A Manitoba Regional Perspective on Wetlands

By

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A Thesis
Submitted to the Faculty of Graduate Studies
In Partial Fulfillment of the Requirements
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ABSTRACT

Part one provides a general review of the wetlands topic from a Manitoba regional perspective with regard to wetlands distribution, values, protection efforts, definitions, classification systems and existing inventories. There is qualitative information claiming the developed portion of Manitoba has lost more than 70% of its wetlands due to agriculture but there is no comprehensive inventory information against which to compare for change assessments.

Part two provides an inventory of wetland magnitude and distribution by surface watersheds and by land and water cover types throughout the agricultural portion of Manitoba. The inventory is based on a land cover database compiled during the 1980s by the Manitoba Forestry Branch. Groundtruthing was completed to confirm the database's current relevance.

The inventory found that on average, 11% of the study area was covered with wetland vegetation. The portion of wetland cover in the 28 watersheds of the study area ranged from 0.5 to 36%. The portion of privately-owned wetlands in the watersheds ranged from 5 to 92%. Wetlands have been almost eliminated in some of the most intensively drained and farmed watersheds. In these areas a more active approach is required if representative wetland environments are to be saved.

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PART ONE

THE WETLANDS TOPIC

Background

Wetlands cover approximately six percent of the earth's land area. Most are concentrated between 45 and 75 degrees north latitude (Gore, 1983). A general definition of a wetland is land that is covered with shallow water or water tolerant vegetation. Wetlands are commonly grouped according to whether they are comprised of peat or mineral soil and of fresh or salt water. Three quarters of the world's wetlands are inland fresh water wetlands and approximately one third are peatlands (Williams, 1990).

Canada contains one quarter of the world's wetlands (Bond *et al.*, 1992). Their area totals approximately 130 million hectares, 14 % of Canada's land area. They are mainly concentrated in the north and are mainly within federal or provincial crown-owned land. Approximately 90 % of wetlands are peatlands (Zoltai, 1988). Canada contains 54 % of the world's peatlands, the former USSR contains 30 % (Canada, 1992).

The largest concentration of Canada's wetlands is located in the Hudson Bay lowlands of Manitoba and Ontario. The Canadian province with the largest portion of its territory in wetlands is Manitoba (43%). Manitoba

contains 23.3 million hectares of wetlands (Halsey *et al.*, 1997) mostly bog and fen peatlands (muskeg) located in the northern and eastern parts of the province. Marshes and shallow water wetlands (potholes, sloughs and lakes) also occur in the southern and western parts of the province.

On geological time scales, wetlands are temporary landscape features. Time and geomorphic processes transform them either into dry land or deep water. Transformation to dry land occurs by sedimentation processes or by reduced water levels. Occasionally, wetlands are transformed into deep water habitats by increased water levels at which time new wetlands are created in adjacent low lying areas.

Human activities relating to wetlands have been documented from relatively early times. Rural residents in northern Europe have cut peat from wetlands to be used as fuel for centuries. Gerard Boate classified Irish bogs in the seventeenth century. The Dutch documented wetland reclamation and the Soviets utilized wetland peat in industry in the eighteenth century. Wetland drainage for agricultural production was well under way in Europe in the nineteenth century (Williams, 1990) and in North America in the twentieth century.

The term "wetlands" was coined in 1956 by hydrologists S. P. Shaw and C. G. Fredine, working for the United States Fish and Wildlife Service (Prince, 1997). The term is absent from most periodical literature prior to 1970 but since then, wetlands have been studied as distinct natural

environments. Williams observed that of 2051 citations in an authoritative book "Ecology and Management of Wetlands" by Hook *et al.*, 85 % were post 1970 (Williams, 1990). A similar chronology of increased recent wetland interest is evident in geoscience literature. GEOREF is an abstracts database compiled by the American Geological Institute which monitors 5000 journals in 44 languages. During the early 1970s, it cites less than 10 wetland articles per year. From the 1980s onwards, it cites in excess of 150 per year. A similar abstracts compilation "Geo Abstracts"; monitors approximately 1000 physical geography journals; it cites less than 10 articles per year on wetlands in the early 1970s, and nearly 100 per year by the early 1990s. Wetlands continue to be studied by researchers (Gray, 1990) and by developers (Steinberg, 1988).

