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Special Report 01-1

Technical Manual for Manitoba RM Soils and Terrain Information Bulletins

Soils and Terrain

An introduction to the land resource

Land Resource Group (Manitoba)
Semiarid Prairie Agricultural Research Centre

Canada

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Technical Manual for Manitoba RM Soils and Terrain Information Bulletins

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PREFACE

Digital soil and terrain data bases were prepared by the Manitoba Land Resource Group from 1995 to 1999, for all Rural Municipalities in southern Manitoba. The digital data bases were used to produce a series of Soils and Terrain Information Bulletins for each Rural Municipality. Each of the 119 RM bulletins includes a generalized description of the area, as well as a set of commonly utilized derivative and interpretive map products for agricultural land use planning applications. The set of RM Soils and Terrain Information Bulletins were originally published in hard copy, and are now available on a CD-ROM (RMSTB v1.0, 2001) in PDF format.

This manual provides an overview of the process used to compile the digital soil and terrain data bases and an explanation of the guide tables, classes and procedures used to produce the interpretative maps and tables in the RM Bulletins. This publication serves as a supplement to the RM bulletins, for users who require a more detailed explanation of the methodology behind the derived and interpretive maps. More detailed information may be obtained by contacting:

Land Resource Group (Manitoba),
Room 360 Ellis Bldg, University of Manitoba,
Winnipeg, Manitoba R3T 2N2
Phone: (204) 474-6118 FAX: (204) 474-7633.

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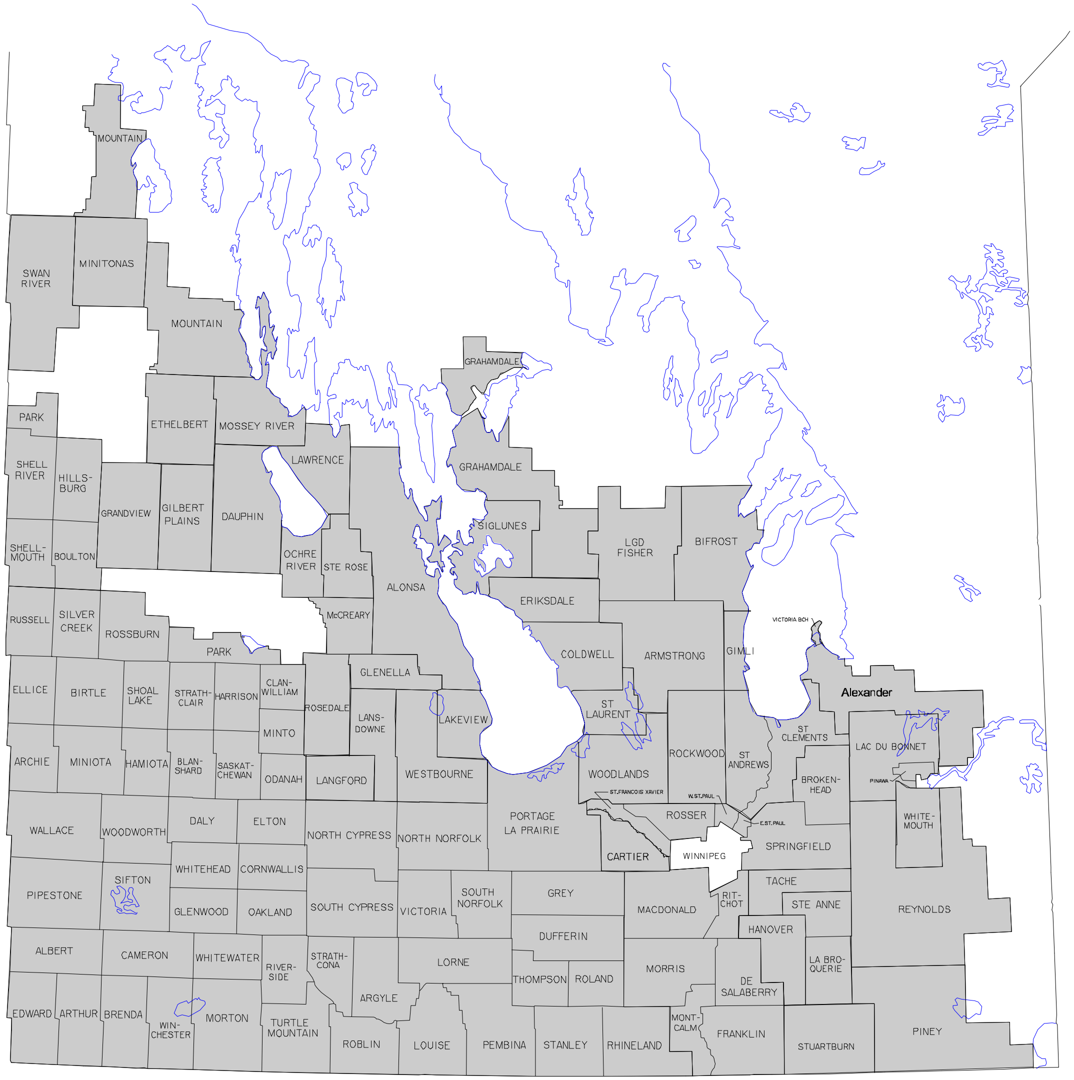

Figure 1. Rural municipalities in southern Manitoba with digital soil and terrain map information (2000)

INTRODUCTION

This manual describes the methodology used in the production of a new series of Information Bulletins for individual rural municipalities (RMs) in southern Manitoba (Figure 1). Two of the 117 Manitoba Rural Municipalities (The RM of Park and The RM of Mountain) had separate North and South administrative areas. These were mapped separately, resulting in a total of 119 RM digital soil data sets and bulletins.

A brief description of the soil and terrain data available from the soil survey program is presented as well as procedures used to derive the databases for inclusion in the RM bulletins. Standardization of the available soil survey information was accomplished through soil data enhancement procedures designed to make historical soil data as compatible as possible with the information contained in modern soil surveys. This project included correlation and terrain analysis procedures to accommodate differences in the soil data base related to the age, scale and level of detail of individual soil surveys.

The soil and terrain maps and related data bases were compiled and registered to National Topographic System (NTS) base maps using Geographic Information System (GIS) technology. The GIS data bases were used to create the generalized interpretive maps and statistics contained in the municipal bulletins.

RMSTB - RM Soils and Terrain Information Bulletins

Soils and Terrain Information Bulletins were originally produced in hard copy by the AAFC Land Resource Group (Manitoba). A limited number of copies of each RM Bulletin were produced and distributed to individual municipalities and government agencies. Manitoba Agriculture and Food, Soil Resource Section is the current distributor for printed RM Bulletins (see address below).

The complete set of Manitoba RM Soils and Terrain Bulletins, RMSTB, Version 1.0, has been compiled on CD-ROM. The CD has separate files for each of the 119 RM Bulletins, in Adobe Acrobat (PDF) format. A copy of this report, *Technical Manual for Manitoba RM Soils and Terrain Information Bulletins*, *Special Report 01-1*, is also included on the RMSTB v1.0 CD-ROM (LRG, 2001b).

RMSID - RM Soil Information Data Base

The digital soil maps for each Manitoba Rural Municipality are available in Arc Export E00 format (UTM, NAD 83) on the RMSID CD-ROM v1.0 (LRG, 2001a). Each Manitoba RM is a separate folder, containing the digital soil coverage and a data base of soil polygon information.

RMAgInterp - RM Agricultural Interpretations Data Base

RMAgInterp v1.0 (LRG, 2001c) is a data base of agricultural soil interpretation ratings used to produce the interpretive maps in the RM Information Bulletins. This information is also be distributed in CD-ROM format, and can be joined in a GIS to the basic RMSID soil data tables. The AgInterp CD ROM has separate data base files, in DBF format, for each of the 119 RM data sets, as well as a file describing the data base information.

User Support

The individual RM Information Bulletins provide a general overview of soil conditions in the RM, and a brief explanation of each soil interpretive map. Additional details regarding RM digital soil map compilation and soil interpretation procedures are included in this Technical Manual.

The original published soil survey reports provide more detailed explanations of individual soils and soil landscape relationships. Basic knowledge of soils and the Canadian System of Soil Classification (Soil Classification Working Group, 1998) is recommended. Users unfamiliar with general soils information should consult one of the many soils textbooks, or contact their local soils or land resource extension specialist.

Users of the RMSID digital soil map and RMAgInterp data bases are assumed to have basic familiarity with GIS software procedures. Those requiring technical or scientific assistance with acquiring or using RMSID V1.0 2001 data should contact:

Data Developer

Land Resource Group (Manitoba)
Semiarid Prairie Agricultural Research Centre
Research Branch, Agriculture and Agri-Food Canada
Rm 360 Ellis Bldg., University of Manitoba
Winnipeg, Manitoba, R3T 2N2
Ph: (204) 474-6119 Fax: (204) 474-7633

Data Distributor

Manitoba Agriculture and Food
Soil Resource Section
Room 346, Ellis Building
University of Manitoba
Winnipeg, Manitoba
R3T 2N2
Ph: (204) 474-6112 Fax: (204) 474-7643

RMSID DATA LAYERS

The soil and terrain information in each RM Information Bulletin was prepared as an introduction to the new digital land resource data bases now available for southern Manitoba. The basic soil information was compiled from historical maps, reports and related data bases produced by the soil survey program in Manitoba. Since the earliest soil surveys in the 1920's, changes in mapping methodology, kind of map units and mapping scale have occurred as the needs and objectives for the survey evolved. In many instances lack of uniformity in the soil data base restricted its application for a standardized analysis of the land resource. Therefore, soil correlation and terrain analysis procedures were undertaken to make the historical soil data as compatible as possible with the information contained in modern soil surveys. The result was a more uniform data set that enabled analysis of the land resource at the generalized level, as demonstrated in the Soil and Terrain Bulletins.

Soil surveys in Agro-Manitoba were originally undertaken to collect information and provide knowledge of the land resources for general agricultural purposes. However, current environmental and intensive agricultural issues could not have been anticipated at that time. As a result, this historic information required updating, using available expertise and modern technologies since many currently important soil and landscape properties were not systematically recorded during those early surveys. Several field correlations were made but no new field activities such as sampling or mapping, were undertaken in this project. The result of these enhancement activities was increased availability, flexibility, consistency and access to the land resource information for all of rural municipal Manitoba.

The information provided is intended for general planning and application purposes only. Users are encouraged to conduct "in-field" or "on-site" specific evaluations for all local land use and/or management activities.

The soil and terrain information for each municipality was compiled and analyzed in digital form, using the GIS facilities of the Land Resource Group (Manitoba). Three distinct layers of information were used (Figure 2) and are described in the following sections.

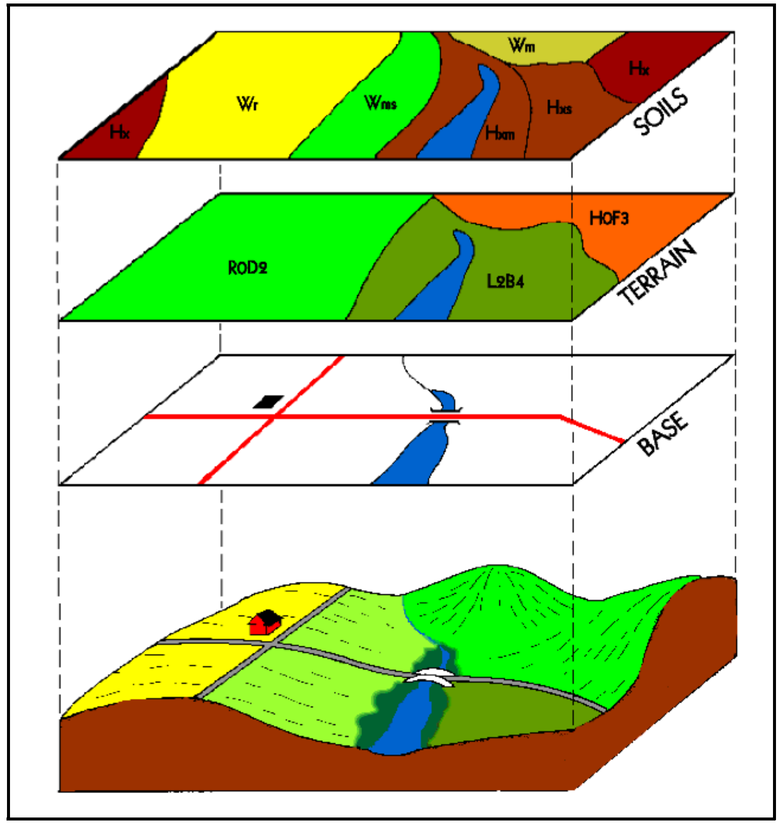

Figure 2. Soil, Terrain, and Base Map data.

