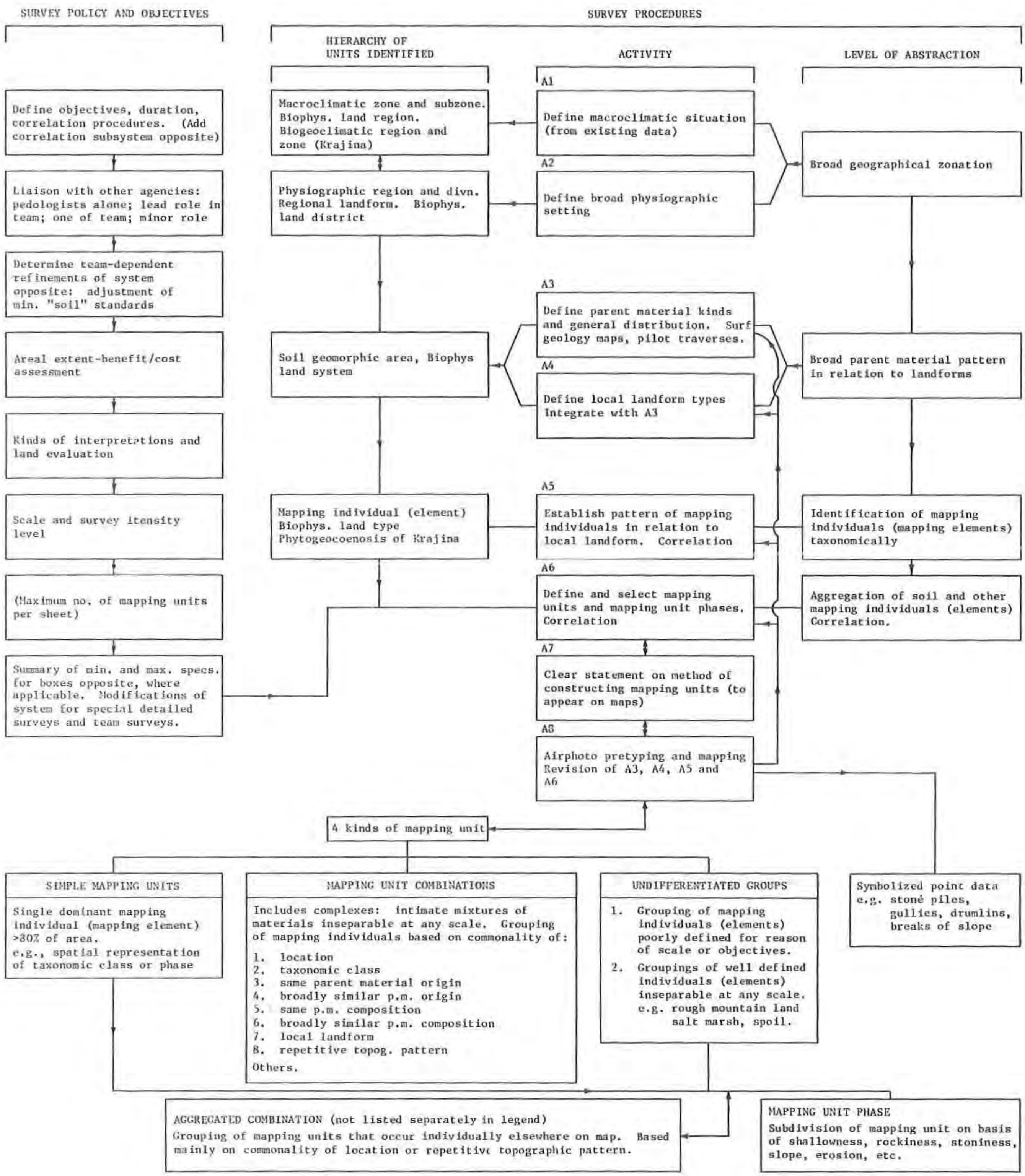
We have elaborated the proposals of Dumanski and Marshall into a soil mapping system which is depicted as a flow chart in Figure 6. It is designed as an aid to discussion, and puts the various elements of soil surveying in roughly their correct perspectives. With further refinement and the addition of minimum specifications for some of the boxes, it might be made into a formalized mapping system.

Commencing at the top of the diagram the system is represented as having two thrusts, one at the left depicting decisions on survey policy and objectives, and the other outlining survey procedures. These merge together in the selection and definition of mapping units.

The first thrust involves considering the kinds of interpretations to be made and the best ways of making them within the constraints of the size of the area. The scale and intensity of the survey and the possible maximum number of mapping units that might be recognized must also be considered. While it has been stated that the number of units should be limited for human comprehension, this would seem to apply more to published information and less to the inhouse documents on which interpretive published information is based.

The survey procedures portion is divided into sequential levels of abstraction that one passes through in focussing on the mapping individuals, and the activities leading to the successive establishment of a hierarchy of landscape and soil units that molds individuals into mapping units.

FIGURE 6: A SOIL MAPPING SYSTEM



REPORT OF THE SUBCOMMITTEE 4: SOIL WATER REGIMES

E.E. MACKINTOSH, CHAIRMAN

Background and Summary

A proposed system for describing "soil water regimes" was distributed to committee members for review in January, 1976. It is included as the last part of this report. The contents of this proposal was discussed at the C.S.S.C. meetings on Thursday morning, February 26th and the following section briefly summarizes the outcome of these discussions and, incorporates individual comments received by mail.

Briefly, consensus was reached by the group on the following points:

1. The system developed for describing "soil water regimes" in Canada should be based predominantly on site characteristics rather than taxonomic criteria.

2. The system should be refined and implemented over a period of years as criteria are developed and measurements become available. During the intervening period, the present soil drainage classification will continue to be used in conjunction with those segments of the new scheme which have been developed to a workable stage.

3. The proposed system should be modified by deleting the soil drainage classes and the hydrologic soil groups. Furthermore, considerable modification is required in adapting soil moisture regime subclasses for field use.

4. The guidelines for describing "soil water regimes" will consist of the following classes of information:

   i) Climatic criteria for subdividing the country into regions.
   ii) Landscape criteria for identifying discharge-recharge areas (to be developed).
   iii) Soil moisture regime classes based on modified soil family criteria to be used at the site level.
   iv) Soil transmissibility classes (equivalent to soil permeability classes) with the addition of a descriptor for lateral subsurface movement (horizontal transmissibility).
   v) Zones of water saturation.

Second Approximation for Guidelines to describe "Soil Water Regimes"

Climatic Criteria

1. It was generally agreed that the soil moisture subclasses developed for the soil climatic map of Canada were inadequate for use in differentiating moisture regions, particularly in B.C. and northern Canada. The present system should however be expanded, modified and developed in more detail for use at the soil family level.

2. Consensus was reached that regionalization of Canada was necessary for adequate descriptions of "soil water regimes", and that these criteria should be developed strictly from climatic information.

3. Development of further guidelines for climatic regionalization should continue, particularly with reference to the unique conditions in B.C. and northern Canada. Lavkulich and Tarnocai, respectively, are being contacted to develop further input in these areas.

Landscape Criteria

1. A need was expressed to develop a classification which would relate surface-subsurface hydrology to landscape position.

2. This system is in its infancy and W. Pettapiece has agreed to strike a small subcommittee to develop a proposal over the next few months.

Soil Moisture Criteria for the Site Level

1. These would parallel the guidelines established for soil families (Proc. 9th C.S.S.C. Meeting, Saskatoon, 1973). However modifications in the temperature and moisture subclasses are necessary to fit British Columbia and northern Canada conditions.

2. Further, the soil family criteria should be modified to include quantifiable soil characteristics such as porosity, pore size distribution and depth of the control section.

3. Individuals will be contacted for further ideas and contributions in this area.

Soil Transmissibility Classes

1. The term permeability was replaced by transmissibility, otherwise the written definitions remain the same.

2. It was suggested that the number of quantitative classes (vertical transmissibility) be expanded to coincide with the U.S.D.A. system and these are as follows:

		cm/hr	in/hr
Low	very slow	<0.15	<0.06
	slow	0.15-0.50	0.06-0.2
Medium	moderately slow	0.5-1.5	0.2-0.6
	moderate	1.5-5	0.6-2.0
	moderately rapid	5-15	2.0-6.0
High	rapid	15-50	6.0-20
	very rapid	>50	>20

3. A need was identified to have an additional descriptor added for horizontal transmissibility and several individuals will be contacted to participate in this phase.

Zones of Water Saturation

1. Only minor alterations were made to this section: "apparent" was replaced by observed which now reads "observed water table"; and two classes were tentatively developed for origin of water, ie. telluric and stagnant. Development of definitions to describe these two classes are required.

2. Concern was expressed by several individuals over the distinction between surface water gleys and ground water gleys. It was generally felt that they could be differentiated and accommodated within the "zones of water saturation". Jerry Beke, together with his Maritime colleagues, has volunteered to prepare a report suggesting procedures for their inclusion. Karel Michalica has already prepared a draft and this could be used as a starting point.

PROPOSED SYSTEM FOR DESCRIBING 'SOIL WATER REGIMES'

Background

The scheme for describing soil moisture and drainage is similar to that described in Appendix I of the report of the C.S.S.C. subcommittee on soil water regimes given at the Meeting of the C.S.S.C. at Saskatoon in 1973. This scheme consists very much of what has traditionally been considered as soil drainage, except that regional aspects of soil moisture are included, as are criteria for describing zones of water saturation (water table). Internal drainage is replaced by soil permeability classes and surface run-off is handled by a hydrologic soil group.