In areas of high agricultural, industrial or urban development, natural wetland functions have been given little consideration and value. In such areas, land occupied by wetlands is often found to be more valuable if drained or filled and converted to commercially productive uses. Converted wetlands support the commercial production of peat, wood, straw and agricultural crops. Canada shares near equal ownership of most of the world's commercially valuable peat deposits with the former Soviet Union. World fuel and horticultural peat production was 220 million tons in 1980. The Soviet Union accounted for 90 %. In 1990, North America produced 1.2 million tons of horticultural peat and no fuel peat (Williams, 1990). In

1993, peat shipments in Canada were valued at 112.9 million dollars (Twolan-Strutt, 1995).

By 1980, 160 million hectares of the world's wetlands were functioning as agricultural land. North America accounted for 70 million hectares of this converted area (Williams, 1990). In Canada it is estimated that 85 % of wetland losses have been due to agriculture. Regionally, it is estimated that the central prairie region has lost 70 % of its sloughs, southern Ontario and the St. Lawrence valley have lost 70 to 80 % of their hardwood and shoreline swamps and the east and west coasts have respectively lost 65 and 70 % of their salt marsh wetlands (Cox, 1993).

Wetlands Uses and Values

Natural wetlands in the landscape perform useful environmental and social functions. Many of these functions are integral to biological, geomorphological, hydrological, biogeochemical and atmospheric processes (Richardson, 1994). Wetland ecosystems are recognized as contributing to:

(i) flora and fauna habitat

(ii) water purification

(iii) the hydrologic cycle

(iv) the control of global climate

(v) education and recreation

These functions will be discussed in the following.

(i) Wetlands and Flora and Fauna Habitat

Wetlands contain nutrient rich water that supports a rich aquatic ecosystem and nutrient rich soil that supports productive terrestrial ecosystems. They support plants, fish, birds and animals and they provide subsistence harvesting and related recreational activities. Wetlands are among the most prolific of primary and secondary biological producers on the planet. They cover only six percent of the earth's surface but are estimated to produce 24 % of the world's net primary production. Fresh water swamp and marsh along with tropical rain forest are the world's greatest net primary

producing environments. On average, they are capable of producing 2000 grams of plant biomass per cubic meter per year. In comparison, boreal forest produces only 1000 grams per cubic meter per year and cultivated land only 600. Wetlands are also prolific secondary producers. In North America, the central Prairie pothole region is estimated to comprise 10 % of the waterfowl breeding area but produces 50 % of the waterfowl population (EOSAT, 1987).

Wetland-dependent flora and fauna contribute to global biodiversity. Wetlands are characterized by many different kinds of flora and fauna compared to other ecosystems (Office of Technology Assessment, 1984). Wetlands are some of the last remaining wilderness in the United States (Council on Environmental Quality, 1989). In some extensively disturbed environments, wetlands may be the last preserve of the natural species.

(ii) Wetlands and Water Purification

Wetlands are traps and sinks for a variety of water and sediment-borne pollutants and toxins including heavy metals, pesticides, herbicides, fertilizers and human and animal wastes. Within a wetland, physical, chemical and biological processes bind pollutants to the bottom clay and organic sediments, micro-organisms decompose them and they are taken up by plants.

Constructed and natural wetlands are use to treat and improve the

quality of low volumes of rural runoff and secondary urban wastewater. They do so by reducing the biochemical oxygen demand, and the nitrogen, phosphorus, sediment and metals concentrations (Horwitz, 1978; Kent, 1987; Williams, 1990; Dugan, 1993; United States, 1993; Olsen, 1993). When treating secondary wastewater, wetlands may experience a several-fold increase in vegetation biomass and a vegetation shift to cattail and duckweed communities. In addition, the chemical and visual aspects of the water column and substrates are altered (Kaldec, 1987). Wetland water treatment systems exist and are being developed in at least 67 locations in Canada. In Manitoba a wastewater tertiary treatment wetland is functioning at the Oak Hammock Marsh Conservation Centre (Pries, 1994).

Mine drainage water quality can be improved by releasing it through wetlands. The mining of coal and metals results in acidic drainage water with high concentrations of sulphides, iron, aluminum, manganese, zinc and other metals depending on the geologic deposit (Council on Environmental Quality, 1989). This drainage degrades the water quality of receiving streams and impacts fish populations and other aquatic life. Investigations have also revealed that some wetlands are degraded by the receipt of such pollutants and there is evidence that the capacity of some wetlands to remove and store pollutants is limited (Kent, 1994).