Base Layer

The National Topographic System (NTS) 1:50 000 scale topographic maps were selected as base maps for the Soil Enhancement Project. The base maps are available in both hard copy and digital formats from:

Map Sales, Land Information Division
Manitoba Conservation
1007 Century Street
Winnipeg, Manitoba, Canada
R3H 0W4
Phone: (204) 945-6666 Fax: (204) 945-1365
E-mail: mapsales@nr.gov.mb.ca

Digital base map information utilized for this project includes the municipality and township boundaries, major streams, constructed drains, roads and highways. Major rivers and lakes from the base layer were also used as common boundaries for the soil and terrain map layers. Water bodies larger than 25 hectares in size were digitized as separate polygons.

The soil and terrain layers were registered (georeferenced) to 1:50 000 scale digital NTS base maps in UTM NAD27 using PAMAP GIS and were subsequently converted to ArcInfo coverage files in UTM NAD83. Revisions to soil polygon lines (edge matching) along RM boundaries were made using provincial NAD83 municipal and township boundaries.

NTS and provincial base maps are not provided with the digital soils information. Users must obtain these base maps separately from the above address.

Terrain Layer

Modern soil maps produced since the 1950s use stereo airphoto interpretation techniques to more accurately describe soil and terrain conditions and to define soil map unit boundaries. Many RMs in the complex landscapes of southwestern Manitoba have older, reconnaissance level soil maps that lack specific soil landform information required for modern soil interpretations. New terrain information was collected for these areas to supplement the older soil association maps (Figure 3).

The terrain information was compiled by aerial photo-interpretation techniques, using recent 1:50 000 scale stereo air photo coverage. Each terrain polygon was described by the following characteristics:

Differentiating Characteristics:	**Modifying Characteristics:**
Landform	Wetland size
Slope gradient	Erosional modifiers
Slope length	Extent of eroded knolls
Percent wet areas	

The definitions and symbology along with examples illustrating the application of the Terrain Classification System are described in a separate report (Eilers et al., 2001a).

The terrain information was transferred from the photographs onto the NTS base maps and digitized as a separate terrain layer in the GIS.

In areas with older reconnaissance soil maps, the new terrain polygon information was overlaid, resulting in a partitioning of the original broadly based soil association polygons into new, smaller soil and terrain polygons with more detailed topographic information. The new combined polygons were then described in terms of modern soil component combinations, with specific slopes and slope lengths assigned to each component.

The modern terrain lines were considered more positionally accurate than the same boundary portrayed on the historical reconnaissance soil maps. Where the soil and terrain boundaries coincided, such as along prominent escarpments and stream channels, the new terrain lines were used for both layers. Similarly, other terrain features derived from air photo interpretation, such as dunes, wetlands and waterways, were used to refine the delineation and description of existing historical reconnaissance map unit boundaries.

The slope gradients and slope lengths are included as part of the enhanced digital soils database, as these are primary attributes required for the systematic application of soil interpretations. The percent wet area, wetland size, as well as presence and estimated extent of apparent erosion were used to assign representative soils series and corresponding modifiers to the new soil polygons and map unit files. The terrain data for southwestern Manitoba is currently archived in digital files for each municipality.

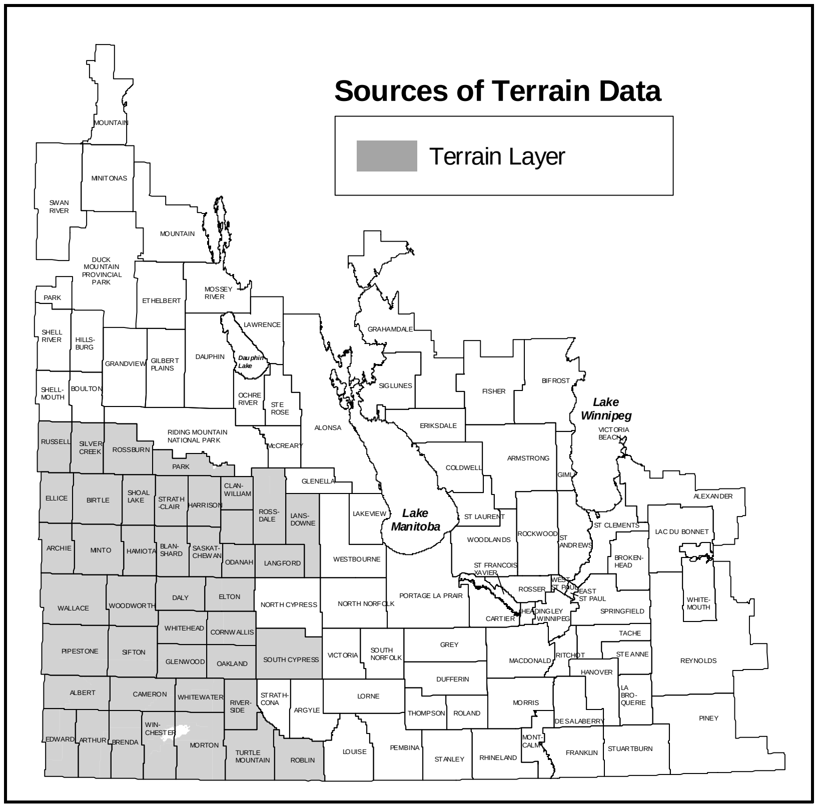

Figure 3. Sources of terrain data.

Slope gradients within the level to very gently undulating landscapes were extrapolated from detailed and reconnaissance soil survey maps and reports (Figure 4). This information was supplemented by expert knowledge of soil and landscape relationships, and verified with 1:50 000 NTS topographic base maps and site specific air photo interpretation as required.

Soil Layer

Soil maps at various scales have been published for most agricultural areas of Manitoba. Under this project, they have been compiled, digitized, and archived for each Rural Municipality (RM) from the most recent soil maps available for the area. In many RMs, the only soil maps available were older reconnaissance level soil maps, typically produced at scales of 1:126 720 (0.5 inches = 1 mile). In some areas, the early reconnaissance maps have been replaced by more modern, detailed soil surveys, at scales from 1:50 000 (1.25 inches = 1 mile) to 1:20 000 (3.5 inches = 1 mile). Where extensive areas of more modern soil maps were available, they have been digitized in preference to the older reconnaissance soil map coverages.

Soils terminology and map symbology have evolved throughout the course of the soil survey program in Manitoba. The objective of the digital soil mapping project was to provide translations of the various historical soil map symbol formats into a consistent set of modern soil data base attributes and terminology. This will facilitate future soil interpretations and analysis on a more consistent basis across all areas of agricultural Manitoba. While published soil maps ranged in scale from 1:126 720 to 1:20 000, many of the scale differences are not apparent when individual soil attribute or interpretive maps are portrayed at a common scale in the GIS.

Although GIS map products can be made at any scale, it is recommended that generalized or interpretive soil maps be made at similar or smaller scales, than the original published soil map information. For all areas of Agro-Manitoba with digital map coverage, GIS products at scales of 1:100 000 or smaller are appropriate. Where more recent, detailed soil map information has been digitized, interpretive maps can be made at more detailed scales.

Three types of historical soils maps are included in the digital coverage for Agro-Manitoba (Figure 4). These are (1) reconnaissance level maps (soil association based) published prior to 1961, (2) modern reconnaissance soil maps (series based) published subsequent to 1961, and (3) modern detailed soil maps (series based) published since 1972. The steps involved in the digital compilation were somewhat different for each type, as described on the following pages.

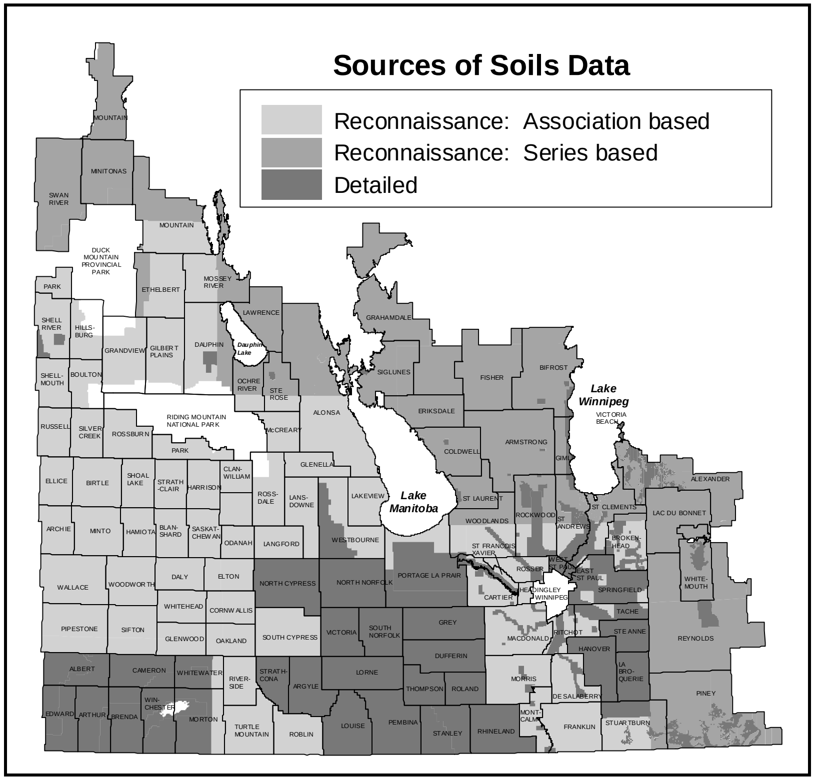

Figure 4. Sources of soils data.

SOIL DATA COMPILATION

The soil survey maps and reports available for Agro-Manitoba can generally be considered as three different types, characterized by date, kind of map units, and the level of detail or map scale. The level of detail varies from small scale reconnaissance maps to semi-detailed and detailed soil maps. Characteristics of the different survey types are:

1) Reconnaissance level maps, soil association based, 1:126 720 scale mapping published prior to 1961.

2) Reconnaissance level maps, soil series based, 1:126 720 and 1:100 000 scale mapping published subsequent to 1961.

3) Detailed (1:20 000 scale) and semi-detailed (1:50 000 and 1:40 000 scale) maps, soil series based, published since 1972.

The Soil Enhancement Project was initiated in 1995 to standardize available soil and terrain information and enable a uniform interpretation of existing soil survey data for a variety of purposes. Part of this project analyzed terrain characteristics such as slope gradient, slope length, landform and percent wet area. The enhancement procedure applied mainly to early historical soil association based surveys that did not contain slope information. The Soil Enhancement Project involved two basic steps:

1) Terrain analysis utilizing photo-interpretation techniques to characterize landforms including slope gradients and lengths, wetland percent and size and the kind and extent of actual erosion. This applied to areas covered by reconnaissance level soil association mapping and surveys based on soil series mapping for which slope length and gradient was not available.

2) A regional correlation procedure in which soil types portrayed in the soil association mapping were correlated with modern soil series equivalents. The closest equivalent soil series to the dominant and subdominant soil associates within each soil association was determined and incorporated in the data bases.