There is need to modify the traditional approach to soil drainage because of several considerations. Firstly the traditional scheme does not differentiate adequately between water availability and permeability. For example a very permeable, coarse gravelly soil occurring in a wet depression would have to be classed as very poorly drained. Secondly the traditional approach does not indicate regional moisture differentiation as a function of precipitation. For example, a rapidly drained site occurring in a wet coastal zone would receive much more water from precipitation than would a similar site in a dry interior or continental zone. Thirdly, the present drainage classification does not distinguish between external (surface) drainage and internal (profile) drainage. Thus, a well drained lacustrine clay soil on gently rolling topography may have good surface drainage but its internal drainage may be restricted by permeability. Many more examples could be found, but these three indicate that there are macro and micro as well as internal and external elements in soil moisture and drainage, and that these should be recognized.

The total scheme consists of five parts: 1) soil moisture regime subclasses; 2) soil drainage classes; 3) soil permeability classes; 4) zones of water saturation and 5) hydrologic soil groups. The first relates to the moisture regime subclasses of the soil climate map of Canada, and provides a statement on regional moisture conditions. These are intended for use at regional levels and should not be confused with local or site drainage classification. It is intended that all subsequent descriptions of 'soil water regimes' be made with reference to a soil moisture subclass. The second is a redefined adaption of present soil drainage classes; this provides a statement on soil site drainage. The third, soil permeability classes, relates to the potential of a soil to transmit water internally. Permeability is independent of field moisture and is therefore independent of climate (moisture regime) and drainage class. The fourth, zones of water saturation, classifies soils according to depth to water table, kind of water table, time of year that the water table is highest and the source of water. Zones of water saturation augment the drainage and perviousness classes. The fifth, hydrologic soil groups, is adopted from the Soil Conservation Service of the U.S.D.A. and is intended to substitute for surface runoff classes. Its inclusion allows one to estimate runoff from small watersheds. The scheme therefore allows for a five stage statement on soil moisture and drainage, ranging from a regional moisture assessment (moisture regime), to the ability of a soil to transmit water (soil permeability class).

Soil drainage classes are defined in terms of available water storage capacity and source of water. Soil drainage in a dynamic sense refers to the rapidity and extent of the removal (relative to the addition) of water from soil. It is affected by a number of factors acting separately or in combination, including texture, structure, gradient, length of slope, water holding capacity, evapotranspiration.

Soil permeability classes are introduced to eliminate confusion between drainage and permeability. In that they refer to the potential of a soil to transmit water internally, they are inferred from characteristics of the soil such as structure, texture, porosity, cracks, and shrink-swell properties. They are closely related to measures of saturated hydraulic conductivity, percolation rate, infiltration rate, etc., but these are reserved for actual measurements using standard techniques. Permeability can apply to a soil or a horizon. In this case it is meant to apply to a soil, in which case the class is controlled by the water-transmitting potential of the least permeable layer in the soil.

Hydrologic soil groups are used in estimating runoff from small water sheds. Flood prevention work, for example, uses estimates of the amount of runoff from streams of expected intensity for design of structures and for water control practices. The potential of the soils of a watershed to permit the entry of water at the surface and to transmit it internally, is one of the important factors affecting runoff. The hydrologic soil groups are determined according to their infiltration and transmission rates.

Runoff refers to the loss of water from an area by flow over the surface. The amount and rate of runoff depends on several factors, including: 1) the duration and intensity of the rainfall; 2) anticedent moisture conditions; 3) surface cover; 4) the physical capacity of the soil to take in and dispose of water internally, and 5) topography. Estimation of the amount of runoff from individual kinds of soil require consideration of all of these factors. Because of the qualitative nature and extreme variations in some of these parameters it is questionable whether runoff classes serve a useful purpose. Furthermore, many of the inferences they support can be made from hydrologic groups, permeability classes and drainage classes.

The Classification Scheme

Ideally, all categories of the scheme should be defined quantitatively. However, the necessary data and monitoring systems to define and use such a system are lacking. Thus the proposed scheme is mainly qualitative but it can be used until data are collected.

1. Soil moisture regime subclasses
   (from soil climate classification)

Aquic Regime

Soil is saturated for significant periods of the growing season.

Peraquic

Soil saturated for very long periods. Ground water level at or within capillary reach of the surface.

Aquic

Soil saturated for moderately long periods.

Subaquic

Soil saturated for short periods.

Moist Unsaturated Regime

Varying periods and intensities of water deficits during the growing season.

Perhumid

Soil moist all year, seldom dry. No significant water deficits during the growing season. Water deficits 0-<2.5 cm (<1 inch). Climate moisture index >84.

Humid

Soil not dry in any part as long as 90 consecutive days in most years. Very slight deficits in growing season. Water deficits 2.5-<6.4 cm (1-<2.5 inches). Climatic moisture index 74-84.

Subhumid

Soil dry in some parts when soil temperature is >5°C (>41°F) in some years. Significant deficits within growing season. Water deficits 6.4-<12.7 cm (2.5-<5.0 inches). Climatic moisture index 59-73.

Semi-arid

Soil dry in some parts when soil temperature is >5°C (>41°F) in most years. Moderately severe deficits in growing season. Water deficits 12.7-<19.1 cm (5.0-<7.5 inches). Climatic moisture index 46-58.

Subarid

Soil dry in some parts or all parts most of the time when the soil temperature is >5°C (>41°F). Some periods as long as 90 consecutive days when the soil is moist. Severe growing season deficits. Water deficits 19.1-38.1 cm (7.5->15 inches) in BOREAL and CRYBOREAL classes, 19.1-<50.8 cm (7.5-20 inches) in MESIC or warmer classes. Climatic moisture index 25-45.

Arid

Soil dry in some or all parts most of the time when soil is >5°C (>41°F). No period as long as 90 consecutive days when soil is moist.

Very severe growing season deficits. Water deficits >38.1 cm (15 inches) in BOREAL and >50.8 cm (20 inches) in MESIC or warmer classes. Climatic moisture index <25.

Xeric

Soil dry in all parts 45 consecutive days or more within the four month period (July to October) following the summer solstice in more than 6 years out of 10. Soil moist in all parts for 45 consecutive days or more within the four month period (January to April) following the winter solstice in more than 6 years out of 10.

Quantitative Climate

Aquic Regime	Moisture Deficits (cm)	CMI
Peraquic	-	-
Aquic	-	-
Subaquic	-	-

Moist Unsaturated Regime	Moisture Deficits (cm)	CMI
Perhumid	<2.5	>84
Humid	2.5-<6.4	74-84
Subhumid	6.4-<12.7	59-73
Semiarid	12.7-<19.1	46-58
Subarid	19.1-<50.8	25-45
Arid	>50.8	<25
Xeric	-	-

Arid and Zeric subclasses are not believed to occur extensively in Canada but may be found in local areas of microclimate.

CMI - Climatic moisture index is an expression of the percentage contribution of growing-season precipitation to the total amount of water required by a crop if lack of water is not to limit its production.

2. <u>Soil drainage classes</u>
(from C.S.S.C., 1973)

Very rapidly drained

Water removed from the soil very rapidly in relation to supply. Excess water flows downward very rapidly if underlying material is pervious. There may be very rapid subsurface flow during heavy rainfall provided there is a steep gradient. Soils have very low available water storage capacity (usually <2.5 cm (1 inch)) within the control section and are usually coarse textured and/or shallow. Water source is precipitation.

Rapidly drained

Water removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep gradients during heavy rainfall. Soils have low available water storage capacity (2.5-3.8 cm (1-1.5 inches)) within the control section, and are usually coarse textured and/or shallow. Water source is precipitation.

Well drained

Water is removed from the soil readily but not rapidly. Excess water flows downward readily into underlying pervious material or laterally as subsurface flow. Soils have intermediate available water storage capacity (3.8-5 cm (1.5-2 inches)) within the control section, and are generally intermediate in texture and depth. Water source is precipitation. On slopes subsurface flow may occur for short durations but additions are equalled by losses.

Moderately well drained

Water is removed from the soil somewhat slowly in relation to supply. Excess water is removed somewhat slowly due to low perviousness, shallow watertable, lack of gradient or some combination of these. Soils have intermediate to high water storage capacity (5-6.2 cm (2-2.5 inches)) within the control section and are usually medium to fine textured. Precipitation and significant additions by subsurface flow are necessary in coarse textured soils.

Imperfectly drained

Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Excess water moves slowly downward if precipitation is major supply. If subsurface and/or ground water is main source, flow rate may vary but the soil remains wet for a significant part of the growing season. Precipitation is main source if available water storage capacity is high; contribution by subsurface and/or groundwater flow increases as available water storage capacity decreases. Soils have a wide range in available water supply, texture and depth, and are gleyed phases of well drained subgroups.

Poorly drained

Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen. Excess water is evident in the soil for a large part of the time. Subsurface flow and/or ground water flow in addition to precipitation are main water sources; there may also be perched water table with precipitation exceeding evapotranspiration. Soils have wide range in available water storage capacity, textures and depth, and are gleyed subgroups, gleysols and organics.

Very poorly drained

Water is removed from the soil so slowly that the watertable remains at or on the surface the greater part of the time the soil is not frozen. Excess water is present in the soil the greater part of the time. Ground water flow and subsurface flow are major water sources.

Precipitation is of lesser importance except where there is a perched watertable with precipitation exceeding evapotranspiration. Soils have a wide range in available water storage capacity, texture and depth, and are either gleysolic or organic.

Quantitative Limits

	Available Water Storage capacity (cm)
Very rapidly drained	<2.5
Rapidly drained	2.5-3.8
Well drained	3.8-5.0
Moderately well drained	5.0-6.2
Imperfectly drained	Variable
Poorly drained	Variable
Very poorly drained	Variable

3. Soil permeability classes
(abridged from preliminary write-up for the revised USDA-SCS soil survey manual)

High permeability

The capacity to transmit water vertically is so great that the soil would remain wet for no more than a few hours after thorough wetting if there were no obstructions to water movement outside the body classified. The horizons and soils have large and continuous or connecting pores and cracks that do not close with wetting. Many, but not all, fragmental, sandy, skeletal soil bodies provide these conditions, as do some medium and fine textured horizons that have extremely strong, granular structure and large, connecting pores.