(iii) Wetlands and the Hydrologic Cycle

Wetlands influence the global hydrologic cycle by storing surface water, slowing runoff, reducing downstream peak streamflows, increasing streamflow duration and groundwater recharge. In shoreline environments, they provide erosion protection and critical aquatic and terrestrial flora and fauna habitat (Richardson, 1981). They can be the interface between the land and the surface water and groundwater regimes. The open water in wetlands may indicate the elevation of the local groundwater table. Wetlands can also function as recharge or discharge areas for the regional or local groundwater regimes (Mills and Zwarich 1984, Office of Technology Assessment 1984, Hubbard 1988, Winter 1989).

(iv) Wetlands and Global Climate

Wetlands are recognized as influencing global atmospheric gas cycles and consequently global climate. They are ideal environments for the biogenic production of carbon, nitrogen and sulphur gases. The world's peatlands contain 330 billion tons of dry organic matter, which if burned would release 500 billion tons of carbon dioxide, almost doubling the amount in the atmosphere today (Dugan, 1993). Carbon dioxide and methane are the two most significant naturally produced greenhouse gases. Wetlands are estimated to account for 15 to 40 % of their sources (Canada,1992). Bellamy refers to them in conjunction with coral reefs and marine plankton

as the true lungs of the earth, performing the vital function of keeping the gases of the atmosphere in balance (Dugan, 1993).

Wetlands contribute 40 to 50 % of total global atmospheric methane emissions (Whiting and Chanton, 1993). The world's main natural methane sources are anaerobic bacteria digesting in swamps, wetlands and rice paddies, termites, and enteric fermentation in ruminants. Polar stratospheric methane clouds from increased wetland area have been proposed as a potential cause of Eocene climate changes (Sloan *et al.*, 1992). It is proposed that the wetlands carbon dioxide and methane sink functions may control atmospheric greenhouse gases and explain the glacial/inter-glacial climate cycle (Franzen, 1994; Franzen *et al.*, 1996).

(v) Wetlands and Education and Recreation

Wetlands also provide education and recreation opportunities. Wetland flora and fauna specimens are used for scientific research, education and display purposes. Outdoor recreational activities such as photography, hiking, canoeing and bird watching employ the appreciation of wetlands (Furtman, 1991). Filion *et al.*, (1993) estimated that in 1991 almost four million Canadians took trips to watch, photograph and study wildlife. They estimated that in Manitoba, similar to other provinces, 19 % of the population participated in non-consumptive uses of wildlife for an average of 19 days per year.

Wetland Evaluation

A wetland evaluation guide was published in Canada in 1992. It details a comprehensive procedure for evaluating wetlands which can be used during development decisions. The evaluation procedure is valid for all wetland types identified in the Canadian wetland classification system and it includes consideration of a wetland's biological, hydrological, social/cultural and production components (Bond *et al.*, 1992).

The province of Ontario published an evaluation system to measure the biological, social, hydrological and special feature values of the wetlands south of the Canadian Shield in Ontario in 1983. The objectives were to increase the scientific understanding of the ecological role of wetland's, and to provide an analytical basis for solving conflicting land use claims. The guide required information be gathered from existing sources and from site investigations (Ontario and Canada, 1983).

Wetlands Protection

Society often views land as private property and water as public property. While wetlands include aspects of both land and water they have mainly been considered as land and therefore as private property. During the early agricultural development of the Prairie Provinces in Canada, the law was perceived to hinder the drainage of wetlands but by 1937 the law had been changed to facilitate their drainage (Percy, 1993). Until the mid-1970s, the North American legal framework and many government policies encouraged the destruction of wetlands (Council of Environmental Quality, 1989).

Today, wetlands are becoming valued as ecological resources and are less frequently seen as wastelands. Increased societal recognition of their value is changing the attitude towards wetland development and destruction. Wetlands are being formally protected in an increasing variety of ways. The common wetland protection methods used in Canada are legislation, policy and programs, incentives, and acquisition. Legislation, policy and programs and incentives are mainly government procedures used to guide crown-owned wetlands management, and to encourage the protection of private wetlands. The protection of wetlands by acquisition is mainly a non-government organization method.