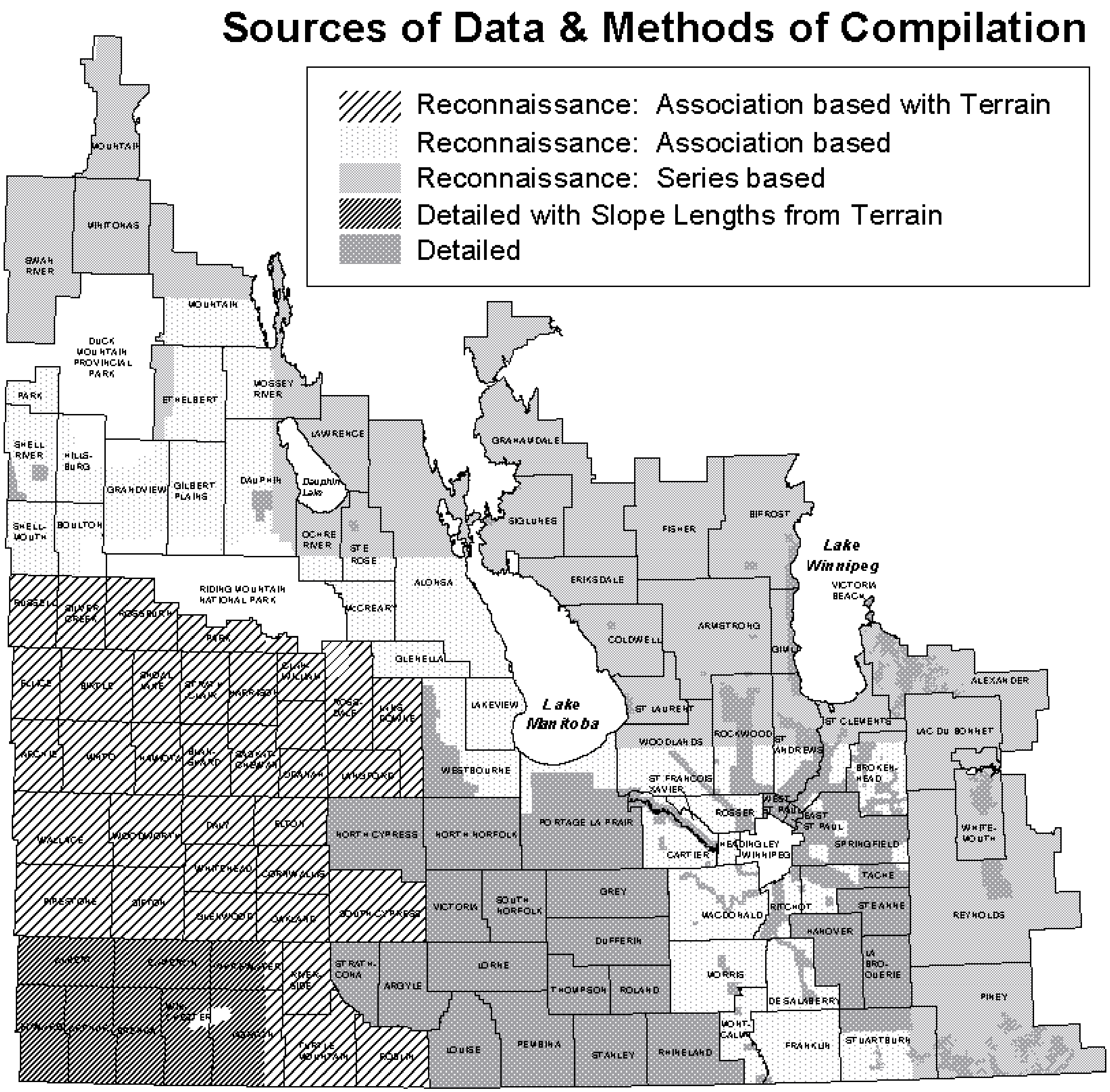

Figure 5. Overview of Soils and Terrain Data.

The area covered by each kind of soil resource information is shown in Figure 5. Compilation of standardized soil and terrain data bases required separate procedures tailored specifically to the type of soil resource information that was available for each area. These are described in the following sections.

(1) Reconnaissance soil maps with terrain layer information

Older, reconnaissance scale soil maps (1:126 720 scale) represented the only available soil data source for many rural municipalities. These maps were compiled on a soil association basis, in which soil landscape patterns were identified with unique surficial geological deposits and textures. Each soil association consists of a range of different soils ("associates") that occur in repetitive positions in the landscape. Modern soil series that best represent these soil associates in each digital soil polygon were recorded in the soil map unit file.

In some instances, areas of wetter soils, sand dunes, or other features were indicated with overprinted symbols on the historical maps. These included both landscape attributes (steep slopes) and soil features (salinity, stoniness, marshy, organic/peaty, alkalinized and degraded, or wooded soils). These indicators were used to assign specific soil and modifier codes. Where the overprinted symbols covered sufficient area (> 25ha), they were digitized as separate soil polygons. The combined soil association and overprinted symbol polygons were then translated into modern soil series and landscape class equivalents. The soil and modifier codes then provide a link to additional data bases of soil properties. In this way, both detailed and reconnaissance soil map polygons were related to soil drainage, surface texture, and other soil properties to produce various derived and interpretative maps.

Older reconnaissance maps lacked detailed site-specific information on landform and slope conditions, as they were mapped without the use of air photo interpretation. Modern air photo interpretation techniques were used to create a new terrain map for these map areas. This information was digitized as a separate layer, registered to the NTS map base and combined with the soil map layer. This resulted in a new digital soil map with a considerably larger number of polygons than the original reconnaissance soil map, with modern soil and slope attributes.

(2) Reconnaissance soil maps without terrain information

The Winnipeg-Morris (Erlich et al., 1953), Grandview Erlich et al., 1959), and the eastern portion of the West-Lake map (Erlich et al., 1958) are older, soil association based reconnaissance soil map areas where no separate terrain layer was produced. The Grandview area had been digitized and translated into modern soil series components prior to 1995, with a separate air photo analysis to characterize landforms and assign slope and slope length classes to the soil components. Data compilation for this area primarily involved re-registration to the 1:50,000 digital NTS base maps, and correlation with surrounding map areas.

The Winnipeg-Morris and eastern West-Lake map areas are predominantly low relief plains, and did not warrant compilation of a separate digital terrain layer. For these areas, the original soil association map units and overprinted symbol areas were digitized, georeferenced, and translated into modern soil series equivalents. Each soil series component was assigned a general translation for attributes such as slope, stoniness, erosion and salinity based on the typical values identified for each soil type, as published in the soil legend for the area. Slope lengths were assigned based on slope gradient and soil type. Steep slopes and areas with complex ridge and swale topography were assigned shorter slope length classes than low relief plains. In some cases, airphoto interpretation or topographic maps were used to identify specific polygons where slope conditions varied significantly from the average for particular soil types. A portion of these areas had been resurveyed at more detailed scales and where they occupied significant sized blocks they were digitized in place of the older map information. The detailed “windows” also served to validate the translation of the original map symbols into modern soil series, slope, and slope length equivalents.

(3) Soil series based reconnaissance soil maps

More recent reconnaissance level soil maps have been published on a soil series basis. Each polygon has been described as a specific combination of one or more soil series, or phases of a soil series. In most cases, the existing soil series and phase symbols were simply translated into modern equivalents. Each soil series was assigned a general translation for attributes such as slope, stoniness, erosion, and salinity based on the typical values identified for each soil type, as published in the soil legend for the area. Slope lengths were assigned based on slope gradient and soil type. Steep slopes and areas with ridge and swale topography were assumed to have shorter slope lengths. In some cases, air photo interpretation or topographic maps were used to identify particular polygons where slope conditions varied significantly from the average for particular soil types.

(4) Detailed soil maps with slope lengths from terrain layer

Eight RMs in south western Manitoba have detailed 1:20 000 and semi-detailed 1:40 000 scale soil map information from the Boissevain-Melita Report No. 20 (Eilers, R.G., L.A. Hopkins and R.E. Smith, 1978). The individual photomosaic soil map sheets were digitized and compiled as a single seamless layer and georeferenced to match the digital RM bases. Each map polygon is described by one or more soil series components with corresponding erosion, slope, stoniness and salinity classes. Steep slopes and areas with ridge and swale topography were assumed to have shorter slope lengths. Where terrain analysis and detailed digital soil data overlapped, slope lengths were derived from the terrain layer. Soil data base information was produced for each polygon to meet national standards (MacDonald and Valentine, 1992).

(5) Detailed soil map areas

Comprehensive detailed 1:20 000 scale and semi-detailed 1:50 000 scale soil maps have been published for many rural municipalities (Figure 5). Where these maps covered a significant area, the individual soil map sheets were digitized, edge matched, and georeferenced as a single layer to match the digital RM base. Each map polygon is described by one or more soil series components with corresponding erosion, slope, stoniness and salinity classes. Slope lengths were assigned based on slope gradient and soil type. Steep slopes and areas with ridge and swale topography were assumed to have shorter slope lengths. Soil data base information was produced for each polygon, to meet national standards (MacDonald and Valentine, 1992).

RMSID SOIL DATA BASES

The Manitoba RM Soil and Terrain Information Bulletins (RMSTB v1.0) are a set of publications derived from the Manitoba RMSID and RMAgInterp digital soil data bases. A general overview of the files used to produce the RM Bulletins is provided below.

RMSID v1.0 CD-ROM includes the set of Arc Export E00 files which contain the digital soil maps, and the basic soil component information, stored in RM Soil Map Unit Files. A separate RMAgInterp v1.0 CD-ROM includes data files with the soil interpretive information. Basic soil attributes and agricultural soil interpretive map information can be linked or joined in a GIS to each RM digital soil map.

It is important to emphasize that the set of derived and interpretive maps and statistics in the RM Information Bulletins (both hard copy and PDF file versions) were fixed at the time of original publication. Soil data bases, and interpretations based on them, are subject to periodic review and updates. GIS maps and statistics produced using the latest RMSID and RMAgInterp information may differ from those produced at the time of original RM Bulletin publications.

Derived and interpretive maps produced for the RM Bulletins were reduced in size to fit the RM Bulletin format. Larger, more detailed, and updated versions of the maps in the RM Bulletins can be produced from more recent versions of the RMSID GIS data base. GIS software can also be used to join individual data sets together to portray larger geographic areas, or to regroup existing RM interpretative classes for particular applications.

(1) Soil Map Unit File

The RMSID Soil Map Unit File (SMUF) contains basic soil component information for each digital soil polygon. The TAGID data field identifies the soil map polygon and provides a 1:1 link between the GIS soil polygon and the soil component information in the soil map unit file. This file also serves as the primary link between the digital GIS soil map and other data bases of soil attributes.

The original published soil map symbol for the polygon is recorded in the MAPUNITNOM field. Published soil maps have used a variety of different symbol formats, from one or two letter codes on older reconnaissance maps, to complex sequences of soil series and landform phase codes on more recent detailed maps. All soil map units in the SMUF, regardless of their original format, were translated into a sequence of up to three modern soil series components, each identified by a unique SOIL_CODE and MODIFIER. Each soil component was also identified with specific landscape conditions within the polygon, such as slope, stoniness, erosion, and salinity class, as well as an estimated areal extent (0 to 100%). Each soil attribute fields has three versions, to record the values associated with each soil component.

The Soil Map Unit File is an extension of the standard Soil Map Unit File structure defined by the Agriculture and Agri-Food Canada National Soil Data Base (NSDB). Additional soil attribute fields have been added for salinity, erosion, and slope length.

(2) RM Soil Interpretations File

The RM Soil Interpretations File includes standard soil interpretation classes and classification codes used to generate the set of derived and interpretive maps in the RM Bulletins. RMAgInterp v1.0 is an extension of RMSID v1.0. The RM Agricultural Interpretations Data Base (RMAgInterp) includes 119 RM Soil Interpretations files in DBF format, and is distributed on a separate CD- ROM (LRG, 2001c).

RMAgInterp Soil Interpretations Files have a standard format, in which each soil polygon component (a maximum of 3 per polygon) has its own rating for each soil interpretation. The TAGID field provides a 1:1 linkage between GIS soil map polygons and the interpretations data for the soil polygon components.

A set of 10 RMAgInterp classification data fields (designated by a "C-" prefix) was used to record the overall interpretive classification for each soil polygon. For ArcView users who wish to retain the RM Bulletin interpretive map colour schemes, a set of separate colour code (.avl) files are also provided for each RM soil interpretation.

(3) Additional Soil Attribute Files

The RMSID and RMAgInterp CD-ROMs are the two primary data bases of Manitoba soil resource information intended for public distribution.

The AAFC Land Resource Group (Manitoba) and the provincial Soil Resource Section maintain additional soil data bases of Manitoba soil attributes. While they are intended for internal soil correlation and soil interpretation purposes, they may also be related to RMSID data files. These include the Manitoba Soil Names and Soil Layer Files, and field inspection data recorded during inventory mapping and monitoring.

The Manitoba Soil Names File contains attributes that apply to the entire soil, such as taxonomy, drainage, and parent material. The Soil Layer File contains soil attributes that vary with depth, such as texture, pH, and organic carbon. Soil attributes in the Soil Names and Soil Layer File are considered as modal, representative values for each soil type, based on estimates or actual site data where this is available.

The Canadian Soil Information System (CanSIS) of Agriculture and Agri-Food Canada has established standard data base formats and files for Canadian digital soil maps. The CanSIS format consists of a digital soil map linked to a specific set of relational soil data base tables. These include a Soil Map Unit File, and soil attribute information stored in Soil Names and Soil Layer files. Digital soil maps archived and distributed through the AAFC National Soil Data Base (NSDB) have standard CanSIS formats. Further details are available from the AAFC CanSIS website (http://sis.agr.ca/cansis/index.html).