Moderate permeability

The capacity to transmit water vertically is great enough that the soil would remain wet for no more than a few days after thorough saturation if there were no obstructions to water transmission outside the body classified. Most moderately pervious soils hold relatively large amounts of water against the force of gravity, and are considered good, physically, for rooting and supplying water to plants. Soil horizons may be granular, blocky, weakly platy or massive (but porous) if continuous conducting pores or cracks are present which do not close with wetting.

Low permeability

The potential to transmit water vertically is so low that the horizon or the soil would remain wet (saturated) for periods of a week or more after thorough wetting whether or not there were obstructions to water movement outside the body classified. The soil may be massive, blocky or platy, but connecting pores that could conduct water when the soil is wet are few, and cracks or spaces among peds that may be present when the soil is dry close with wetting. Roots are usually few or absent, even in positions accessible to them, and if present, they are localized along cracks when the soil is wet.

Suggested Quantitative Limits

Name	inches/hour	cm/day
High	2->20	121.9->1200
Moderate	0.2-2	12.5-121.9
Low	<0.2	<12.5

Each subclass can be further subdivided as required.

4. Zones of water saturation
(in part from preliminary write-up for the revised USDA-SCS soil survey manual)

A seasonal high water table is a zone of saturation at the highest average depth during the wettest season. It is at least 15 cm (6 inches) thick, persists in the soil for more than a few days, and occurs within 2 m of the soil surface. Most water tables occur within the soil and are measured from the surface of the soil down to the free-water level. In swamps and marshes, however, the water table is above the surface of the soil much of the time and the water table is measured from the surface of the water down to the soil surface.

Soils that have seasonal high water tables are classified according to depth to the water table, kind of water table, time of year that the water table is highest and the origin of the water.

Depth

Depth of seasonal high water table from the soil surface should be given in metres. The range from the soil surface should reflect the year to year variation in average highest depth. Depth to water table within the soil should be recorded with the small number first, eg. 2-3. Water table above the soil surface should be used for marshes and swamps and should be recorded with the large number first, eg., 2-0.5.

Kind

Three kinds of seasonal high water table are recognized within the soil: apparent, perched, and artesian. Another kind is above the soil surface much of the time as in marshes and swamps.

Apparent water table is the level at which water stands in a freshly dug unlined borehole. It is influenced by the hydrostatic pressure of soil water and by pressure at greater depths penetrated by the borehole, water relations across impermeable layers, and other factors. In the absence of evidence that would permit greater specifity, therefore, the term apparent water table should be used for the level at which water stands in an uncased borehole after adequate time for adjustment in the surrounding soil.

Perched water table is one that exists in the soil above an unsaturated zone. A water table may be inferred to be perched on the basis of general knowledge of the water levels of an area, the landscape position, the permeability of soil layers, and from other evidence. To prove that a water table is perched, it is necessary to observe the water levels in cased wells placed above, in, and below the less permeable layer. If the water in the well above the less permeable layer is consistently higher than the other two, the water table is perched.

Artesian water table is one that exists under hydrostatic head beneath an impermeable layer; when the impermeable layer has been penetrated by a cased borehole the water rises. The final level of the water in the cased borehole may then be characterized as an artesian water table.

Areas with water tables above the surface of the soil much of the time are characterized as marsh or swamp--marsh having herbaceous vegetation and swamps having woody vegetation.

Time

The percent time that the water table persists at the 30 cm, 90 cm and 150 cm depth on a yearly basis and on a growing season basis should be recorded.

Origin of water

This class is used to differentiate between those soils that may be saturated with water for long periods, and yet maintain a high redox environment as opposed to those in which reducing (oxygen deficient) conditions predominant. The former conditions are often associated with medium to coarse textured soils on sloping topography where lateral subsurface water flow is prevalent.

Specific subclasses are not proposed at this stage.

5. Hydrologic soil groups
(after SCS, USDA)

A. (Low runoff potential). Soils having high infiltration rates even when thoroughly wetted. These consist chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission in that water readily passes through them.

B. Soils having moderate infiltration rates when thoroughly wetted. These consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C. Soils having slow infiltration rates when thoroughly wetted. These consist chiefly of soils with a layer that impedes downward movement of water or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

D. (High runoff potential). Soils having very slow infiltration rates when thoroughly wetted. These consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

REPORT OF SUBCOMMITTEE 5: LANDFORMS

A.N. BOYDELL AND D.F. ACTON

A proposed system of landform classification for Canada was described. The system was adopted for use by the Canada Soil Survey Committee and will be published as Chapter 17 in Canada Soil Survey Committee 1978, The Canadian System of Soil Classification. Can. Dept. Agric. Publ. 1455. Revised. Supply and Services Canada, Ottawa, Ont.

The system as used in British Columbia was published as - Staff of the Resource Analysis Unit 1976. Terrain Classification System. E.L.U.C. Secretariat, Victoria.

REPORT ON CRYOSOLIC SOILS

W.W. PETTAPIECE AND C. TARNOCAI

A proposed classification of Cryosolic soils was presented. Amendments were suggested during the discussion and in subsequent correspondence. As a result the "Cryosolic order" has been adopted for use and is included as Chapter 6 in Canada Soil Survey Committee 1978. The Canadian System of Soil Classification. Can. Dept. Agric. Publ. 1455. Revised. Supply and Services Canada, Ottawa, Ont.

APPENDIX I

MEMORANDUM

TO All Members of CSSC

FROM J.H. Day
National Soil Correlator
Soil Research Institute

Date 4 April 1975

SUBJECT Meeting of Subcommittee (17) on Mapping Systems, Units and Legends

In a letter dated 9/1/75 it was proposed to establish a subcommittee to investigate intensively principles and practices used in the establishment of mapping units and legends, in order to: (1) have on record clear statements of the various procedures being used in Canada; (2) serve as a basis for decisions on the most appropriate procedures to use for various purposes. It was also suggested that Nowland, Shields and Day would act as co-chairmen.

This proposal was accepted by most of the few respondents. The time suggested was for fall after mid October, preferably in sequence with soil water regimes subcommittee. Given these requirements and those of holidays and space the proposed time is October 6-8 soil water regime, October 9-10 mapping systems units and legends. Location - Guelph. Confirmation of these dates is requested.

The attendance at these workshops will necessarily be somewhat restricted by space and funds available. The reason for consecutive sessions is to include a reasonable number of persons and to minimize travel costs when possible. It is recommended that officers in charge designate persons to participate taking into consideration: (a) work responsibility or project; (b) experience.

Topics that should be reviewed by provincial groups are listed below. The review should begin now, and a report should be prepared by each group in a format suitable for early circulation to all groups.

A. Relationship of mapping units to the taxonomic system. At what level in the system are the map unit components classified at scales 1:25,000, 1:50,000-1:125,000, 1:250,000?

B. How are the map units and components shown on the map and described in the legend: Is the symbolization complex with simple legend, or the reverse?

C. Degree of incorporation of geomorphological units into the symbols and legend.

D. Degree of incorporation of climate or vegetation zonation into the mapping unit: definitive or descriptive?

E. Method of incorporating stoniness, topography, and erosion into the symbol and in the legend.

F. Method of handling complexes - "pure" oversimplified mapping units with assumptions noted in footnotes or elsewhere - or "honesty with vagueness" approach, ie., indicative rather than specific delineations to show all things that occur within the units and how to recognize them, but not exactly where they are.

G. Relative interpretability of different types of mapping unit. How can interpretation ratings be shown on maps given either complex symbols and short legend, or simple symbols and complex legend?

H. What unique problems does the level of survey intensity pose for construction of symbols and legends?

If we refer to intensities of surveys as follows:

Order 1	<1:12,000
Order 2	1:12,000 - 1:31,680
Order 3	1:31,680 - 1:125,000
Order 4	1:125,000 - 1:300,000
Order 5	1:300,000 - 1:1,000,000

What in your view should be the taxonomic level used and the types of complex groupings shown in map units and map legend at each of these scales?

I. Describe, if possible the relationship between map symbol or legend complexity and the degree of expertise required by different categories of users. Is it reasonable to expect all users to understand and utilize the more complex kinds of symbols?

J. What level of cartographic errors and costs are you willing to accept in order to have the more complex symbols used on your map?

K. What is your view of "land" and "soil"? Do you seek to characterize one more than the other: if so, why?

L. If possible, write a paragraph stating the philosophy that underlies your responses to the previous questions:

Philosophy can be defined as:

1. a body of philosophical principles or general conceptions underlying a given branch of learning, a major discipline, or a human activity, and the application of it.

2. an integrated and consistent personal attitude toward life or reality expressed in beliefs or principles of conduct.

Please write about any other related matter that has been omitted. Please return responses by May 30 so that we can circulate all at the same mailing.

APPENDIX II

THE CONCEPT AND UTILIZATION OF THE SOIL ASSOCIATION IN SASKATCHEWAN*

J.G. Ellis
Saskatchewan Institute of Pedology
University of Saskatchewan
Saskatoon, Saskatchewan

The Concept of the Soil Association in Saskatchewan

The concept of the Soil Association (1) has greatly influenced soil mapping in western Canada (9), (14). In 1945 it was adopted by the National Soil Survey Committee (2), (9) - a body representing all soil survey organizations in Canada. On July 4, 1969 the name of the aforementioned committee was changed to the Canada Soil Survey Committee (3). Those familiar with the Association and Catena concepts will have read their interpretation by such soil scientists as Milne (4), Bushnell (5), (6), Glentworth (7), Winters (8), Moss (9) and Simonson (10). These people published their concepts in scientific soil journals dating from the years 1935 to 1971. It is somewhat surprising, in view of the fact that the concept of the Association was accepted by the C.S.S.C. in 1945, that fundamentals of the Association concept which were described in 1932 (1) are so unfamiliar to some Canadian soil scientists and many soil scientists in other parts of North America.