The protection of wetlands in central North America is often the result

of joint international waterfowl conservation efforts. The first refuge for waterfowl in North America was established in 1887 at the current Lost Mountain Lake in Saskatchewan. The Canadian Migratory Birds Convention Act, ratified in 1916, is an international convention for the protection of migratory birds between Canada and the United States. The Canadian Wildlife Service administers 11 million hectares in 100 sanctuaries protected under this act. These sanctuaries have been established mainly on federal and provincial crown land and mostly in the Northwest Territories (Gillespie, Boyd and Logan, 1991). An additional 45 wetland areas are protected under the 1973 Canada Wildlife Act (Percy, 1993).

The "Ramsar International Convention on Wetlands of International Importance Especially as Waterfowl Habitat" was signed by 18 countries in Ramsar, Iran in 1971 (Carp, 1972). This convention seeks to encourage wetlands preservation by establishing a list of internationally valuable wetlands, and by 1990 it had 60 signatory nations. In 1993, the list identified 650 valuable wetland sites totalling in excess of 34 million hectares. Canada signed the Ramsar convention in 1981. There are 32 Ramsar sites in Canada covering 13 million hectares of wetlands (Rubec, 1994). Five of these sites are located in the prairie pothole region and two of them, Delta Marsh and Oak Hammock Marsh are located in Manitoba (Gillespie, Boyd and Logan, 1991).

The North American Waterfowl Management Plan was agreed to by

Canada and the United States in 1985, and by Mexico in 1989. The plan requires 2.2 billion dollars (1.7 billion of this in Canada) to be spent over 15 years to restore waterfowl populations to 1970 levels by protecting 2.5 million hectares of wetlands (Lynch-Stewart *et al.*, 1993). By 1994, it had expended 187 million dollars in Canada and acquired over 830,000 hectares of wetland and upland habitat (Rubec, 1994).

Canada adopted a policy of " no net loss" of wetlands functions in 1981 (Lynch-Stewart, 1992). Canada, with most of its wetlands located on crown-owned land, has avoided the use of federal legislation and enforcement instruments to oblige the protection of private wetlands and instead relies on a policy approach to encourage their protection. "No other nation has pursued wetland programs so actively from this perspective" (Lynch-Stewart *et al.*, 1993, p. 20). Unfortunately, Canada also enforces Income Tax legislation that devalues privately-owned wetlands. Gifts of wetlands as environmentally significant land to charity or to a government are seldom accompanied with a usable tax receipt commensurate with the value of the gift. Some view this as treating gifts of natural heritage with less respect than those of cultural significance (Denhez, 1992).

The Canadian Constitution grants authority over wetlands to the Provinces (Percy, 1993). Limited, indirect federal authority to influence wetlands is provided in five acts. The Fisheries Act, revised 1985, allows for the protection of water used by fish, including fish bearing wetlands. The

Migratory Birds Convention Act, ratified in 1916, protects migratory birds and their nests, which may be in wetland areas. The Canada Wildlife Act, revised 1985, facilitates joint federal provincial programs to protect wildlife and federal acquisition of land for conservation, interpretation and research of wildlife and habitats. The Canada Water Act, revised 1985, allows the federal government to form agreements with provinces for the conservation, development and utilization of any waters where there is significant national interest (Alberta, 1993). The Endangered Species Act Protection, proposed 1997 currently Bill C-65, provides protection to wetlands if they contain habitat for threatened wildlife (Canada, 1997).

These laws limit the federal government's direct authority over wetlands to those located on federally owned and controlled land (National Parks and Wildlife Management Areas, Military Reserves, Community Pastures and Indian Reserves). The Fisheries Act could possibly extend to privately-owned fish-bearing wetlands but this has not been pursued (Percy, 1993). All of these acts are limited by provincial jurisdiction. Additional federal laws in other jurisdictions, such as agriculture, transportation and navigable waters, can also have indirect impacts on wetlands (Alberta, 1993). The provinces have jurisdiction over wetlands but most (including Manitoba) have not passed laws protecting them, especially those located on private land. Provincial legislation exists mainly in Ontario and Quebec, but also in Prince Edward Island, to protect approximately one third of

Canada's wetland area (Rubec, 1994).