It is anticipated that the Manitoba RMSID data sets will eventually be available through the NSDB. The Manitoba RMSID Soil Map Unit File, Soil Names and Soil Layer Files follow NSDB data base formats, with some additional data fields. The Manitoba Soil Interpretations File is unique, as soil interpretations are not standardized nationally within the CanSIS NSDB. Additional soil interpretations, beyond those provided in RMSTB v1.0, may be available in the future.

Further information regarding RMSID, RMAgInterp, and other Manitoba soil data files can be obtained by contacting the Land Resource Group (Manitoba) or the Soil Resource Section of Manitoba Agriculture and Food.

RM BULLETIN SOIL INTERPRETATIONS

Introduction

The RMSID and RMAgInterp digital soil data bases have a large number of soil and landscape attributes. Many soil attributes can be portrayed directly, however optimal use of the land resource information occurs when soil data is interpreted or evaluated for particular purposes.

The current series of Soils and Terrain Bulletins is intended to serve as an introduction to the land resource of individual municipalities and create awareness of the digital soil resource information that is now available for southern Manitoba. As agriculture is a major land use in most rural municipalities, each Bulletin contains a selection of typical derived and interpretive map products and some statistics relevant to agricultural land use planning applications.

Consistent interpretation of soil data for agriculture (or any other purpose) depends on knowledge of soil properties and their response to management. As a general rule, special groupings or interpretations of soil are based on a select number of characteristics known to be relevant to the purpose at hand. Guide tables have been developed to portray the relevant soil and landscape attributes used in each interpretation, and to illustrate the logic of their relationship to the interpretive classes. The various assumptions, guidelines, and criteria used to make consistent interpretations for Dryland Agriculture Capability, Irrigation Suitability, Potential Environmental Impact from Irrigation, and other interpretations for the RM Bulletins are documented in this section.

Interpretive maps in the RM Bulletins are produced at various scales (typically from 1:150 000 to 1:250 000). The map scale was adjusted depending on the size of each RM, so that each map fit on an individual page. At these scales, the maps portray only the generalized legend class colour, representing only the dominant interpretive class for each soil polygon. Minor components or inclusions in the map polygons, which may have important implications for certain agricultural practices, are not shown on these maps. For this reason, the maps are intended for general applications only. RMSID and RMAgInterp data bases typically have more detailed information, including individual interpretive class and subclass ratings for each soil landscape component in each polygon. More detailed, larger scale versions of the RM Bulletin interpretive maps can be produced from the RMSID/ RMAgInterp data bases to show this additional information.

It should also be noted that the scale of the original soil map information in the RMSID data base serves as an upper limit to the scale at which the interpretive map information should be portrayed. Where RMSID maps are digitized from older reconnaissance maps, the interpretive maps derived from them should also be limited to smaller scales, such as 1:100 000. Where RMSID maps are derived from more detailed, modern soil survey information (1:50 000 to 1:20 000 scale), soil interpretive maps can be made at a wider range of scales, up to the published map scales. At smaller scales such as 1:100 000, many of the scale differences in the digital soil map coverage are not apparent in the generalized soil interpretative maps.

The generalized soil interpretive maps in the RM Bulletins, as well as the more detailed interpretive information found in RMSID and RMAgInterp, are intended for general planning purposes only. An assessment of individual land parcels requires additional detailed on site inspections.

Derived and Interpretive Maps

Maps produced in the RM Bulletins can be considered as two basic types, **derived** maps and **interpretive** maps. Derived maps are made directly from attributes in the data base. Interpretive maps are more complex, involving the integration of several types of information in the soils data base, often combined with some external information and assumptions. Examples of derived and interpretive maps included in the RM bulletins are:

DERIVED	INTERPRETIVE
Slope	Agriculture Capability
Surface Texture	Irrigation Suitability
Drainage	Potential Environmental Impact
Salinity	Water Erosion Risk
Management Considerations	Land Use

The derived and interpretive map types produced for the RM Information Bulletins will each be discussed separately.

Slope Maps

Slope maps portray the steepness of the landscape surface. Slope maps for RM Bulletins were produced in two different ways.

For RMs in south western Manitoba covered by older reconnaissance soil maps and a new terrain layer (Figure 5), the slope map is derived from the terrain layer. The slope class represents the most significant, limiting slope class for each terrain polygon. This was estimated by air photo interpretation with some field verification.

For all other RM Bulletins, the slope maps are based on the slope of the first soil component in the RMSID Soil Map Unit File. For areas with modern detailed soil maps coverage, the most significant slope associated with each soil component was recorded directly in the map symbol. For older reconnaissance map areas, slopes were estimated from the soil descriptions in the reports and legends, as well as knowledge of typical soil slope relationships from similar detailed survey areas.

All RM Bulletin slope maps have 6 classes, each of which is assigned a separate classification code and legend colour:

0 to 2%
2 to 5%
5 to 9%
9 to 15%
15 to 30%
> 30%

A Slope Class Table is also included in each Bulletin, showing the areal extent of the slope classes in each RM. This was produced by assigning the total area of each polygon to the dominant slope class in each soil polygon.

The RMSID data base table includes up to 3 separate soil and slope components for each soil polygon. This information is not portrayed in the generalized RM Bulletin slope maps.

Surface Form Maps

Surface form maps describe the shape of the land surface.

These interpretive maps were produced for RM Bulletins in southwestern Manitoba with older reconnaissance soil maps and a separate, modern terrain layer (Figure 5). Surface form was a key differentiating characteristic of each terrain polygon. Twelve surface form classes were recognized, and are described in detail in a separate Terrain Manual (Eilers et al., 2001a). Surface form class, and other terrain characteristics, were estimated by modern air photo interpretation techniques, with some field verification.

Terrain polygons and legend information was digitized as a separate GIS data layer. The RM Bulletin surface form maps and classes were derived directly from the surface form attribute in the terrain data base.

Surface Texture Maps

Surface texture is a fundamental soil property, and is related to several other soil attributes, such as soil moisture holding capacity, soil structure, permeability, ease of tillage, and susceptibility to erosion.

Surface texture maps portray the estimated sand, silt and clay content of the upper most soil horizon. Surface texture maps were produced for RM Bulletins where the RMSID data base was derived from detailed or semi detailed soil maps (1:20 000 to 1:50 000 scales). These are shown in Figure 5.

RM Bulletin surface texture maps represent the texture group for the first soil component (normally the dominant soil), and assigns this class to represent the entire soil polygon. The texture group is based on the estimated surface texture class for the same soil recorded in the Manitoba Soil Names File. The surface texture classes in the Soil Names File represent estimated USDA soil textures for the upper 15cm of each soil. For the RM Bulletin maps, these were regrouped into six more broadly defined surface texture groups and four non soil groups, as follows:

Surface Texture Group	Surface Texture Class
Organics	O, F, H, M
Coarse sands	CS, S, MS, GRLS, GRSL, LCS
Sands	S, LFS, LS, FS, LFS
Coarse Loamy	VFSL, SL, SIL, FSL, VFS, LVFS
Loamy	L, SIL, SICL, CL
Clayey	SIC, C, HC
Unclassified	
Marsh	
Eroded slopes	
Water	

Each of the 10 surface texture groups was assigned a connotative classification code in the surface texture map and legend.

RM Bulletins with surface texture maps also have a table showing the areal extent of the surface texture classes in each RM. The total area of each soil polygon was assigned to the surface texture class associated with the first soil component.

Alternative surface texture group maps can also be generated from RMSID, by linking to the Manitoba Soil Names File and regrouping the specific USDA surface texture classes into different textural groups. This has been done for some recent Manitoba soil reports.

Generalized Soil Maps

Generalized Soil Maps were produced for RM Information Bulletins that had predominantly reconnaissance scale soil map coverage in RMSID (Figure 5). Two types of generalized soil maps were produced for RM Bulletins - Soil Association Maps and Generalized Soil Maps. These have many similarities, but were produced for specific sets of RMs using different techniques.

Soil Association Maps. These were produced for RMs in south western Manitoba with older soil association based reconnaissance maps symbols. During digital map compilation, the original soil association map symbols were recorded in the RM Soil Map Unit File (RMSMUF). The original map symbol codes were used to assign similar names and colours to the digital RM polygons. The resulting RM Bulletin Soil Association maps were quite similar to the original published soil maps, although they were reproduced at smaller scales. Some regrouping and reassignment of original soil association names and codes was done, particularly for RMs that covered portions of adjoining reconnaissance soil maps.

Generalized Soil Maps. These maps were produced for RM Bulletins with more modern reconnaissance scale soil map coverages (Figure 5). The newer reconnaissance soil maps have extensive legends of individual soil series components. Generalized soil maps published at reduced scales can accommodate only a limited number of map unit types and colours. Since no published soil association groups existed for these soil types, a new form of soil grouping was devised. This was done by grouping soil series that had a similar set of values in the following soil characteristics:

- soil parent material mode of origin
- soil parent material textural group
- soil parent material calcareousness class
- soil drainage
- soil taxonomy

Connotative soil colour codes were also assigned to each group. These were chosen to emulate, as far as possible, the connotative colour codes used for similar soil types in the published reconnaissance soil maps. For example, deep and shallow organic soils were assigned dark green and light green colours respectively. Sand and gravel outwash deposits are pink, Chernozemic lacustrine soil colours range from light yellow for sands to orange for loams and brown for clays. Poorly drained, Gleysolic soils developed on these parent materials were assigned darker shades of the same colours. Other soil types, such as glacial tills, were also assigned soil colours to resemble the colours on some historical soil maps.

Note that the Generalized Soil Groups map and table in the RM Bulletins are based on the properties of the first (usually dominant) soil component in each soil polygon.

The RMAgInterp database contains updated Generalized Soil Group codes for all polygons in each RM. The older Generalized Soil Maps in some RM Information Bulletins may differ from the latest Generalized Soil Group information available for these RM maps.

Drainage Maps

Soil drainage relates to the rapidity and extent of the removal of water by runoff or flow through the soil. Saturated soil conditions limit the growth of most agricultural crops, and inhibit soil trafficability and management. Soil drainage classes are based on the frequency and length of time that a soil is saturated within the plant root zone.

Soil drainage class is a fundamental soil attribute, and is normally listed in the legend of modern soil series maps and reports. Older, Manitoba reconnaissance soil maps used different terms (phytomorphic, hydromorphic, etc.) for each soil associate, which were correlated with modern soil series and drainage class equivalents. The drainage class of all unique Manitoba soil series defined in RMSID is recorded in the Manitoba Soil Names File.

Soil drainage maps produced for the RM Information Bulletins recognized 6 drainage classes.

<u>Drainage Class</u>

Very Poor
Poor (no systematic improvements)
Poor, drained (extensive drainage improvements)
Imperfect
Well (Well and Moderately Well)
Rapid (Rapid and Very Rapid)

RM soil drainage maps were derived from the soil drainage classes for the same soil in the Manitoba Soil Names File, although some classes were regrouped for this application. The Well drained class includes Well and Moderately Well drained soils, while the Rapid class includes the Rapid and Very Rapid drainage classes from the Soil Names File. RM drainage maps also recognize two types of poorly drained soils. In some areas, such as the Red River valley, poorly drained soils now have an extensive network of surface drains that enable them to be used for annual crop production. Although these soils are still considered Gleysols, the drainage has been improved over similar native soils in non agricultural areas. A new "Poor, drained" class was created for these extensive areas of dominantly agricultural Gleysolic soils. A letter "d" is recorded in the RMSMUF and SNF MODIFIER data fields to designate these soils.

The Soil Drainage class map and table in the RM Bulletins are generalized, based on the drainage class of the first (usually dominant) soil component in each soil polygon. The soil drainage class and extent of the second or third soil code in each polygon, if present, are not shown, although they are provided in the RMAgInterp data base.

Salinity Maps

Saline soils are those soils that contain soluble salts in sufficient quantities to interfere with the growth of agricultural crops. Soil salinity is determined by the electrical conductivity of a saturated soil extract, measured in deciSiemens per meter (dS/m). Salinity classes in RM Bulletin maps are:

Colour	Class	Conductivity (dS/m)
Green	Non saline	0 to 4
Yellow	Slightly saline	4 to 8
Orange	Moderately saline	8 to 16
Red	Strongly saline	> 16

All soil polygon components in the RMSID data base have been assigned a soil salinity class. For detailed soil map areas, this is part of the published map symbol. For older reconnaissance soil map areas, salinity phases were assigned for specific soil components based on the published soil map and report descriptions and from detailed map "windows" in similar soil landscapes.