The concept of the Association, as it was presented by the late Dr. J.H. Ellis to the Soil Group Section of the C.S.T.A. in 1931 at their 11th Annual Convention in Guelph and later published in Scientific Agriculture, Volume XII in 1932, is as follows, "The basis of the scheme is the grouping together into a category called an "association", the genetic soil types or "associates" which are found together on the same geological parent material in any given physiographic region. The associations which are found in any given physiographic region constitute a combination, and the combinations in a climatic soil region or belt, constitute a zone." Thus, the categories from broadest to the narrowest, are:

1. The Soil Zone
2. The Combination
3. (a) The Association and (b) The Associates
4. The Phases

The Soil Zone

The Soil Zone is a refinement or a subdivision of the Soil Region. The Soil Region is used for very broad separations such as the Grassland Region, Forest Region, Tundra Region, Pre-Cambrian Region, etc. For more detailed divisions the Grassland or Chernozemic Regions can be subdivided into the Brown, Dark Brown, Black and Dark Gray Soil Zones. The Forest

*Submitted as part of a reply dated 12th January 1976 to memos from J.H. Day dated 4th April and 19th December 1975.

Regions can be subdivided into the Luvisolic, Brunisolic and Podzolic zones. The Tundra Regions and Pre-Cambrian Regions, except in rare cases, are not subdivided on the basis of zonality because of the lack of climatic data and the time and costs involved to identify pockets or islands of Brunisolic, Luvisolic, Podzolic, and other soils which have a zonal connotation. These Regions are mainly subdivided on the basis of combined or contrasting soil formations on the various parent materials contained in or forming the various physiographic divisions within the respective Regions.

The zonal identification is considered the initial step at the start of either broad or detailed surveys. The identification of soil zones is based on the effect of climate and vegetation and their delineation within a map area is a necessary orientation procedure. Today, workers utilizing the Bio-Physical Land Classification System for the classification of Forest Lands and associated Wetlands (11) refer to the concept of Soil Zones as Bio-Climatic zones and delineate Land Regions on this basis.

The Combination

"The Combination is based on the physiographic regions within the zone". (1) All soils developed in a given physiographic region constitute a combination. A soil zone may cross a number of physiographic regions and each physiographic region (or division) will have its own combination of soils.

The Bear Hills Combination occurs in the northwest corner of the west half of the Rosetown Map Sheet, 720 (12). This Combination consists of Dark Brown zonal soils developed on a gently to strongly rolling morainic plain containing local silty and sandy glacio-lacustrine plains. The morainic plain slopes from approximately 725 m (2375 feet) on the west to approximately 610 m (2000 feet) along its eastern boundary. There is limited external drainage and in the interior the local drainage is to the depressional areas.

The identification and description of the physiographic divisions within each soil zone of a map area results in a knowledge of the landforms, relief patterns, drainage patterns, surficial geological deposits and vegetation patterns. Postulations can now be made regarding the soil combinations which occur within each physiographic region. The Combination concept is analogous to the concept described in the Guidelines for Bio-Physical Land Classification for the delineation of "Land Districts".

The Association

"The Association is based on geological parent material" (1). The establishment and separation of Soil Associations therefore requires the identfication and delineation of the various surficial geological deposits (parent materials) within each physiographic division in each soil zone in the map area.

"An Association includes the genetic soil types (great groups, subgroups) or Associates (series) found in association on a given parent material. In each Combination (physiographic region) within a given Soil Zone soils are developed on different parent materials" (1). Soils on different parent materials in the same zone constitute different Associations as do soils on similar parent materials in different zones.

In the Bear Hills Combination the dominant parent material, in this portion of the Dark Brown Soil Zone, is unsorted glacial till which occurs on rolling morainic plains. Interspersed throughout the moraine are local areas of sandy glacio-lacustrine materials which overlie modified and unsorted glacial tills. There are also local areas of silty glacio-lacustrine materials which overlie modified and unsorted glacial tills. Therefore, within the Bear Hills Combination in the Dark Brown Soil Zone three different parent materials occur, namely unsorted glacial till, sandy glacial-lacustrine deposits over tills and silty glacio-lacustrine deposits over tills. These parent materials are designated as the Weyburn, Alert and Keppel Soil Associations respectively.

The "Land System" concept presented in the Guidelines for Bio-Physical Land Classification is not unlike the Association concept.

The Associate

The Associates within the Association are genetic types which may be classified at the Great Group or Subgroup level. Thus a Chernozemic Association could contain Rego, Calcareous, Orthic, Solonetzic, Eluviated and Solodic Associates. The Associates on a given parent material in a given Soil Zone are largely the result of the topographic conditions (slope, aspect, frequency) and local environment (internal and external drainage conditions, atmospheric climate and soil climate). It is suggested that, in an area of uniform climate and uniform parent material, the amount of moisture entering the soil, and effecting the soil climate and subsequent soil development, is determined to a large extent by local relief.

Relief is a fundamental factor in the determination of some local soils. A soil in the normal well-drained position will be determined chiefly by the regional climate. Local variations in topographic position, however, such as knolls, slopes and depressions, will result in soil climates which differ from the normal regional soil. If, with the exception of level or flat landscapes, the rainfall in an area is in excess of that which can infiltrate the soil the excess moisture will move from the highs downslope and collect in the depressions. The movement of excess moisture downslope is accelerated by an increase in slope or increase in relief between the highs and lows throughout the landscape. The moisture regimes and subsequent expressions of soil development throughout the landscape from highs to lows are therefore different at various sites along the slope - with the highs being locally arid compared to the mid-slopes and the lows being locally humid. It is assumed that the mid-slope position represents the well drained sites and the soils in these positions best reflect the soil development caused by the regional environmental conditions. Along the slope there are varying expressions of soil development, as reflected in the soil profile, which may be classified according to the characteristics expressed. There is no abrupt beginning or ending to each specific profile at a particular site on the slope but each different profile blends one into the other and each is in equilibrium with the soil forming factors at that site. Each of the various soil profiles are referred to as Associates. The number of Associates separated in any Association depends on the detail desired. Some maps record the delineation of only the dominant (12) Associate; others the dominant and significant (12) Associates; others each individual Associate, and finally highly detailed maps record finer distinctions where subdivisions within Associates are noted and separated as Phases.

The Associate concept has been utilized in Bio-Physical Classification to delineate "Land Types".

The Phase

The Phase is a subdivision within the Association. If a particular Associate is selected as that which best reflects the regional climatic environment then other Associates which exhibit slightly dissimilar characteristics, such as being shallower or deeper, may be separated out as shallow Phase or deep Phase. The Canadian Soil Classification makes provision for saline phases, carbonated phases, grumic phases, gleyed phases and lithic phases. The delineation of phases would only occur on highly detailed large scale soil maps which cover restricted areas and are utilized for specific purposes.

The Use of the Soil Association in Saskatchewan

The Association is defined and used in Saskatchewan as follows, "The Association is a group of related soil series (Associates) developed on a particular parent material and occurring in a given Soil Zone" (12). Therefore a change in a) the group of related soil series, or b) the nature of the parent material, or c) the Soil Zone would necessitate the establishment of a new Association. When Associations are established in Saskatchewan they are given a geographical name which usually indicates the locality within the province where the Association was first encountered.

The following examples are given to illustrate how Soil Associations are used in Saskatchewan. A group of related Chernozemic soil series occur on glacial till in the Brown Soil Zone. The group of related soil series may contain one or more or all of the following Subgroup profiles, Orthic, Rego, Calcareous, Eluviated, Solonetzic and Solodic. Some of these Subgroup profiles may be saline, carbonated or gleyed. Areas of badly eroded knolls, which prior to cultivation, were formerly Rego, Calcareous or Orthic Subgroup profiles are classified as Orthic Regosols, because they no longer possess a Chernozemic Ap horizon, and are considered to be part of the Association. Gleysolic Subgroup series in the poorly drained depressions are also considered to be part of the Association. It could be logically argued that the Gleysolic series are azonal and should not be included in the Association. Saskatchewan pedologists have often contemplated deleting these soils from the Association but have not as yet taken this step, firstly, because of complicating the soil map from the layman's point of view, and secondly because the parent material in the depressions represents depositional material from the upslope positions and therefore is related to the glacial till material along the slope.

The Haverhill Association consists chiefly of Chernozemic Brown soils of medium to moderately fine texture developed on unsorted glacial till.

The Haverhill Association contains the following soil series: Orthic Brown, Calcareous Brown, Eluviated Brown, Orthic Regosols, salinized or carbonated phases of the aforementioned series, and several series of Gleysolic soils.

The Orthic Brown is the dominant series and occurs on the well-drained intermediate slopes.

The Calcareous Brown series occurs on the upper slopes and knolls or ridges above the Orthic series. Eroded Calcareous Brown series, which appear as whitish coloured knolls or ridges in cultivated fields, are referred to as Orthic Regosol series. This latter series also occurs on the knolls or ridges of uncultivated landscapes where due to the excessive aridity of the site there has been little or no profile development.

The Eluviated Brown series occurs below the Orthic Brown, on lower and more gentle slopes. Eluviated Brown series are most common on undulating topography where slope lengths are longer and less steep than those in high frequency undulating landscapes.

Salinized or carbonated phases of the Orthic, Calcareous and Eluviated Brown series occur in the same positions throughout the landscape as their normal counterparts described previously.

The Gleysolic series occupy the undrained depressions (sloughs) and flat lands occurring in the poorly drained lower areas. Several series of Gleysolic soils may occur in a depression but in most instances the area occupied by each series is too small to be significant as a mapping unit.

The distribution of the various series and their areal extent and occurrence is dependent on local relief. There is an increase in locally arid profiles and locally humid profiles with an increase in relief.