In contrast to Canada's approach, the United States has pursued wetland protection with more rigor. The federal government designates and monitors wetlands, and enacts and enforces legislation regulating permissible activities, even in privately-owned wetlands. The Clean Water Act, Section 404 regulates dredge and fill activities in navigable waters and adjacent uplands. It is estimated to control 20% of the activities that imperil wetlands, mainly coastal wetlands (Kent, 1994). The jurisdiction over and protection of most remaining wetlands is given by the Food Security Act and exercised by the Swampbuster and Conservation Reserve programs. They regulate drainage, ditching and channelization for agricultural development. Swampbuster is enforced by revoking violators rights, on all of their land, to federal benefit programs including crop insurance, commodity credit corporation loans and disaster assistance programs (Leitch, 1992). At least 25 federal and many state statutes are coordinated to impact activities around wetlands (General Accounting Office, 1991).

Policies protect wetlands by establishing conservation minded land management procedures to guide the creating agency or organization. Canada established a federal water policy in 1987 including a specific wetlands preservation statement (Canada, 1987). The Canadian government adopted a wetlands policy in 1991. The policy's objective is to "promote the conservation of Canada's wetlands to sustain their ecological and socio-

economic functions, now and in the future" (Canada, 1991, p.7). The policy commits all federal departments to "no net loss" of wetlands functions. Seven strategies are detailed to manage federal wetlands and to insure that effective wetland science and public awareness be conducted. Canada has resolved to become the world leader in the utilization of the policy approach to wetlands conservation.

The North American Wetlands Conservation Council (Canada) was established in 1990. It promotes wetland ecosystems awareness and conservation in Canada, and assists in the coordination of the North American waterfowl management plan. Since 1990, wetland policies have been prepared and adopted by two industries and six governments in Canada. Throughout Canada, 22 wetland conservation programs were being implemented in 1993 (Lynch-Stewart *et al.*, 1993). Policy trends include inputs from non-government organizations and from the public, the utilization of a full range of initiatives from public awareness programs to federal land management, recognition of social and environmental wetland values, practicing sustainable development of wetlands, and the pursuit of scientific wetland knowledge. Provincial policies refer to programs ranging from waterfowl crop damage compensation to property tax incentives and highway corridor maintenance.

Wetland conservation policies are estimated to affect approximately two thirds of Canada's wetland area. These policies apply to Canada and,

to a lesser degree, Ontario (Ministry of Natural Resources, 1993) and Alberta. They are also applied, to a minor degree, by Newfoundland, Manitoba, Saskatchewan, Nova Scotia and New Brunswick. Manitoba and Saskatchewan policies are estimated to affect 1.5 % of Canada's wetlands (Rubec, 1994). Wetland protection policy statements were also adopted by the Canadian Sphagnum Peat Moss Association in 1991 and the Canadian Pulp and Paper Association in 1992 (Lynch-Stewart *et al.*, 1993). Manitoba has references to wetlands in its water policies (Manitoba, 1994a), land use policies (Manitoba, 1994b) and natural lands and special places policies (Manitoba, 1997). These policies oblige the agencies to consider wetland conservation during natural resource planning and decision making.

Incentives are used by governments to protect privately-owned wetlands. They include making government taxes and regulations that promote the conservation of wetlands. These include property tax exemptions, the removal of capital gains charges from land easement purchases by environmental charities, and the freeing of individuals from an environmental charities purchase ceiling based on percentage of income. The Ontario Conservation Land Act (1988) allows tax rebates of 100% to the owner for the protection of provincially significant wetlands and areas of natural and scientific interest. In Alberta, land assessment class is based on agricultural use value and most wetlands are not taxed. In Manitoba, ecologically sensitive portions of farm lands can be identified as conservation

lands and assessed at very low rates. However, environmental charities are not exempt from taxes (Denhez, 1992).

Acquisition for the purpose of protecting wetlands is used mainly by non-government agencies, individuals or organizations. It may deal with ownership rights or activity rights (easements). Easements or covenants (servitudes in Quebec) can be acquired by conservation-minded organizations relatively cheaply. They purchase only certain activity rights but they can bind current and future land owners to wetlands conservation activities. All other property rights remain with the land owner. British Columbia, Manitoba, Ontario, Nova Scotia, Prince Edward Island and the Yukon, have acts facilitating conservation easements by non-government agencies (Silver *et al.*, 1995).

Wetlands Definitions

There are numerous wetland definitions, most of which are tailored to meet the particular needs of the defining organization or person. The most detailed definitions usually accompany wetland classification systems which are used to compile scientific inventory information. These definitions are written to encompass the various types of wetlands found in an entire region or country. There is no standardized world wetland terminology.