RM salinity maps identify the *maximum class of soil salinity for any soil component in each soil polygon*. Note that the maximum level of soil salinity can occur for either the first, second, or third soil component, and may be a subdominant soil condition in the polygon. Salinity map areas assigned a yellow colour, for example, have a slight salinity condition in at least one soil component, while other soil components may be non saline. This is fundamentally different than other generalized RM interpretative maps, which are based on the first (usually the dominant) soil condition in each polygon. Soil salinity is more frequently associated with imperfect and poorly drained soils, which are typically the second or third soil components. A salinity map based on the first soil component only would not represent salinity in subdominant soil components in such polygons.

The RM Salinity class table reflects the area of each class on the RM salinity map. This assigns the entire area of each soil polygon to the "worst case" salinity class. A different representation of the areal extent of soil salinity, based on the actual salinity classes and areal extent of all soil components in each polygon, can be obtained from analysis of the RMSID data base.

Management Considerations Maps.

Management consideration maps are derived from several interrelated soil and landscape characteristics important to agricultural land use. This map does not presume a specific land use, but highlights several soil landscape attributes that the land manager must consider for any intended land use. The individual factors are:

- **Fine texture**
- **Medium texture**
- **Coarse texture**
- **Topography**
- **Wetness**
- **Organic**
- **Bedrock**

F = Fine texture - soil landscapes with **fine textured soils (clays and silty clays)**, and thus low infiltration and internal permeability rates. These require special considerations to mitigate surface ponding (water logging), runoff, and trafficability. Timing and type of tillage practices used may be restricted.

M = Medium texture - soil landscapes with **medium to moderately fine textured soils (loams to clay loams)**, and good water and nutrient retention properties. Good management and cropping practices are required to minimize leaching and the risk of erosion.

C = Coarse texture - soil landscapes with **coarse to very coarse textured soils (loamy sands, sands and gravels)**, have a high permeability throughout the profile, and require special management practices related to application of agricultural chemicals, animal wastes, and municipal effluent to protect and sustain the long term quality of the soil and water resources. The risk of soil erosion can be minimized through the use of shelterbelts and maintenance of crop residues.

T = Topography - soil landscapes with **slopes greater than 5 %** are steep enough to require special management practices to minimize erosion risk.

W = Wetness - soil landscapes that have **poorly drained soils and/or >50 % wetlands** (due to seasonal and annual flooding, surface ponding, permanent water bodies (sloughs), and/or high water tables), require special management practices to mitigate adverse impact on water quality, protect subsurface aquifers, and sustain crop production during periods of high risk of water logging.

O = Organic - soil landscapes with **organic soils**, requiring special management considerations of drainage, tillage, and cropping to sustain productivity and minimize subsidence and erosion.

R = Bedrock - soil landscapes that have **shallow depth to bedrock (< 50 cm) and/or exposed bedrock** which may prevent the use of some or all tillage practices as well as the range of potential crops. They require special cropping and management practices to sustain agricultural production.

RM Management Consideration Maps also have classes for specific combinations of factors. These are:

Fine Texture and Wetness
Fine texture and Topography
Fine texture, Wetness and Topography
Coarse Texture and Wetness
Coarse Texture and Topography
Coarse texture, Wetness and Topography
Topography and bedrock
Wetness and Topography

The RM Bulletin Management Considerations maps, tables and legend classification codes are based on the analysis of the first soil component in each soil polygon only. Management Considerations classes for all three soil components in each soil polygon are included in the RMAgInterp data base.

Agriculture Capability Maps

The Canada Land Inventory (CLI) Soil Capability for Agriculture is one of the most widely recognized agricultural interpretations. Guidelines were developed to manually rate various soil, landform and climatic factors (Canada Land Inventory, 1965).

The CLI Agriculture Capability system has 7 classes. All soils in the same class have a similar relative degree or risk for annual crop production. Subclasses are used to indicate the most significant types of limitation or hazard. CLI Agricultural Capability maps were originally produced in the 1970's at 1:250 000 scale, based on reconnaissance soil map information.

In Manitoba, the original CLI Agricultural Capability guidelines have been further developed. These have been used to produce updated CLI Agriculture Capability ratings for all Manitoba soil and landscape components in RMSID, and the Agriculture Capability maps in the RM Information Bulletins. A summary of the revised Manitoba guidelines for determining Agriculture Capability are described in Table 1.

Agricultural Capability maps in the Information Bulletins are derived from CLI ratings for the first (usually dominant) soil component and its associated slope and stoniness phases in each soil map polygon. Connotative CLI class colour codes were assigned to each soil map polygon, based on the dominant soil class. The most productive soils (class 1) were assigned a dark green colour, with progressively lighter shades of green for class 2, 3 and 4. (less productive agricultural lands). Class 5, 6 and 7 were assigned yellow, orange and red colours respectively, indicating their lower potential for agricultural use. The page sized CLI agricultural capability maps in the RM Information Bulletins are generalized, and show only the dominant CLI class for each soil polygon. Soil polygon boundaries are omitted for clarity.

Map areas with the same CLI class can have quite different subclass limitations. For example, light green areas of CLI class 3 may be 3M, 3W, 3P or 3T, reflecting a similar overall risk class, but different subclass limitations. It is not possible to portray this additional CLI subclass information in page size RM Bulletin maps. The areal extent of the various CLI classes and subclasses in each RM, based on the dominant soil in each soil polygon, is provided in an accompanying CLI table in the RM Bulletin.

It should also be noted that the CLI Agriculture Capability guidelines, as well as some of the digital soil maps and data base files, were reviewed and revised during the 5 year period when RM Information Bulletins were published. This can result in differences between the hard copy RM Bulletin Agricultural Capability maps, and the updated ratings in the RMAgInterp data base. For example, soils developed on extremely calcareous glacial till were originally published as CLI class 3 in some RM Information Bulletins. After further review, the CLI rating criteria were modified, and these soils are now classified as CLI class 4. The CLI maps in the RM Bulletins have not been revised, although the newer, revised ratings are included in the RMAgInterp v1.0 data base.

Individual CLI Agriculture Capability class and subclass ratings for all soil components (a maximum of 3) in each RM soil map polygon are recorded in the RMAgInterp data base. This information can be used to produce more detailed and up to date Agriculture Capability maps using a GIS if required.

CLI Agriculture Capability Assumptions:

1. It is an interpretive classification based on the effects of combinations of climate, soil and terrain features and their general productive capacity for common field crops.
2. Soils will be well managed and cropped, using a largely mechanized system of culture.
3. Soils within a capability class are similar with respect to degree but not kind of limitation. Each class included many different kinds of soils and many soils within any one class require different management.
4. Soils considered economically feasible for improvement by drainage, irrigation, stone removal, structural amelioration, or protection from overflow or flooding are classified according to their continuing limitations or hazzards after improvement has been made.
5. The capability classification of the soils in an area may be changed when major reclamation works are installed that permanently change the limitations for use in agriculture.
6. Distance to markets, kinds of roads, location, size of parcel of land, characteristics of farm size, ownership, cultural patterns, skill or resources of the operators are not criteria for capability groupings.
7. Capability groupings are subject to change as new information about the behaviour and responses of soils become available.

Classes

All soils have been grouped into seven agriculture capability classes:

Class 1

Soils in this class have no important limitations for crop use. The soils have level or gently sloping topography; they are deep, well to imperfectly drained and have moderate water holding capacity. The soils are naturally well supplied with plant nutrients, easily maintained in good tilth and fertility; soils are moderately high to high in productivity for a wide range of cereal and special crops.

Class 2

Soils in this class have moderate limitations that reduce the choice of crops or require moderate conservation practices. The soils have good water holding capacity and are either naturally well supplied with plant nutrients or are highly responsive to inputs of fertilizer. They are moderate to high in productivity for a fairly wide range of crops. The limitations are not severe and good soil management and cropping practices can be applied without serious difficulty.

Class 3

Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices. The limitations in Class 3 are more severe than those in Class 2 and conservation practices are more difficult to apply and maintain. The limitations affect the timing and ease of tillage, planting and harvesting, the choice of crops and maintenance of conservation practices. The limitations include one or more of the following: moderate climatic limitation, erosion, structure, permeability, low fertility, topography, overflow, wetness, low water holding capacity or slowness in release of water to plants, stoniness and depth of soil to consolidated bedrock. Under good management, these soils are fair to moderately high in productivity for a fairly wide range of field crops.

Class 4

Soils in this class have severe limitations that restrict the choice of crops or require special conservation practices or both. These soils have such limitations that they are only suited for a few crops, or the yield for a range of crops may be low, or the risk of crop failure is high. The limitations may seriously affect such farm practices as the timing and ease of tillage, planting and harvesting, and the application and maintenance of conservation practices. These soils are low to medium in productivity for a narrow range of crops but may have high productivity for a specially adapted crop. The limitations include the adverse effects of one or more the following: climate, accumulative undesirable soil characteristics, low fertility, deficiencies in the storage capacity or release of soil moisture to plants, structure, permeability, salinity, erosion, topography, overflow, wetness, stoniness, and depth of soil to consolidated bedrock.

Class 5

Soils in this class have very severe limitations that restrict their capability to producing perennial forage crops, and improvement practices are feasible. These soils have such serious soil, climatic or other limitations that they are not capable of use for sustained production of annual field crops. However, they may be improved by the use of farm machinery for the production of native or tame species of perennial forage plants. Feasible improvement practices include clearing of bush, cultivation, seeding, fertilizing and water control.

Some soils in Class 5 can be used for cultivated field crops provided unusually intensive management is used. Some of these soils are also adapted to special crops requiring soil conditions unlike those needed by the common crops.

Class 6

Soils in this class are capable only of producing perennial forage crops and improvement practices are not feasible. Class 6 soils have some natural sustained grazing capacity for farm animals, but have such serious soil, climatic or other limitations as to make impractical the application of improvement practices that can be carried out on Class 5 soils. Soils may be placed in this class because their physical nature prevents the use of farm machinery, or because the soils are not responsive to improvement practices, or because stock watering facilities are inadequate.

Class 7

Soils in this class have no capability for arable culture or permanent pasture because of extremely severe limitations. These soils may or may not have a high capability for forestry, wildlife and recreation.

CLI Subclasses

All subclass limitations are ranked according to the ease with which they may be overcome. Climate, as an overriding limitation which cannot be improved, is listed first. Subclasses following it are listed in order of increasing ease with which soil and landscape limitations could be improved or overcome. Two subclasses which were not included in this rating guide are fertility (F) and adverse soil characteristics (S). Because fertilizer use is widespread, low natural soil fertility is easily overcome, and should not be considered in rating land use capabilities. Adverse soil characteristics (S) has historically been used in place of moisture (M), salinity (N), structure (D) and fertility (F) limitations, either individually or as a group, on the Canada Land Inventory 1:250 000 scale maps. This subclass is not as descriptive as listing the individual limiting subclasses, and is therefore not used in assigning a class to the soils.

A maximum of two subclasses can be used to determine a class. Generally, only those subclasses which determine the class of the land are assigned, with exceptions as listed in Table 1. The subclasses are listed in the order given in the table (from top to bottom), with exceptions as given in the Table 1 footnotes. If more than two subclasses are class determining, the first two subclasses as listed in the guide table are given as limitations, and the remaining limitations are dropped for classification purposes. Land is always classed according to its most limiting subclass.

Subclass criteria

Climate (C)

Climate is limiting to a minimum class of 3, as indicated in Table1. Ecodistricts of Manitoba as reported by Smith et al, 1998, were used. No ecodistricts with a climate rating lower than 3C are found within the ARDA boundary (Figure 6). It should be noted that soils placed in this subclass have no other limitation but climate and are therefore the highest rated soils in their subregion. Subregions are those areas that have adverse climates as compared to the median climate (1C) of the entire region. Generally, the median climate includes the Black and Dark Gray soils, while Gray Luvisols below 3000 feet elevation have a highest possible class of 2C, and Luvisols above 3000 feet have a highest possible class of 3C.