The current mapping program in Saskatchewan is published at a scale of 1 inch to 2 miles or 1:126,720. At this scale the separation of Map Units within an Association is readily accomplished. A Map Unit is a portion or segment of a Soil Association composed of Series or Series Complexes. A Series is a particular Subgroup profile on a particular parent material and a Series Complex is a grouping of particular Subgroup profiles. As mentioned previously the occurrence and extent of the Series or Series Complexes are related to the changes in relief. A Series or Series Complex is considered to be Dominant when it occupies over 40% of the Map Unit and is Significant when it occupies over 15%, but not more than 40%, of the Map Unit. In the Haverhill Association the following Map Units have been established in the Rosetown Map Area (12).

Hr1 - Dominantly Orthic Brown occurring on knob and kettle roughly undulating and dissected gently sloping topography. Nearly all this map unit whether it occurs alone or in complex with map units of other Associations is cultivated. Hr1 represents the best areas of Haverhill soils.

Hr2 - Dominantly Orthic Brown, with significant combinations of Calcareous Brown and Orthic Regosol series, and a significant amount of

Gleysolic soils. This map unit occurs mainly on morainic landscapes which have a variety of topography, from gently to strongly rolling. This is one of the poorest Haverhill map units due to significant amounts of poorer kinds of soil on the knolls (Calcareous Brown and Orthic Regosols) and the poorly drained depressions (Gleysolic series).

Hr4 - Dominantly Orthic Brown with significant combinations of Calcareous Brown and Orthic Regosol series. It occurs on a variety of topography from roughly undulating to moderately rolling. Most Hr4 landscapes are dissected. Agriculturally the Hr4 unit is somewhat better than Hr2 since the latter occurs principally on undissected landscapes and contains numerous undrained sloughs.

Hr8 - Dominantly Orthic Brown, with significant Calcareous Brown and significant Eluviated Brown series. This map unit occurs on rough undulating to gently rolling topography. Agriculturally, areas of Hr8 are second only to the Hr1 map unit. The slightly lower productivity of Hr8 soils is largely due to the calcareous knolls.

Hr9 - Dominantly a combination of Calcareous Brown and Orthic Regosol with a significant amount of a combination of Orthic Brown, Eluviated Brown and Gleysolic series. This map unit occurs on moderately rolling topography with a high frequency of undulations, that is many per half mile. This is one of the poorer Haverhill map units due to the low productivity on the arid knolls and in the poorly drained depressions.

Hr11 - Dominantly a combination of Orthic and Calcareous Brown series with a significant combination of Eluviated Brown series and Gleysolic series. This map unit occurs on roughly undulating and gently rolling topography. The agricultural potential of Hr11 areas is slightly lower than that of Hr8 areas because of the poorly drained Gleysolic soils.

If similar subgroup profiles, as the Haverhill, occur as Series and Series Complexes on a different parent material in the Brown Soil Zone a new Association would be established. For example, the Birsay Association which consists of Chernozemic Brown series developed on sandy glacio-lacustrine deposits is separated from the Haverhill series which are developed on unsorted glacial till.

Conversely if a different suite of subgroup profiles occur on nearly similar parent material in the same Soil Zone as the Haverhill Association another Association would be established - for example, the Flaxcombe Association which consists of Brown Solonetzic subgroup profiles is separated from the Haverhill Association.

A group of subgroup profiles similar to those in the Haverhill Association but occurring in a different Soil Zone would necessitate the establishment of another Association. For example, the Haverhill and Weyburn Associations differ in that the former are Chernozemic Brown soils while the latter are Chernozemic Dark Brown soils.

The relationship between the Association, Map Unit, Series, Series Complexes, Parent Material and Zone is illustrated in Table IIA which is extracted from a portion of the Rosetown Map Sheet Legend (12).

The utilization of the Association and its Map Units as a mapping device in Saskatchewan would not be illustrated completely if the importance of the local landforms and relief were omitted. Thus Table IIB, which is part of the Rosetown Map Sheet Legend, is presented to indicate the major landforms and types of landform and the range of slope classes and topography which accompany the Association Map Unit edit on Saskatchewan soil maps. The Textural Grouping and Classes in Table IIB are used to denote the surface texture of the Map Units delineated and are related to the parent materials described in Table IIA.

The interpretation of the map legends presently in vogue in Saskatchewan and the significance of the divisions in the map legends are as follows:

The purpose of the legend is to present a systematic arrangement of the soils of the area and to indicate how these soils may be identified and located on the map.

In the map legend the Soil Associations are arranged alphabetically under the captions which broadly describe their classification. Such headings as Dominantly Chernozemic Brown Soils, Dominantly Brown Solonetzic Soils, etc., are utilized.

The horizontal divisions of the legend present the information by which each Soil Association and its Map Units may be identified on the map. This information is presented at the top of the legend under the following headings from left to right: Color and Association, Map Unit, Series and Series Complexes, Parent Material (see Table IIA). These terms are interpreted as follows:

COLOR - The colors on the map (along with the printed symbols) are used primarily to identify the Soil Associations and to show their location and extent throughout the map area. The color also indicates the different geological deposits or parent materials on which the various Associations occur. Thus different types of glacial till are colored blue and mauve, glacio-fluvial gravels are brown, fluvial lacustrine sands are yellow, glacio-lacustrine silts are orange, glacio-lacustrine clays are pink (light phase) and red (heavy phase), glacio-lacustrine sands are tan, aeolian sands are light yellow, recent alluvium deposits are green, and bedrock exposures and hillwash deposits are gray.

ASSOCIATION - The Soil Association is the most important unit of the soil map, since it represents a group of related Soil Series developed on a particular parent material deposit and occurring in a given Soil Zone. Thus the Association name or its map symbol can call to mind a combination of natural features, including the kind of landscape, the prevailing surface color of the soil, the dominant soil textures, and the kind of native vegetation.

MAP UNIT - Once the Soil Association has been identified, the Map Unit is the next most important feature of the soil map. It represents a portion or segment of a Soil Association and is composed of one or more Soil Series. Different Map Units are separated on the basis of different proportions of Soil Series occurring within the Association. Within the Map Unit the various Soil Series profiles are associated with differences in topographic position and related drainage conditions. Hence, in the

ASSOCIATION[1]	MAP[2] UNIT	SERIES[3] AND SERIES COMPLEXES[4] DOMINANT[5]	SIGNIFICANT[6]	PARENT MATERIAL
DOMINANTLY CHERNOZEMIC BROWN SOILS				
HAVERHILL	Hr1	Orthic Brown		Medium to moderately fine textured, moderately calcareous, unsorted glacial till
	Hr2	Orthic Brown	(Calcareous Brown, Orthic Regosol) Gleysolics	
	Hr4	Orthic Brown	(Calcareous Brown, Orthic Regosol)	
	Hr8	Orthic Brown	Calcareous Brown, Eluviated Brown	
	Hr9	(Calcareous Brown, Orthic Regosol)	(Orthic Brown, Eluviated Brown, Gleysolics)	
	Hr11	(Orthic Brown, Calcareous Brown)	(Eluviated Brown, Gleysolics)	
BIRSAY	By1	Orthic Brown		Medium to moderately fine textured, moderately calcareous, sandy glacio-lacustrine deposits having over 15% clay
	By2	Orthic Brown	Calcareous Brown	
	By3	Orthic Brown	Eluviated Brown	
	By5	(Brown soils and their salinized and/or carbonated phases)		
	By6	Salinized Calcareous Brown		
	By7	(Salinized and/or carbonated Brown and salinized and/or carbonated Gleysolics)		
DOMINANTLY BROWN SOLONETZIC SOILS				
FLAXCOMBE	Fc2	(Brown Solodized-Solonetz, Brown Solod)	Brown Solonetz	Moderately fine textured, moderately calcareous glacial till
	Fc3	(Brown Solod, Brown Solonetz)		
	Fc4	Brown Solonetzic soils		

TABLE IIA A portion of the Rosetown Map Sheet Legend, Saskatchewan

TEXTURAL GROUPINGS AND CLASSES

Textural Group	Textural Class and Symbols
Coarse textured	Sand (s), loamy sand (ls)
Moderately coarse textured	Sandy loam (sl), sandy loam gravelly (sl(g)), fine sandy loam (fl)
Medium textured	Very fine sandy loam (vl), loam (l), loam gravelly (l(g)), silt loam (sil)
Moderately fine textured	Sandy clay loam (scl), fine sandy clay loam (fcl), very fine sandy clay loam (vcl), clay loam (cl), silty clay loam (sicl)
Fine textured	Sandy clay (sc), silty clay (sic), clay (c), heavy clay (hc)

MAJOR LANDFORMS

M . . . Moraines
G . . . Glacial till plains
F . . . Glacio-fluvial plains
L . . . Glacio-lacustrine plains
S . . . Mixed Glacio-fluvial and lacustrine plains
A . . . Alluvium plains
E . . . Aeolian or wind-worked Glacio-fluvial and lacustrine plains

TYPES OF LANDFORMS

a . . . Knob and kettle or knoll and depression with no external drainage
r . . . Ridge and swale with limited external drainage
m . . . Mixed a and r types with limited external drainage
d . . . Dissected with external drainage

SEQUENCE OF MAP SYMBOLS

Sequence $\dfrac{\text{Soil Association and Map Unit/Uncomformity} \quad \text{Texture}}{\text{landform} \quad \text{Slope Class}}$

Map Symbol $\dfrac{\text{A6/G sl-ls}}{\text{Sa2}}$

SLOPE CLASSES AND TOPOGRAPHY

Class	Slope%	Simple Topography[1]	Complex Topography[2]
0		Depressional	Depressional
1	0-0.5	Depressional to level.	Depressional to nearly level
2	0.5-2	Very gently sloping	Very gently undulating
3	2-5	Gently sloping	Gently and roughly[3] undulating
4	6-9	Moderately sloping	Gently rolling
5	10-15	Strongly Sloping	Moderately rolling
6	16-30	Steeply sloping	Strongly rolling

[1]**Simple Topography**—has single slopes giving a regular surface.
[2]**Complex Topography**—has multiple slopes giving an irregular surface and frequency pattern.
[3]Roughly undulating has higher frequency than gently undulating.