Some common regional names for wetland environments include peatlands, muskeg, bog, swamp, marsh, pothole, slough, meadow, and mud flats. In 1983, Tony Gore referred to approximately 90 terms from various countries for wetlands (Gore, 1983). Different countries sometimes use the same name for different types of wetlands. In North America and in Europe the term "swamp" commonly refers to a wooded wetland. In Africa the term "swamp" commonly refers to a wetland covered in herbaceous vegetation, which in North America is referred to as a "marsh".

Generally, a wetland is land covered with shallow water or water tolerant vegetation. The Canadian vegetation classification system defines a wetland as "a body of permanently standing or flowing water less than two meters in depth" (Strong, Oswald and Downing, 1990, p. 11). David Hawke, a naturalist and a wetland educator from southern Ontario, defines a wetland as "an area which is wet all or part of the year and which supports the type

of vegetation and aquatic life that requires wet or seasonally wet conditions for growth and reproduction" (Hawke, 1993, p. 17). The most agreed upon international definition is that used by the 60 signatory countries of the Ramsar wetlands protection convention. It defines wetlands as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (Carp, 1972, p. 18).

Canada's National Wetlands Working Group refers to wetlands as "areas that are waterlogged all or most of the time. They are neither firm "lands" in the conventional sense nor bodies of open water; hence they occupy a transitional position between land and water" (Tarnocai, 1988, p.3). The group's formal definition is "land that has the water table at, near, or above the surface or which is saturated for a long enough period to promote wetland or aquatic processes as indicated by hydric soils, hydrophytic vegetation, and various kinds of biological activity that are adapted to the wet environment" (Tarnocai, 1988, p. 3).

The Manitoba Heritage Marsh agreement defines wetlands as "depressional lowlands including, sloughs, potholes, marshes, oxbows and fringed open water, one acre or more in area, containing temporary, intermittent or permanent water and supporting emergent vegetation consisting of a variety of reeds and grasses such as cattail, bulrushes,

bluejoint, whitetop and phragmites and submerged and floating aquatic plants such as water milfoil, bladderwort, pondweed and water lily" (Manitoba *et al.*, 1985, p. 4)

Wetlands Classifications and Inventories

Comprehensive wetland management requires the classification and inventory of all wetlands within the area of interest. Establishing a wetlands classification system involves the theoretical description of separate groups or classes of wetlands based on distinct characteristics. Completing a wetlands inventory requires a reconnaissance of the area of interest and the itemization of the location and description of the wetlands contained.

Wetland classification systems have evolved from earlier land classification systems and they vary depending on their purpose and the location of their intended use. Generally, the larger and more diverse the area, the more detailed the classification system. The most commonly used classification characteristics are hydrology (water regime, water permanence) and vegetation cover type. Other characteristics used include water chemistry, topographic setting, size, disturbance, waterfowl production capability, substrate soil morphology, and associated avian fauna (Mulamoottil *et al.*, 1996).

A variety of wetland information has been established in central North America. A review of the Manitoba regional development of wetland classification and inventory information follows.

The Canada Land Inventory was undertaken by the Agricultural Rehabilitation and Development Act in 1961 to provide an inventory of the

settled southern areas of rural Canada. This nation-wide reconnaissance level (1:50,000 scale) survey classified present land use into 14 categories from aerial photography. Wetlands were identified as existing mainly in the "swamp, marsh or bog" category and, to a lesser degree, in the categories of; "rough grazing and rangeland", "unproductive woodland", "unproductive land" and "water". This inventory covered 260 million hectares of southern Manitoba (Hodgson and Hiller, 1973).

A biophysical Land Classification system for Canada was set up during the 1960s. Its objective was to provide a reconnaissance inventory (1:125,000 scale maps) of northern forest land and associated wild land resources for all Canada except the Maritime provinces. Land area was to be inventoried from aerial photography into five categories; landforms, soil, vegetation, open waters and wetlands, and outstanding natural phenomena (Lacate, 1969). Wetlands were classified in a hierarchical system with three levels: Classes, Subclasses, and Types. There are four classes: Marsh, Swamp, Fen and Bog, based on their water nutrient status. Subclasses and Types are based on vegetation, water regime and topography (Adams and Zoltai, 1969).