The climatic rating is the starting point from which all limitations subsequently downgrade the class rating. However, the soil can only be downgraded if the additional limitation is at least equally as limiting as climate. For example, an imperfectly drained soil in the median climate may be rated 2W. A soil with similar drainage in the 2C climate will be downgraded to 3W; but a soil with similar drainage in the 3C subregion will remain rated as 3C. In this case, the excess wetness limitation is not as great as the climatic limitation, so the soil will not be downgraded. Conversely, a soil with an additional limitation much greater than the climatic limitation will not be downgraded due to climate. For example, a very poorly drained soil will be rated 6W regardless if it is in the median climate or either of the subregions.

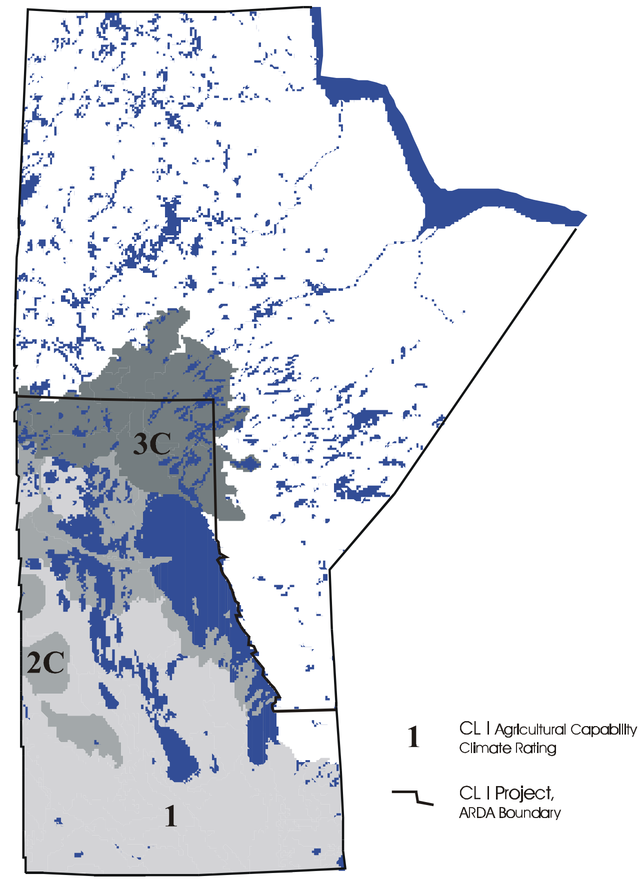

Figure 6. Agricultural Capability Ratings for Ecodistricts within the ARDA boundary.

Table 1. Agriculture Capability Guidelines for Manitoba

This table is based on the Soil Capability Classification for Agriculture (Canada Land Inventory, 1965), with modifications made for interpreting soil information at larger mapping scales. Soil erosion, topography, stoniness and salinity phase classes are defined in recent Manitoba detailed soil inventory reports and maps.

Subclass Limitations	**Class 1**	**Class 2**	**Class 3**	**Class 4**	**Class 5**	**Class 6**	**Class 7**
	No significant limitations in use for crops.	Moderate limitations that restrict the range of crops or require moderate conservation practices.	Moderately severe limitation that restrict the range of crops or require special conservation practices.	Severe limitations that restrict the range of crops or require special conservation practices or both.	Very severe limitations that restrict soil capability to produce perennial forage crops, and improvement practices are feasible.	Soils are capable only of producing perennial forage crops, and improvement practices are not feasible.	No capability for arable culture or permanent pasture.
Climate (C)	All Ecodistricts[1] within ARDA boundary not explicitly listed under 2C and 3C.	Ecodistricts: 664, 666, 668, 670, 671, 672, 674, 675, 676, 677, 714, 715, 716	Ecodistricts: 356, 357, 358, 359, 363, 366, 663, 665	None within ARDA boundary			
Consolidated Bedrock (R)				50-100 cm	20-50 cm	< 20 cm	Surface bedrock, Fragmental over bedrock
Moisture limitation[2] (M)		Stratified loams Moderate moisture holding capacity	Loamy Sands Low moisture holding capacity	Sands Very low moisture holding capacity	Skeletal Sands Very severe moisture deficiency	Stabilized sand dunes	Active sand dunes
Topography[3] (T)	a, b (0-2%)	c (>2-5%)	d (>5-10%)	e (>10-15%)	f (>15-30%)	g (>30-45%) Eroded slope complex	h (>45-70%) i (>70-100%) j (>100%)
Structure and/or Permeability (D)	Granular Clay	Massive clay or till soils [4] Slow permeability	Solonetzic intergrades Very slow permeability	Black Solonetz Extremely slow permeability			
Salinity[5] (N) a.00-60cm depth b.60-120cm depth	NONE < 2dS/m < 4dS/m	WEAK 2-4 dS/m 4-8 dS/m	MODERATE (s) 4-8 dS/m 8-16 dS/m	STRONG (t) 8-16 dS/m 16-24 dS/m	VERY STRONG (u) [6] 16-24 dS/m >24 dS/m		Salt Flats
Inundation [7] (I)	No overflow during growing season	Occasional overflow (1 in 10 years)	Frequent overflow (1 in 5 years) Some crop damage	Frequent overflow Severe crop damage	Very frequent overflow (1 in 3 years) Grazing > 10 weeks	Very frequent overflow Grazing 5-10 weeks	Land is inundated for most of the season
Excess Water (W)	Well and Imperfectly drained		Loamy to fine textured Gleysols with improved drainage	Coarse textured Gleysols with improved drainage	Poorly drained, no improvements	Very Poorly drained	Open water, marsh
Stoniness (P)	Non stony (0) and Slightly Stony (1)	Moderately Stony (2)	Very Stony [8] (3)	Exceedingly Stony (4) [9]		Excessively Stony (5)	Cobbly Beach, Fragmental
Erosion [10] (E)		Moderate erosion (2)	Severe wind or water erosion (3) lowers the basic rating by one class to a minimum rating of Class 6 [11].				
Cumulative minor adverse Characteristics[12] (x)							

Rev.(2001)

1 Smith, R.E., H. Veldhuis, G.F. Mills, R.G. Eilers, W.R. Fraser, and G.W. Lelyk, 1998. Terrestrial Ecozones, Ecoregions and Ecodistricts, An Ecological Stratification of Manitoba's Natural Landscapes. Technical Bulletin 98-9E. Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada, Winnipeg, Manitoba. Report and map at 1:1 500 000 scale.

2 With the exception of class2, ratings as indicated are based on the assumption of a single parent material, using the most readily drained representative of each textural class. Prevailing climatic conditions within the Ecodistrict, soil drainage and stratification will affect the moisture limitation accordingly.

3 Topographic classes are based on the most limiting slope covering a significant portion of an area of complex, variable slopes. Map units with long, unidirectional slopes may be considered equivalent, or one class worse due to an increased erosion hazard.

4 Extremely calcareous loamy till soils with a high bulk density (>1.7g/cm^3) are rated 3D.

5 Soil Salinity is reported in DeciSiemens/metre (dS/m). Soil will be classed according the the most saline depth. For example, if a soil is non-saline from 0-60 cm but moderately saline from 60-120 cm, the soil will be classed as moderately saline (3N).

6 Strongly saline (u) soils are rated 5N with the exception of poorly and very poorly drained soils, which are rated 6NW.

7 Inundation may be listed as a secondary subclass for some fluvial soils. In this case, inundation is not class determining, but may become a limitation if the soil is otherwise improved.

8 Extremely calcareous loamy till soils with a high bulk density (>1.7g/cm^3) and stony 3 are rated 4DP (4RP if depth to bedrock is 50-100 cm).

9 Stony 4 soils will be rated 4P unless their primary physical composition is sandy skeletal or their parent material is till. In either or both of these cases, the soil will be rated 5P.

10 If erosion is moderate, a subclass of E is assigned as a secondary limitation, but the basic rating is not lowered. If erosion is severe, the basic soil rating is downgraded by one class, and E becomes the primary limitation. For example, if a soil has a basic rating of 4T, the presence of moderate erosion will result in a rating of 4TE. If erosion is severe, the rating will be lowered to 5ET. Erosion will be the sole limitation only if the basic rating has a subclass of X. For example, a soil with a rating of 3X will be assigned a rating of 3E if moderate erosion is present.

11 The rating is not lowered from class 6 based on erosion. A rating of 6TE indicates a soil with g topography and either moderate or severe erosion.

12 Use only for soils with no other limitation except climate. The subclass represents soils with a moderate limitation caused by the cumulative effect of two or more adverse characteristics which are singly not serious enough to affect the rating. Because the limitation is moderate, soils may only be downgraded by one class from their initial climate limitation. Therefore, a soil with a climate limitation of 2c and 2 or more minor adverse characteristics will be rated as 3X. This symbol is always used alone.

Consolidated bedrock (R)

Soils in this subclass have a rooting zone restricted by consolidated bedrock. The presence of bedrock below 100 cm of the soil surface does not affect the capability class of the soil. Bedrock within 100 cm of the soil surface results in a soil capability rating of 4R or lower:

Moisture Limitation (M)

This subclass group includes soils which are subject to droughtiness owing to inherent soil characteristics. These soils are generally coarse textured, but are rated also according to drainage, stratigraphy and ecoclimate. Logic for this subclass rating system is given in the CLI Guide Table and is supplemented by a separate table on Moisture Limitations of various soil Great Groups found in Manitoba. The Manitoba Agricultural Capability Guidelines differ from that of the Soil Capability Classification for Agriculture (1965) in that the Manitoba Guidelines allow the use of 2M as a soil classification. Under the new Guidelines for Manitoba, moisture (M) and excess water (W) are not used together to define a subclass limitation.

Topography (T)

This subclass consists of soils where topography is a limitation for agricultural use. The topographic classes are based on the most limiting slope covering a significant portion of an area of complex, variable slopes. Map units with long, unidirectional slopes may have equivalent limitations, or may be rated one class lower due to an increased erosion hazard.

Structure and/or permeability (D)

Soils with adverse structure or permeability. These soils may have a root zone restriction due to inherent soil characteristics (not depth to water table or consolidated bedrock). Class 2 soils include massive clay and till soils, while class 3 soils are Solonetzic intergrades and class 4 includes Solonetzic soils. *(Exception: Morris series (MRS) is a very weak Solonetzic intergrade and is rated 2DW rather than 3D).* Extremely calcareous loamy till soils with a high bulk density (>1.7 g/cm^3) are rated 3D.

Salinity (N)

This subclass is composed of soils adversely affected by the presence of soluble salts. Class determining values of soil salinity (dS/m) are given for two depths: 0-60 cm and 60-120 cm. Soils are classed according to the most saline depth. For example, if a soil is non saline from 0-60 cm but moderately saline from 60-120 cm, then the soil will be classed as moderately saline (3N). Strongly saline (u) soils are rated 5N with the exception of poorly and very poorly drained soils, which are rated 6NW.

Inundation (I)

Soils which are subject to inundation from streams or lakes are assigned this subclass. Limits for the frequency of flooding are derived from Canada Land Inventory Report No.2 (Canada Land Inventory, 1965). The following guidelines were developed for the classification of fluvial soils:

- 2I well drained fluvial Chernozems, if they still flood. (Higher terrace soils that never flood are rated the same as lacustrine soils of similar texture).
- 2I well drained fluvial Regosols.
- 2IW imperfectly drained fluvial Chernozems.
- 3I imperfectly drained fluvial Regosols (lack of Chernozemic A horizon indicates more frequent flooding).
- 5WI all poorly drained fluvial Gleysols.
- 6WI all very poorly drained Gleysols. (Inundation receives secondary limitation status for Gleysols because excess wetness is a more serious limitation than periodic flooding on these soils).

Inundation may also be listed as a secondary subclass for fluvial soils, if there are less than 2 limiting subclasses. In this case, inundation is not class determining, but may become a limitation if the soil is otherwise improved.

Excess Water (W)

Soils which are limited in their agricultural capability by excess water not brought about by inundation are assigned this subclass. These conditions may be a result of poor soil drainage, runoff from nearby fields, high water table, or seepage. If drainage is feasible at the farm level, or has been improved by some method, the soil is rated based on the continuing limitations after drainage. Guidelines developed for Manitoba indicate a maximum limitation of 2W for all imperfectly drained soils. Poorly drained soils of any texture are rated 5W if they lack drainage improvements. Coarse textured Gleysols with improved drainage are upgraded to class 4W, while loamy to fine textured Gleysols with improved drainage are upgraded to 3W. This rationale reflects the fact that coarse textured Gleysols generally result from seepage or high water tables, which require continued efforts for improvement, while loamy to fine textured Gleysols mainly have a problem with surface drainage, which may more easily be improved, and may be a one-time improvement.