TABLE IIB Symbols and definitions of classes used in the Rosetown Map Sheet, Saskatchewan field, a Map Unit may be identified first by its landscape (the pattern of differences in relief or height, the kind and frequency of slopes, the comparative roughness of the surface and the drainage of the area). The full identification of the Map Unit requires the recognition of the Soil Series profiles and their place and extent within the landscape.

SERIES AND SERIES COMPLEXES - Listed under this heading are the Soil Series profiles belonging to each Map Unit. The individual Series are identified by the descriptive name of their Subgroup profile -- all profiles of a given Soil Series belong to a single Subgroup.

The Soil Series shown in the legend are divided into those that are Dominant and those that are Significant. These terms refer to the relative proportion of a given Series as it occurs in a Map Unit. Dominant Series occupy over 40% of a given Map Unit, while Significant Series occupy over 15% but not more than 40% of a Map Unit.

As shown by the legend, often only one Series is indicated as Dominant. Where two or more Series are indicated as Dominant, they are grouped together and enclosed in brackets. This means that the several series, considered together, make up over 40% of the Map Unit.

PARENT MATERIAL - This section of the legend provides a brief desription of the texture and kind of geological material on which each Soil Association has developed. The recognition of the parent materials is of the greatest importance in identifying and understanding the various Soil Associations. More detailed descriptions of the parent materials are given in the report under the descriptions of Soil Associations.

TEXTURAL GROUPINGS AND CLASSES - The textures shown on the soil map represent the textures of the cultivated (Ap) layer or horizon, or the uncultivated surface horizon (usually the Ah horizon). On the soil map, only the dominant texture or textures of a Map Unit are shown. Where more than one textural class is shown, the first named texture is considered to be dominant. The symbols used to denote surface textures on the map are given in the legend under the above heading (see Table IIB).

LANDFORMS AND TOPOGRAPHIC CLASSES - This section of the legend explains the symbols used to indicate the various landforms which are associated with the surface deposits in the map area. There are seven major landforms in the legend which may be divided into four different types depending upon the surface configurations within each major landform. In this section the symbols and descriptive material for the slope classes and topography are also presented (see Table IIB).

SEQUENCE OF MAP SYMBOLS - On the soil map each separate soil area is enclosed by a soil boundary line. Within the boundary the soil area is identified by symbols, which are always arranged in the following sequence:

$$\frac{\text{Soil Association - Map Unit - Texture}}{\text{Landform - Slope Class}} \qquad \frac{\text{Hr4.L}}{\text{Md4}}$$

Using Tables IIA and IIB the sequence of map symbols $\frac{\text{Hr4.L}}{\text{Md4}}$ are interpreted as follows:

Hr - Haverhill Association, dominantly Chernozemic Brown soils developed on medium to moderately fine textured, moderately calcareous unsorted glacial till.

Hr4 - Map Unit, in which the Orthic Brown Series is Dominant and there is a Significant combination of Calcareous Brown and Orthic Regosol series.

L - surface texture, loam.

Md - landform and type, dissected moraine.

4 - topography and slope class, moderately sloping with 6-9% slopes.

Thus the soil map and legend provide a concise and comprehensive insight into the use of the Association Map Unit concept as a mapping device. Although much information may be obtained from a soil map and legend, by those familiar with the terminology, the soils report provides the opportunity to describe the Soil Association and its Map Units in detail and to evaluate their characteristics for the enlightenment of others.

The Association concept affords the opportunity to compile broad or detailed soil maps and has been used in Saskatchewan for the production of maps ranging in scale from 1:1,760,320 or .083 inch to the mile to 1:1917.5 or 32 inches to the mile.

In view of the present concern regarding the mapping of the non-agricultural areas in Canada, and the proposals which have been put forward by Canadian workers regarding the surveys of forest land and permafrost areas (13), (10), (11) the Association concept is submitted as an effective and meaningful mapping device for any degree of abstraction at any scale desired.

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(13) Lavkulich, L.M. Surveys of Forest Land and Permafrost Areas. Paper presented at the Western Section, C.S.S.C., Kelowna, B.C. 1972.

(14) Ellis, J.H. 1935. Soil Types Occurring in The Red River Valley Plain. Scientific Agriculture, Volume XV, No. 5, 276-286.

APPENDIX III

MEMORANDUM

TO C.S.S.C. Members MAY 1975

FROM J.H. Day, B. Kloosterman, and J.G. Roberts

SUBJECT Mapping legends and symbols

In a letter to T.M. Lord discussing the Fort St. John legend, it was implied that the CanSIS data system had a limitation as to the number of elements that could be handled in a map symbol. Recently after trying and failing to explain to some Western Mappers, Day asked Kloosterman for detailed instruction explained in A below.

A. The symbol data set was constructed on the basis of twelve packages of four characters each, plus twelve separators, making a total memory capacity of 60 bytes. For this reason, the limit of twelve packages was stated to exist. It did not take very long to discover that many symbols presently in use exceed the 12-package limit.

Bruce and Ed Brandon consequently have decided to rewrite those parts of program that define the 4-byte package in order to remove that limitation, but to retain the 60-byte memory capacity. It, therefore, can be concluded that for the present style of symbols there is no limitation attributable to the CanSIS system. Neither is there any limitation on the amount of prose-style description that can be accomodated in the legend.

B. The prevailing symbols on maps in cartography utilize fairly simple landform terminology and symbology. But the last report of the landform committee has generated a system that has the potential for a much more complicated symbology. This would be required to recognize complex or combined landforms and materials with their erosional modifiers and virgules and colons that inform as to the proportions of components.

The data that are being shown in map symbols include:

Numerator: Soil map unit (as many as 3 components)
Decile proportion
Substrate phase
Surface texture (some with gravelly modifiers)

Denominator: Particle size class of parent material
Landform plus erosional modifier
Relief
Topography
Stoniness
Rockiness

C. In the future it is possible that some persons would wish to expand the symbols to connote additional information. It was suggested recently at a meeting in B.C. that maps should carry information on hydrology and on vegetation, in addition to the soil-landform data presently shown.

It was asked if the CanSIS system could accomodate four symbol data files (soil, landform, hydrology, vegetation) all attached to one set of map boundaries (polygons). The system could be so established but integration of data sets for manipulative purposes would immediately be confronted by the 60-byte memory capacity referred to in (A).

An alternative method would be to use a 4 point nonconnatative or generalized symbol for all of these "Sectors".

D. It seems to us that this subcommittee must consider and eventually reach a decision pertaining to a group of problems.

1. What information should be shown in the map symbol? Should the symbol be as connotative as possible within certain restraints or should the symbol be used to direct user to legend.

2. What restraints exist or should be imposed on a) the categories of information and b) the detail of separation made at map scale used for each information element, in the map symbol.

3. What information should be shown in the numerator and denominator?

4. Should decile proportion be used for soil and landform components, or is it preferable to use only virgules, colons, etc. for landform components. The use of virgules and colons apparently would require changes in the CanSIS commands now in use that are coded into the symbol during cartography.

5. The present trend in soil survey, to attempt to convey the maximum of information via the symbol, is not without disadvantages. Long complex symbols are error-prone during compilation and require large inputs of programming of style and type face. They obliterate base map information such as contours and lot numbers. Draftsmen must spend excessive amount of time locating and relocating symbols to minimize loss of information. Finally long complex symbols are often difficult for nonspecialist users to comprehend.

Inasmuch as professional users, who are accustomed to using long complex symbols, usually have access to preliminary field or map manuscripts, it is timely to ask why we produce several thousand expensive multicolored maps supposedly for the average user, who very often cannot comprehend and use them.

In our opinion the best procedure would be to use long complex all-inclusive soil and landform symbology on preliminary in-house manuscripts only. These would be compiled for early dissemination to special user groups (planners, agronomists). Simple, less connotative symbols should then be derived from input to CanSIS and for general distribution to the public. They would be accompanied by a legend expanded to include all the information formerly contained within the complex symbols.

APPENDIX IV

A GUIDE TO RETRIEVING INTERPRETIVE MAPS FROM THE CANSIS CARTOGRAPHIC FILE

S.M. FAULKNER AND B. KLOOSTERMAN

Introduction

Most users of soil maps are interested in three categories of information, which are best communicated in map form. The three categories are:

1) the location of specific simple features, eg., areas of deep sand deposits.

2) the distribution of ranges of properties over the landscape, eg. surface texture or depth to bedrock.

3) the distribution of interpretations of properties, eg., the information may be illustrated by a map of suitability for hybrid corn production or roadbed construction.

For pedologists and other users, these special maps are better than trying to obtain this information from the soil map and legend directly.

The retrieval subsection of the cartographic file has been designed to produce these three types of information. The first is produced by the FEATURE option, and the second and third by the CLASS retrieval option.

1. Feature Retrieval

   Feature retrievals allow the plotting of all map units that satisfy given criteria. The map unit symbols that meet the criteria may be assigned codes or connotative labels (Table IVA and Figure IVA). It must be remembered that the original soil map symbol in the computer is never changed; the assigned label on a derivative map is the result of a translation for output purposes only.

2. Class Retrieval

   This type of retrieval, although the most powerful, is the most tedious to code. The pedologist is provided with a list of all symbols on the map. He then assigns class names to each symbol for a given interpretation of the soil map (Table IVB). These data are keypunched and used by the computer to replace the original soil symbols with the class name and to delete boundaries which separate delineations assigned to the same class (Figure IVB and Figure IVC). A plot tape and two tables are produced on output. One table lists each assigned class with the accumulated acreage (Table IVC) and the other all the soil map delineation symbols that have been assigned to the class (Table IVD).

Coding Procedure

For purposes of coding, the following terms are defined:

1. FIRST SYMBOL - that part of a unique symbol up to but not including the first separator.

   eg. F 1 in the symbol below.