A peatlands classification system for Manitoba was published in 1970 for scientific applications. Peatlands were classified into the two classes of Bog and Fen based on water nutrient status and into subclasses based on landform type (Tarnocai, 1970).

A classification system for wetlands in the glaciated prairie region was published in 1971 by the United States Fish and Wildlife Service. It was designed to improve a previous nation wide system for regional application (Stewart and Kantrud, 1971). The system included classes based on vegetation cover type and subclasses based on water chemistry. The seven classes were, Ephemeral, Temporary, Seasonal, Semipermanent, Permanent, Alkali and Fen.

A wetland inventory for a 1.5 million hectare area in the Interlake region of Manitoba was completed in 1971 sponsored by the Fund for Rural Economic Development program. Wetlands were classified into six categories; Wet Meadow, Sedge Meadow, Marsh, Fringed Open Water, Swamp and Bog. The inventory also gathered information on water permanency, vegetation cover type and waterfowl production capability. It was used for planning regional waterfowl resources development (Adams, Hutchison and Sieffert, 1971).

A classification system for wetlands in the grassland and parkland regions of Western Canada was established by Millar in 1976. The classification recognized eight types; Wet Meadow, Shallow Marsh, Emergent Deep Marsh, Transitional Open Water, Open Water Marsh, Shallow Open Water, Open Alkali and Disturbed. The types were distinguished on the basis of vegetation cover, extent, density and disturbance, and water salinity. The system also recorded information on

size, depth and alteration of the wetlands and on their origin and watershed position. The system was based on a ten year study of 103 wetlands in Saskatchewan and aimed to improve available classification systems for this region (Millar, 1976). A wetland inventory for the study of the environmental implications of slough drainage in a 720,000 hectare study area in the Whitemud River watershed in Manitoba used the Millar classification system (Osborne, 1979).

A comprehensive inventory of the wetlands in southern Ontario was compiled in 1987. They were classified into four classes; Marsh, Swamp, Fen and Bog, based on vegetation, substrates and water chemistry. The inventory produced 1:50,000 scale maps for an area of 9.3 million hectares. It was used to assist wetland management and wetland policy development (Snell, 1987).

Ducks Unlimited, a private waterfowl protection organization, conducted a wetlands inventory of 90 million hectares of the North American pothole region from 1985 to 1989. The inventory, which covers the southwest corner of Manitoba, is based on 1986 Landsat multispectral imagery and is used for waterfowl habitat conservation planning. Wetlands are classified into four groups, Open Water, Deep Marsh, Shallow Marsh and Wet Meadow based on water permanence (Tedford, 1997).

The Canadian Wetland Classification system, a synthesis of previous systems, was published in 1987 by the National Wetlands Working Group of

the Canadian Committee on Ecological Land Classification (National Wetlands Working Group, 1987) and updated in 1997 (Wetlands Research Centre, 1997). The system is hierarchal with three levels; Class, Form and Type. There are five classes; Bog, Fen, Swamp, Marsh and Shallow Water, each based on genetic origin of the wetland ecosystem and the nature of the wetland environment. There are 122 Forms and Subforms based on surface morphology, pattern and water type and morphology of the underlying mineral soil, and 17 Types based on vegetation characteristics. Waterbodies with four metres or more of water depth are not considered wetlands.

A generalized wetland distribution map of Canada was published in 1988. The map shows the spatial distribution of five categories of percentage cover of wetlands; 0 to 5%, 6 to 25%, 26 to 50%, 51 to 75% and 76 to 100%. The information is based on various sources including estimates by regional resource managers (Zoltai, 1988).

The classification system currently used throughout the United States, including the prairie pothole region, is the Classification of Wetlands and Deep Water Habitats of the United States (Cowardin *et al.*, 1979). It is hierarchal, including; Systems, Subsystems, Classes, Subclasses and Dominance Types. There are five systems; Marine, Estuarine, Riverine, Lacustrine and Palustrine. Subsystems relate to water regime; Class, Subclass and Dominance Types relate to bottom composition, emergent

vegetation and dominant flora and fauna species. This system was published in 1979 by the United States Fish and Wildlife Service to provide nationally uniform wetland concepts and terminology. It is used in the national wetlands inventory program.

The Saskatchewan Wetlands Conservation Corporation published an information document in 1993 as part of the development of provincial wetlands policy. Wetlands were classified into four categories; Temporary, Permanent, Forested and Mudflats based on Ducks Unlimited satellite based inventory. It was estimated that in the agricultural portion of the province they totalled 17 million hectares and that 94% of them were less than two hectares in size (Phillips, 1993).