Stoniness (P)

Soils with enough stones to significantly increase the difficulty of tillage, planting and harvesting are assigned this subclass. Whereas the Canada Land Inventory Soil Capability Classification for Agriculture (1965) determined that soils with stoniness classes 1 and 2 (slightly and moderately stony) would not be limiting to agriculture, the new guidelines for Manitoba have assigned moderately stony soils a rating of 2P. Generally, these soils have enough minor limitations to result in a rating of 2X, so assigning a rating of 2P to these soils does not downgrade the soil class. It does, however, present a clearer picture of the limitations facing use of these soils for agriculture. Very stony soils (3) are rated 3P except for extremely calcareous loamy till soils with a high bulk density (>1.7 g/cm^3) which are rated as 4DP (4RP if also underlain by bedrock within 50-100cm). Exceedingly stony soils (4) will be rated 4P unless their primary physical composition is sandy skeletal or their parent material is till. In either or both of these cases, the soil will be rated 5P. All excessively stony soils (5) are rated 6P.

Erosion (E)

Soils of this subclass have actual damage from wind or water erosion which limits the use of land for agricultural use. This subclass is not class determining in itself, but is used to downgrade soil ratings if erosion is severe. If erosion is moderate, a subclass of E is assigned as a secondary limitation, but the basic rating is not lowered. If erosion is severe, the basic soil rating is downgraded by one class, and E becomes the primary limitation. For example, if a soil has a basic rating of 4T, the presence of moderate erosion will result in a rating of 4TE. If erosion is severe, the rating will be lowered to 5ET. A basic rating of class 6 will not be downgraded due to erosion and erosion will be assigned as a secondary limitation whether it is moderate or severe. Erosion (E) will be the sole subclass limitation only if the basic rating has a subclass of X or C. For example, a soil with a basic rating of 2X will receive a rating of 2E if moderate erosion is present, 3E if the erosion is severe. Some Orthic Regosols have been mapped in place of severely eroded (erosion 3) phases of Chernozems. These soils are rated the same as their equivalent Chernozem soils with severe erosion.

Cumulative Minor Adverse Characteristics (X)

This subclass represents soils with a moderate limitation caused by the cumulative effect of two or more adverse characteristics which are singly not serious enough to affect the rating. This symbol is used only for soils with no other limitation except climate and because the limitation is moderate, soils may only be downgraded by one class from their initial climate limitation. Therefore, a soil with a climate limitation of 2C and two or more minor adverse characteristics will be rated as 3X. This subclass is always used alone.

Irrigation Suitability Maps

Irrigation suitability is an important soil interpretation, particularly for high value crops, such as potatoes. Irrigation involves high initial costs for land and equipment, and has long term implications for soil productivity as well as soil and water quality.

Irrigation Suitability maps in the RM Information Bulletins use guidelines and criteria developed for use on the Canadian prairies (Working Group on Irrigation Suitability Classification 1987). Irrigation suitability is a four class rating system (Excellent, Good, Fair and Poor classes). Irrigation suitability is based on an assessment of the most limiting combination of soil and landscape conditions. Soils in the same class have a similar relative suitability or degree of limitation for irrigation use, although the specific limiting factors may differ. The most significant limiting factors are described by subclass symbols. A detailed explanation of the irrigation suitability rating system assumptions and rating criteria is provided in this section.

Irrigation suitability ratings were made manually for all unique soil and landform class combination in the RMSID data base. The page sized irrigation suitability maps in the RM Information Bulletins are generalized, and portray the ratings for the first (usually dominant) soil component and landform phases listed for each soil map polygon. Connotative "stop light" colour codes were assigned to each irrigation suitability class - the most suitable areas (Excellent) were assigned a green colour, while Good areas were yellow, Fair areas orange, and Poor areas were red. Map areas with the same colour can have different irrigation subclass limitations. It is not possible to portray this additional irrigation subclass information on page size RM Bulletin maps (typically 1:150 000 to 1:250 000). The areal extent of the various irrigation suitability classes and subclasses in each RM, based on the dominant soil in each soil polygon, is provided in an accompanying table.

Irrigation suitability class and subclass rating for all soil components (maximum of 3) in each RM soil map polygon are recorded in the RMAgInterp data base. This information can be used to produce more detailed soil capability maps from a GIS than those printed in the RM Information Bulletins.

Table 2. Soil Features Affecting Irrigation

Symbol	Soil Feature	Degree of Limitation: None (1)	Slight (2)	Moderate (3)	Severe (4)
d	Structure	Granular, Single Grained, Prismatic, Blocky, Subangular Blocky	Columnar Platy	Massive	Massive
k	Ksat (mm/hr) (0 - 1.2m)	>50	50 - 15	15 - 1.5	<1.5
x	Drainability (1.2 - 3m) (mm/hr)	>15	5 - 15	0.5 - 5	<0.5
m	AWHC subhumid mm/1.2m (% vol.) subarid	>120 (>10) >150 (>12)	120 - 100 (8 - 10) 120 - 150 (12 - 10)	100 - 75 (6 - 8) 100 -120 (10 - 8)	<75 (<6) <100 (<8)
q	Intake Rate (mm/hr)	>15	1.5 - 15	1.5 - 15	<1.5
s	Salinity depth(m) (dS/m) 0 - .6 / .6 - 1.2 / 1.2 - 3	<2 <4 <8	2 - 4 4 - 8 8 - 16	4 - 8 8 - 16 >16	>8 >16 >16
n	Sodicity (m) (SAR) 0 - 1.2 / 1.2 - 3	<6 <6	6 - 9 6 - 9	9 - 12 9 - 12	>12 >12
g	Geological 0 - 1.2m Uniformity	1 Textural Group	2 Textural Groups, Coarser Below	2 Textural Groups Finer Below 3 Textural Groups Coarser Below	3 Textural Groups Finer Below
	1.2 - 3m	2 Textural Groups	3 Textural Groups Coarser Below	3 Textural Groups Finer Below	
r	Depth to Bedrock (m)	>3	3 - 2	2 - 1	<1
h	Depth to Watertable (m)	>2	2 - 1.2 (if salinity is a problem)	2 - 1.2 (if salinity is a problem)	<1.2
w	Drainage Class	Well, Moderately Well, Rapid, Excessive	Imperfect	Imperfect	Poor, Very Poor
	*Texture (Classes) 0 - 1.2m	L, SiL, VFSL, FSL	CL, SiCL, SCL, FSCL, SL, LVFS	C, SC, SiC VFS, LS, CoSL	HvC GR, CoS, LCoS, S
	*Organic Matter %	>2	1 - 2	1 - 2	<1
	Surface Crusting Potential	Slight	Low	Low	Moderate

* Other important factors used to interpret type and degree of limitation but which do not present a limitation to irrigation themselves. No symbol is proposed for these factors since they will not be identified as subclass limitations.

Irrigation suitability assumptions:

The ISC is based on a number of assumptions:

1. A sufficiently detailed soil resource data base is available
2. Both permanent and non-permanent soil and landscape factors are considered, as well as the predicted long term impact that sustained irrigation will have on these factors.
3. Good soil and water management practices will be used.
4. Irrigation suitability classes are similar in degree, but not kind of limitation.
5. Irrigation water quality will be compatible with soil quality such that its prolonged use will not be deleterious to the quality of the land.
6. The irrigation classification is based on natural or existing soil and landscape conditions.
7. Economics or feasibility of ameliorating the indicated limitations is not considered.

The irrigation suitability classification (ISC) system considers both soil and landscape features. Climatic factors are not considered as the practice itself will mitigate aridity conditions, as well as some thermal factors. The soil features affecting irrigation suitability relate primarily to soil-water intake, storage, flow and quality relationships. The criteria, class limits, and relative degree of limitation for each factor is presented in Table 2. Terrain features affecting irrigation suitability rating relate to the potential for overland flow or runoff and are summarized according to criteria, class limits and degree of limitation assigned in Table 3. An overall irrigation suitability rating is determined by integrating the soil and terrain features as shown in Table 4. The final definition of the irrigation suitability classes are shown in Table 5.

Table 3. Landscape Features Affecting Irrigation

Symbol	Landscape Features	Degree of Limitation			
		None (A)	Slight (B)	Moderate (C)	Severe (D)
t1	Slope (%) (Simple)	<2	2 - 10	10 - 20	>20
t2	Slope (%) (Complex)	-	<5	5 - 15	>15
e	Average Local Relief (m)	<1	1 - 3	3 - 5	>5
p	Stoniness Classes	0, 1 & 2	3	4	5
I	Inundation (Freq.) Flooding	1:10 (yr)	1:5 (yr)	1:1 (annual-spring)	1:<1 (seasonal)

Table 4. Soil - Landscape Relations and Irrigation Suitability Class

Landscape Limitations \ Soil Limitations	None (1)	Slight (2)	Moderate (3)	Severe (4)
None (A)	1A	2A	3A	4A
Slight (B)	1B	2B	3B	4B
Moderate (C)	1C	2C	3C	4C
Severe (D)	1D	2D	3D	4D

Irrigation Suitability Rating

- Excellent
- Good
- Fair
- Poor

Table 5. Description of Irrigation Suitability Classes

General Rating	Class	Degree of Limitation	Description
Excellent	**1A**	No soil or landscape limitations	These soils are medium textured, well drained and hold adequate available moisture. Topography is level to nearly level. Gravity irrigation methods may be feasible.
Good	**2A 2B 1B**	Slight soil and/or landscape limitations	The range of crops that can be grown may be limited, as well, higher development inputs and management skills are required. Sprinkler irrigation is usually the only feasible method of water application.
Fair	**3A 3B 3C 1C 2C**	Moderate soil and/or landscape limitations	Limitations reduce the range of crops that may be grown and increase development and improvement costs. Management may include special conservation techniques to minimize soil erosion, limit salt movement, limit water table build-up or flooding of depressional areas. Sprinkler irrigation is usually the only feasible method of water application.
Poor	**4A 4B 4C 4D 1D 2D 3D**	Severe soil and/or landscape limitations	Limitations generally result in a soil that is unsuitable for sustained irrigation. Some lands may have limited potential when special crops, irrigation systems, and soil and water conservation techniques are used

Potential Environmental Impact Under Irrigation

A major environmental issue for land under irrigated crop production is the possibility that surface or groundwater may be impacted. This rating is intended to serve as an indicator of potential environmental concern. This potential environmental impact assessment provides a relative rating of land areas in four classes (Minimal, Low, Moderate, and High), based on specific soil and landscape conditions. The factors considered for these interpretative map ratings are mainly related to water retention and movement through the soil, as shown in Table 6. Many of these factors are also considered in the irrigation suitability classification, although here they are combined differently.

It is possible to design and or give special consideration to soil, water and crop management practices that will mitigate adverse impact, on a site-by-site basis. It is not feasible to show these mitigating conditions at the broad generalized scale of the maps in the Soil and Terrain Bulletins.

One very important factor to consider is that this Potential Environmental Impact Rating is based on irrigation land use **only**. All assumptions made under the irrigation suitability classification rating, such as availability of a suitable, high quality water source, are also applicable here. This interpretation has not been designed for, nor should it be interpreted or used for, any other type of environmental impact concerns. These should be addressed separately, using appropriate criteria and assumptions.

Potential Environmental Impact Under Irrigation ratings were made manually for all unique soil and landform class combination in the RMSID data base, based on criteria shown in Table 6. The page sized maps in the RM Information Bulletins are derived from ratings for the first (usually dominant) soil component and landform phases listed for each soil map polygon. Connotative "stop light" colour codes were used in the map legend to represent each class. Areas with Minimal potential impacts are green colour, Low are yellow, Moderate are orange, and High potential environmental impact areas are red. The RM potential environmental impact maps were generalized, and portray the class for the first (usually the dominant) soil in each polygon. The polygon boundaries have been omitted for clarity. The areal extent of the various irrigation suitability classes in each RM are based on the dominant soil in each soil polygon.

Potential Environmental Impact class and subclass rating for all soil components (a maximum of 3) in each RM soil map polygon are recorded in the RMAgInterp data base. It is not possible to portray the information at the reduced scales of the RM Bulletins (typically 1:150 000 to 1:250 000). This information can be used to produce more detailed maps from a GIS than those published in the RM Information Bulletins.

Table 6. Soil and Landscape Factors for Environmental Impact Ratings.