2. UNIQUE SYMBOL - a complete map delineation identifier or symbol.

   eg. F 1; LS-F 2; L/FC3:7

3. SEPARATOR - a non-alphabetical non-numeric character that may be part of the symbol in the surveyor's manuscript or is inserted on input for computer purposes.

   eg. the colon, semicolon, hyphen and slash in the symbol above. The colon may be used to raise the 7, the semicolon may be used to change the style of print and the slash is used to place everything following it into the denominator. The slash must be reserved for this use only. The hyphen (-) indicates the break between dominant and subdominant units.

4. CLASS - one of the categories in an interpretive grouping.

Retrievals are initiated by creating a table of symbols with their corresponding class name for the interpretation in question. This table is written on CanSIS Retrieval Coding forms (Tables IVA and B) and is subsequently keypunched. To avoid processing delays, the forms must be filled out accurately and clearly. Special care must be taken with certain characters and numbers that may be mistaken for others, eg., 2 versus Z, b versus 6, G versus 6, 1 versus L, 7 versus 1, Ø letter versus 0 number, etc.

The forms have two sections. Columns 1-20 are used to code the CLASS NAME and columns 21-80 are used to code the symbol. The CLASS name may be composed of any combination of alphabetic, numeric or special characters. The FIRST or UNIQUE symbol is coded in columns 21-80 (Tables IVE and IVB). The decision to use FIRST or UNIQUE is up to the pedologist. If the map delineation identifier can be assigned to classes on the basis of the first symbol, then one entry on the coding form will carry the interpretation for all UNIQUE symbols carrying the same FIRST symbol (Table IVB). On the computer printout, FIRST symbols appear in heavier type than the UNIQUE (Table IVE). For any given interpretation, one can only use UNIQUE or FIRST symbols. They cannot be mixed.

There are two restrictions to coding symbols; the slash (/) cannot be used because it acts as a special command character for the computer to place everything following it in the denominator with a 60% reduction in print size. Double slashes reduce the print size even further. The other restriction concerns the use of upper and lower case characters in a symbol. The computer works with upper case, therefore, we have to "fudge" lower case. To distinguish between the two on the coding form, the characters that have to be lower case are underlined on the next line (Table IVF). Note that for the two with the underlining, the class name (Col. 1-20) is left blank. The underlining convention is also used for output (Table IVE).

Coding retrievals is laborious at the moment. One way of minimizing the work is to code the complete list of symbols for a map (FIRST or UNIQUE) in columns 21-80 on the forms and make a number of xerox copies if a number of interpretations are desired. Then one needs only to fill in the CLASS name in columns 1-20. Sometime in the near future, we hope to have the symbols preprinted for each soil map. This list could be xeroxed to create a copy for each interpretation and only the CLASS name will have to be entered by the pedologist for each interpretation listing.

Once the forms have been filled in they should be sent to Dr. B. Kloosterman, Soil Research Institute, Central Experimental Farm, Ottawa, Ontario K1A 0C6. He will ensure that they will be processed as rapidly as possible. Since there are always some spelling and keypunching errors, the turn-around time generally is about one month.

SHEET___OF___

TABLE IV A CANSIS RETRIEVAL CODING FORM
with "water bodies" coded

CLASS NAME				UNIQUE SYMBOL							
WATER				ZZ							

FIGURE IV A Mapped water bodies

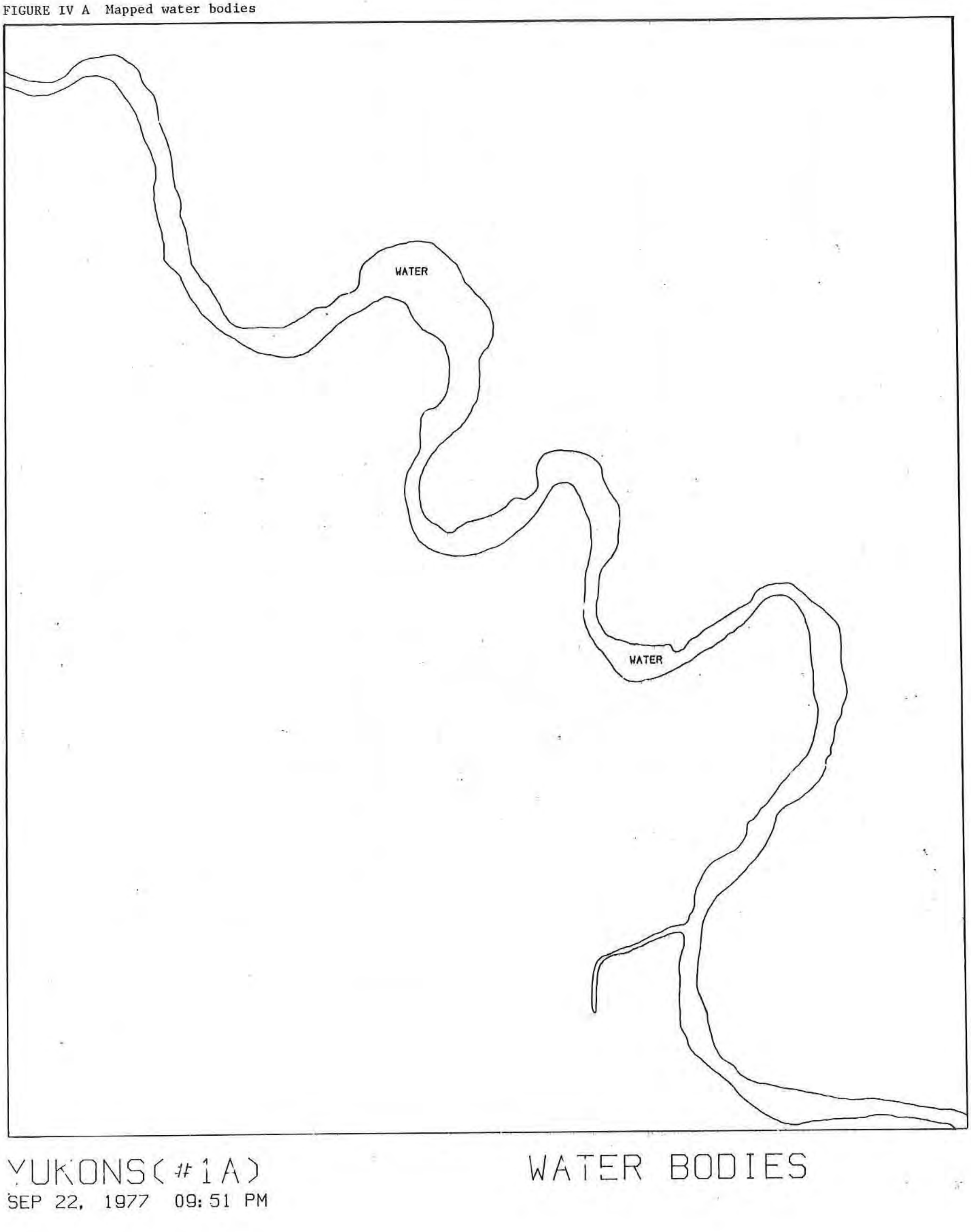


TABLE IV E CANSIS RETRIEVAL CODING FORM FOR YUKON #1A SOIL DRAINAGE AND PERMAFROST

MAP: Sheet #1 Insert

CLASS NAME	UNIQUE SYMBOL
D	FT1:LS/FC3:7
D	FT1:LS/FT3-5:7
D	FT1:LS/FU2:7
D	FT1:LS/FU3:7
WF+D	FT2/FI3:7
WF+D	FT2/FI4-D3:7
WF+D	FT2/F I4:7
WF+D	FT2/FTI3:7
WF+D	FT2/FTI4:7
WF+D	FT2:LS/FF4:7
WF+D	FT2:LS/FI3:7
W+D	TP/AC4:7

SYMBOLS MEAN:

SOIL ASSOCIATION: TEXTURE/LANDFORM AND Slope: Grazing Capability

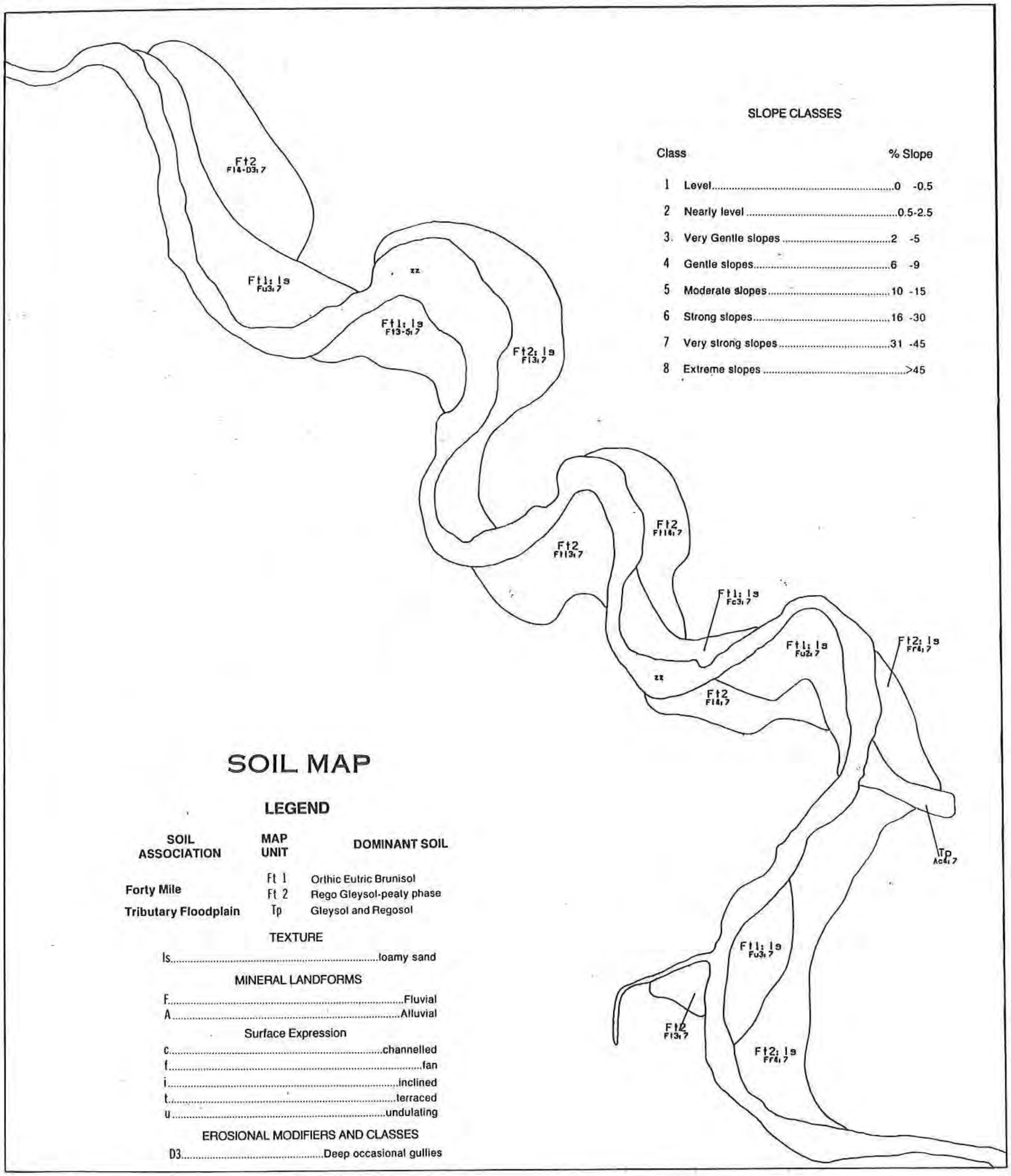
CLASS NAMES

D - WELL DRAINED
W - PERMAFROST
F - VERY POORLY DRAINED

NOTE THE ABOVE UNIQUE SYMBOLS COULD BE CODED WITH FIRST SYMBOLS AS FOLLOWS:

CLASS NAME	UNIQUE SYMBOL
D	FT1
WF+D	FT2
W+D	TP

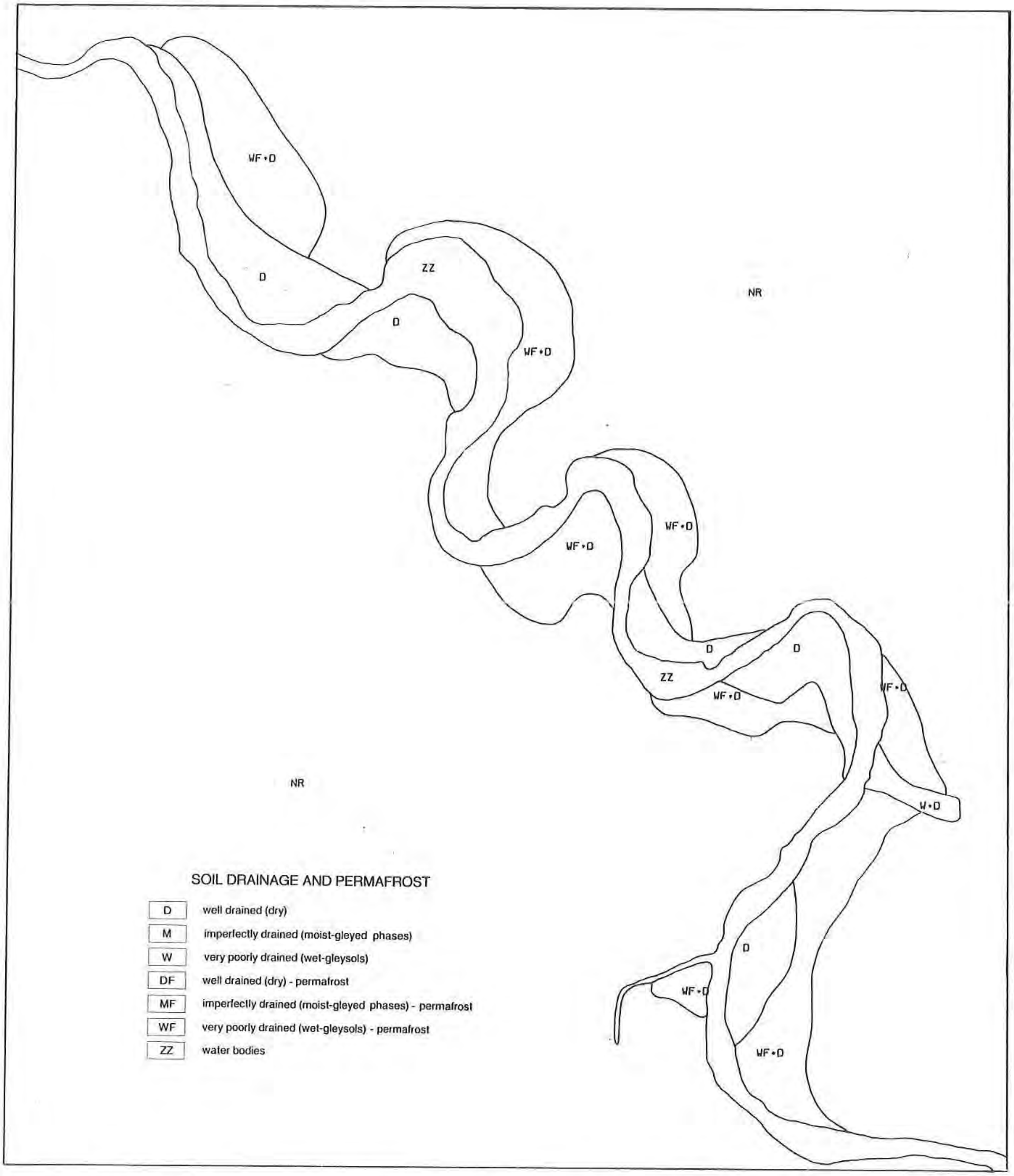
FIGURE IV B Original soil delineations and symbols



YUKON NO 1-A INSERT

MAR 22, 1977 08:17 PM

FIGURE IV C Assigned classes for
Drainage and Permafrost



YUKON #1A SOIL DRAINAGE AND PERMAFROST
MAY 26, 1977 12:28 AM

TABLE IV C Area assigned to each class

EXT0421 .RETRIEVE BY CLASS YUKON #1A SOIL DRAINAGE AND PERMAFROST

EXT0141	NUMBER OF AREAS	TOTAL AREA ACRES	SQ. MILES	
	5	10438.8	16.32	D
	8	19590.1	30.61	WF D
	1	638.6	1.00	W D
	2	247141.3	386.16	NR
	1	15478.7	24.19	ZZ
	17	293285.4	458.28	

TABLE IV D. List of map symbols assigned to each class

EXT0421 RETRIEVE BY CLASS YUKON #1A SOIL DRAINAGE AND PERMAFROST

CLASS NAME	AREAS IN CLASS
D	FT1:LS/FC3:7 FT1:LS/FT3-5:7 FT1:LS/FU2:7 FT1:LS/FU3:7
WF D	FT2/F13:7 FT2/F14-03:7 FT2/F14:7 FT2/F113:7 FT2/FT14:7 FT2:LS/FF4:7 FT2:LS/F13:7
W D	TP/AC4:7
NR	U
ZZ	ZZ

EXT0181 PLOT TITLE: YUKON #1A SOIL DRAINAGE AND PERMAFROST

TABLE IV E List of first and Unique symbols

NKU1SI   MAP INDEX LINKAGE FOR YUKON #9   MAY 10, 1977, 12:46 a.m., Page 5

NO. OF AREAS	TOTAL ACREAGE	TOTAL SQ. MILES		FIRST/UNIQUE SYMBOL	
5	859231.3	1342.55	1	UNCLASSIFIED	
5	850231.3	1342.55	2	UNCLASSIFIED	
1	72580.0	113.41	3	UNCLASSIFIED	
1	72580.0	113.41	4	UNCLASSIFIED	
87	35069.9	54.80	5	ZZ	
87	35069.9	54.80	6	ZZ	
36	5027.7	7.86	7	AV	
36	5027.7	7.86	8	AV/AC3	FIRST SYMBOL
2	164.3	0.26	9	AV	
2	164.3	0.26	10	AV/AC3	
16	51077.1	79.81	11	DQ1	
1	2783.2	4.36	12	DQ1:CLS-CSL/FPR6	
1	2852.1	4.46	13	DQ1:CLS/FH6	
1	1057.2	1.66	14	DQ1:CSL+FP/FH4+NH	
1	5214.0	8.15	15	DQ1:LS+FP/FPR7+NH	
1	331.1	0.52	18	DQ1:LS-S/FP5	
1	1537.5	2.41	19	DQ1:LS-S/FP5-6	
1	965.5	1.51	20	DQ1:LS-S/FP6	
1	15932.7	24.90	21	DQ1:LS-S/FPP6-7	
2	10178.9	15.91	22	DQ1:LS/FPP6	
1	55.3	0.09	23	DQ1:LS/FHP7	
1	7949.7	12.43	24	DQ1:LS/FPP7	
1	561.0	0.88	25	DQ1:LS/FP6	
1	530.5	0.83	26	DQ1:LS/FPP6	
1	789.1	1.23	27	DQ1:S-CSL/FH5	
1	341.7	0.54	28	DQ1:S-LS/FP5	
1	116.5	0.19	29	FML	
1	116.5	0.19	30	FML:EL/AC3	FIRST SYMBOL
27	21261.8	33.23	31	FM1	
2	527.3	0.83	32	FM1/AC3	

TABLE IV F Underlining of symbols to denote lower case

CLASS NAME	UNIQUE SYMBOL
D	FTI:LS/FC3:7

Letters to be considered lower case