Soil Property and Landscape Feature	**Potential Degree of Impact**			
	Minimal	**Low**	**Moderate**	**High**
Textural Groups[1] (Classes[2]) Surface Strata (1.2m)	MF (SCL,CL,SiCL) F (SC,SiC,C) VF (HC)	M (Si,VFSL,L,SiL)	Mco (CoSL,SL, FSL,VFS,LVFS)	Vco (VcoS,CoS); Co (LcoS,LS, FS,LFS)
Geological Uniformity Weighted Textural Groupings[3] Surface Strata (1.2m) / Substrata (1.2-3.0m)	MF to VF / M to VF; M / MF to VF	MF / Mco to Co; F / Co; Mco to Co / MF to Vf	M / Mco to Co; Co / M; MF / VCo	VCo to Co / VCo to Co; MCo / Co to VCo; Co / VCo to MCo; M / VCo
Hydraulic Cond Ksat(mm/hr)	< 1.5	1.5 - 15	15 - 50	> 50
Depth to Water Table (m)	> 2m	(2m---------------------1m)		< 1m
Salinity (dS/m)	0 - 4	4 - 8	8 - 15	> 15
Topography (% Slope)	0 - 2	2 - 5	5 - 9	> 9

Textural Groups[1]**:** VF = Very Fine, F = Fine, MF = Moderately Fine, M = Medium, MCo = Moderately Coarse, Co = Coarse, VCo = Very Coarse

Texture Classes[2]**:**

Very Coarse - Vco
- VCoS - Very Coarse Sand
- CoS - Coarse Sand
- S - Sand

Moderately Coarse - Mco
- CoSl - Coarse Sandy Loam
- SL - Sandy Loam
- FSL - Fine Sandy Loam
- VFS - Very Fine Sand
- LVFS - Loamy Very Fine Sand

Moderately Fine - MF
- SCL - Sandy Clay Loam
- SiCL - Silty Clay Loam
- CL - Clay Loam

Coarse - Co
- LCoS - Loamy Coarse Sand
- LS - Loamy Sand
- FS - Fine Sand
- LFS - Loamy Fine Sand

Medium - M
- Si - Silt
- VFSL - Very Find Sandy Loam
- L - Loam
- SiL - Silt Loam

Fine - F
- SC - Sandy Clay
- SiC - Silty Clay
- C - Clay

Very Fine - VF
- HC - Heavy Clay

[3]Slash indicates surface strata (1.2m) overlying substrata (1.2-3.0 m), ie: MF to VF / M to VF

Notes for Table 6.

1. Guidelines developed for making this impact rating employ four relative degrees of risk of degradation: **Minimal, Low, Moderate and High.** This rating is not part of the irrigation suitability classification, but rather is intended to serve as a warning of possible adverse impact on the soil, adjacent crops or the environment. Since all situations cannot be completely covered by general guidelines, an on-site inspection is recommended for the evaluation of potential adverse environmental impact

2. A major concern for land under irrigation is the possibility of adverse impact on the groundwater and surface water quality in and adjacent to the irrigated area. The soil factors selected for impact evaluation include those properties that determine water retention and movement through the soil and topographic characteristics that affect runoff and redistribution of moisture in the landscape. The risk of altering the soil drainage regime and soil salinity or the potential for runoff, erosion or flooding is determined by the detailed criteria for each property. Soil factors and landscape features considered in determining an environmental impact evaluation are:
    1. Soil Texture
    2. Geological Uniformity
    3. Hydraulic Conductivity
    4. Depth to Water Table
    5. Salinity
    6. Topography

3. Soil texture and the thickness and uniformity of geological deposits (assessed by weighted textures in surface strata and subsurface strata) combine to affect the soil's water holding capacity and hydraulic conductivity (ability to transmit water and leachate either vertically or laterally in the soil). The presence and sequence of strongly contrasting soil textures within 3m of the surface (geological uniformity) are used to determine the potential for downward movement (moderately coarse to fine materials underlain by coarse materials) or lateral movement (very coarse and coarse materials underlain by fine materials) of water and leachate. Uniform, highly permeable materials with low water holding capacity present the highest potential for adverse impact on groundwater quality. Uniform materials of low permeability provide the best buffer against impact on groundwater quality.

4. A shallow depth (<1 m) to water table has a higher risk for contamination than soils with a deep water table. Soils with high levels of salinity may adversely impact on groundwater quality due to the leaching associated with irrigation practices (ie: applied leaching fraction).

5. Topographic patterns with slopes in excess of 2 percent require special consideration for soil and water management to reduce the potential for runoff and erosion. The risk of runoff and potential for local flooding, build-up of water tables and soil erosion increases with slope gradient. Soil erosion results in loss of topsoil and transport of nutrients and pesticides to non-target areas.

Water Erosion Risk Maps

Water Erosion Risk Maps have been provided for all RM Information Bulletins. The risk of water erosion was estimated using the universal soil loss equation (USLE) developed by Wischmeier and Smith (1965) and applied widely in the United States and Canada. Although not originally intended for such use, USLE analyses provide valuable comparisons between polygons on the soil map. The computed values from the soil map can be utilized in a qualitative sense to compare polygons by erosion risk class. Details of the USLE factors and the water erosion risk classification are provided in this section.

Soil loss tolerance is an estimate of the amount of soil loss in tonnes per hectare per year that can be lost without permanently decreasing the potential productivity of the soil. Establishing a tolerance level for specific soils and topography has been largely a matter of collective judgement and is related in a general way to the expected rate of soil development. For various agricultural conditions and locations the values have ranged from 1 to 6 tonnes/ha/yr (Beasley 1976). A typical scenario is to utilize a threshold value of 6 for generalised risk analysis. The soil loss class values utilized in this study are standard classes that have been used by Eilers et al. (1989) for water erosion risk analysis for southern Manitoba based on agricultural considerations

The value of the predicted water erosion rate (**A**, in tonnes/ha/year soil loss) were computed for each soil-slope-slope length components in each polygon. These computed values for each component were then grouped into 5 classes as follows:

	Class	Potential Soil Loss (tonnes/ha/year)
N	**Negligible**	< 6
L	**Low**	6 to 11
M	**Moderate**	11 to 22
H	**High**	22 to 33
S	**Severe**	> 33

Erosion risk ratings were made for all unique soil and landform class combinations in the RMSID data base. USLE predicted erosion rates were computed from available soil, landscape and climatic attributes. The calculated potential soil erosion values are based on assumptions of unprotected soils with no mitigating management practices. The potential USLE erosion rates (tonnes/ha/year) were computed for each soil and landscape component in each soil polygon. A weighted average erosion risk (t/ha/yr) was then calculated for each polygon, based on the values for all soil-landscape component and their areal extents. This averaged erosion risk was then translated into the corresponding erosion risk class for each polygon shown in the page sized RM erosion risk maps. Connotative "stop light" colour codes were assigned to each of the 5 classes.

The RM erosion risk maps are generalized, in that they show the averaged erosion risk class for each soil polygon. Polygon boundaries have been omitted for clarity. Map areas with the same overall erosion risk class can have individual soil landscape components with different erosion risk classes. It is not possible to portray this additional information on page size maps in the RM Bulletins (typically 1:150 000 to 1:250 000). The areal extent of the averaged erosion risk classes in the RM erosion risk map is provided in an accompanying table.

Erosion risk class classes for the individual soil polygon components (maximum of 3) in each RM soil map polygon are recorded in the RMAgInterp data base. The erosion symbols for individual soil components were combined with the estimated percentile distribution to create an overall Water Erosion Risk Symbol . This information can be used to produce more detailed soil capability maps from the GIS than those printed in the RM Information Bulletins.

USLE Factors

The Universal Soil Loss Equation (USLE) requires slope and rainfall data that was not readily available in existing soil data bases. Slope gradient and slope length information for reconnaissance map areas was obtained from the Terrain analysis, while a rainfall erosivity factor was calculated from available climatic data. The USLE uses these factors to predict the risk of water erosion for each soil polygon component.

The water erosion risk maps produced for the RM Information Bulletins show the long term risk of water erosion on bare, unprotected soil surfaces. This is comparable to erosion risk under dryland agriculture crop production, without use of specific conservation management practices. Cropping and residue management practices will significantly reduce this risk depending on crop rotation program, soil type, and landscape features.

The USLE can be written as:

$$\mathbf{A = R_t*K*L*S*C*P}$$

Where:
- A = predicted water erosion rate
- R_t = erosivity of rainfall and snow melt
- K = soil erodibility factor
- L= slope length factor
- S = steepness factor
- C = crop cover and management factor
- P = conservation practice factor.

<u>A - predicted soil loss</u> **-** average annual soil loss per unit area (tonnes per hectare per year, t/ha/year)

<u>R_t - erosivity of rainfall and snowmelt</u> **-** is a combination of the average annual rainfall erosion index (rainfall energies) (Wischmeier and Smith 1978) for a particular area modified according to procedures of McCool et al. (1982) and Tajek et al. (1985) to include a factor for the erosion derived from the energy of running water from snow melt. R_t values were assigned for each soil map polygon from the 1:1 million scale Water Erosion Risk Map of Manitoba (Eilers et al., 1989), converted to SI units.

<u>K - soil erodibility factor</u> **-** is a function of soil properties and conditions. Some soils erode more easily than others under the same rainfall, slope conditions, vegetative cover and management practices. Soil properties that determine erodibility include: texture, structure, organic matter content and permeability. Therefore it is important to know the soil types and their respective properties for the land area of concern. Each soil will have it's own K factor. Soil erodibility (K) in metric units ($t*h*MJ^{-1}*mm^{-1}$) was estimated for all soil series in all map polygons, based on soil structure and permeability, the percent very fine sand, silt, clay, and organic matter. Individual K factors were calculated for each soil series in the polygon, based on data in the Manitoba Soil Names and Soil Layer Files

<u>L - slope length factor</u> **-** the ratio of soil loss from a field with a given slope length to that from a 22m long slope on the same soil type and slope gradient. Slope length is a measure of the distance from the initiation of overland flow to the point in the slope where deposition begins or where water enters a defined channel. The loss per unit area increases with increasing length.

<u>S - slope steepness factor</u> **-** is the ratio of soil loss from the measured slope gradient to that from a 9% slope. As the gradient of the slope increases the velocity of the runoff increases and thus the power to detach and remove soil particles also increases.

<u>LS - slope length and steepness factor</u> **-**.is the relative erosion potential of the soil polygon component median slope and slope length in comparison to standard (fixed) USLE LS erosion plot slope and slope length conditions.

C - crop cover and management factor - is the ratio of soil loss from land cropped under specific conditions to the corresponding loss from continuous fallow and tilled land. This factor measures the combined effect of all the interrelated cover and management variables. The C factor adjusts the soil loss estimate to suit the prevailing management conditions (Beasley 1976). The C factor was set at 1.0 for bare, unprotected soil.

P - conservation practice factor - is the ratio of soil loss from contour tillage, contour-strip cropping or terracing to the soil loss which would occur under straight row farming, up and down slope. These practices slow the runoff water and reduce the amount of sediment it can carry. It represents practices in addition to continuous cover crops, minimum tillage etc. The P factor was set at 1.0, and assumes that there are no conservation practices were applied.

Land Use Maps

Land use maps included in the RM Information Bulletins are based on a supervised classification of LANDSAT Thematic Mapper (TM) imagery. The land use maps were supplied by the Prairie Farm Rehabilitation Administration of Agriculture and Agri-Food Canada. The classification was done by the Manitoba Remote Sensing Centre in the mid 1990's, as part of a comprehensive federal program to evaluate land cover for the Canadian prairies. The classified land use map for each Manitoba RM was prepared as an image file by PFRA, transferred to the Land Resource Group, and incorporated in the RM Information Bulletins.

Seven general land use classes were recognized:

Annual Crop Land - land cultivated on an annual basis.
Forage - land in perennial forages, generally alfalfa or clover with blends of tame grasses.
Grasslands - areas of native or tame grasses, some scattered shrubs.
Trees - areas that are primarily in tree cover.
Wetlands - wet areas, often with sedges, cattails and rushes.
Water - open water lakes, rivers, streams, ponds and lagoons.
Urban and transportation - towns, roads, railways, and quarries.

Many individual spectral signatures were classified and grouped into the 7 general land use classes. A table showing the area (ha) and percent of the RM in each land use class is also provided. Although land use changes over time, and some land use practices on individual parcels may occasionally result in similar spectral signatures, these maps provide a general representation of the land use in each rural municipality at the time of the classification.

The RM Land Use maps are not part of the RMSID and RMAgInterp data bases. Further information on satellite imagery and land use maps can be obtained from PFRA or the Manitoba Remote Sensing Centre.

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