A hydrological classification study for Canadian Prairie Wetlands was published in 1993. The study was conducted from 1980 to 1990 and was based on 111 sloughs in the St. Dennis National Wildlife Area in Saskatchewan (Woo, Rowesl and Clark, 1993). It classifies wetlands into four categories as per Millar, 1976; Wet Meadow, Shallow Marsh, Emergent Deep Marsh and Shallow Open Water and determines inundation duration probabilities for each category.

An analysis by Halsey *et al.*, 1997 investigated the relationships between wetland distribution in Manitoba and allogenic factors of climate and physiography. Wetland complexes throughout Manitoba were classified into 5 classes based on function, vegetation and landform according to the

Canadian wetlands classification system and mapped at a scale of 1:250,000. Individual wetlands were seldom identified. This generalized wetland distribution information has been the most detailed wetlands inventory information available for the agricultural portion of Manitoba. The extent of each wetland class was determined for a 1.7 kilometer square grid block and for each terrestrial ecodistrict. The grid data were contoured and wetland distribution maps with a 10 % contour interval were established. Climatic and physiographic data were assembled for the ecodistricts and correlated to the wetland distribution data. The analysis concluded that four climatic factors and two physiographic factors explain the distribution of wetlands throughout the Province. The climatic factors of mean annual temperature, thermal seasonal aridity, yearly precipitation and moisture deficit were found to have correlation coefficients of 0.87, 0.85, 0.39 and 0.70 respectively. The physiographic factors of bedrock geology and mineral soil texture were found to have coefficients of 0.54 and 0.19 respectively.

Six wetland inventories have previously been completed in Manitoba. Two of these are small scale and general but cover the entire Province. Four are large scale and in the southern portion of the Province but cover only small, unconnected areas. All six use different classification systems.

Wetlands Status

During the early development of Canada, wetlands were viewed as land too wet to work. The law facilitated wetland destruction and conversion to commercially productive uses such as agriculture, industry and urbanization. Since 1970, wetlands have become a popular topic in environmental science literature. Recently, Canada has acknowledged the environmental and social value of its considerable wetland resources and has pledged to protect them.

Protecting wetlands involves the cooperative efforts of various agencies and groups, and working with laws that often only apply indirectly. Canada's crown-owned, mainly northern, wetland resources are relatively easily protected by the formulation and application of policy. Canada's privately-owned, mainly southern, wetland resources are protected through acquisition by non-government organizations and through governments encouraging owners to voluntarily comply with wetland preservation.

Simply espousing the high value of natural wetland's functions may not protect wetlands. The value of converting a natural wetland to commercially productive functions is more easily quantified and recognized than is the value of a wetland's environmental and aesthetic functions. In addition, the value of converting a natural wetland to commercial productive use can be determined by and can accrue to an individual owner. This value

can therefore be easily realized. The value of retaining a natural wetland for its environmental and aesthetic functions accrues to and must be determined by society at large. Realizing this value requires extensive cooperative efforts.

Wetland conservation planning is further complicated by a lack of comprehensive and detailed inventory information. A variety of wetland definitions and classification systems have evolved depending on the defining agency's mandates and interests. More detailed scientific definitions and classifications increase the inventories comprehensiveness over large areas but they also increase the size of the task required to complete the inventory.

The Canadian wetlands working group has compiled a comprehensive classification system which considers water, soil and vegetation factors, but a corresponding Canada wide inventory employing this system has not been undertaken. The only comprehensive wetland inventory information available throughout Canada is a generalized map at a scale of 1:7,500,000 showing the distribution of five categories of percentage wetland cover (0-5%, 6-25%, 26-50%, 51-75% and 76-100%).

Regional wetland inventories have been done using a variety of classification systems. Four wetland inventories have been completed in portions of Manitoba using varying classification systems. An inventory of five classes of wetlands complexes as per the Canadian wetlands

classification system has recently been completed throughout Manitoba based on 1:250,000 scale mapping.

In general, Manitoba has significant amounts of unthreatened wetlands but they are located in the northern, less developed, portion of the Province. In some highly developed, mostly privately-owned, southern portions of Manitoba, which once contained many wetlands, there appears to be few remaining and they continue to become fewer and more isolated.

PART TWO

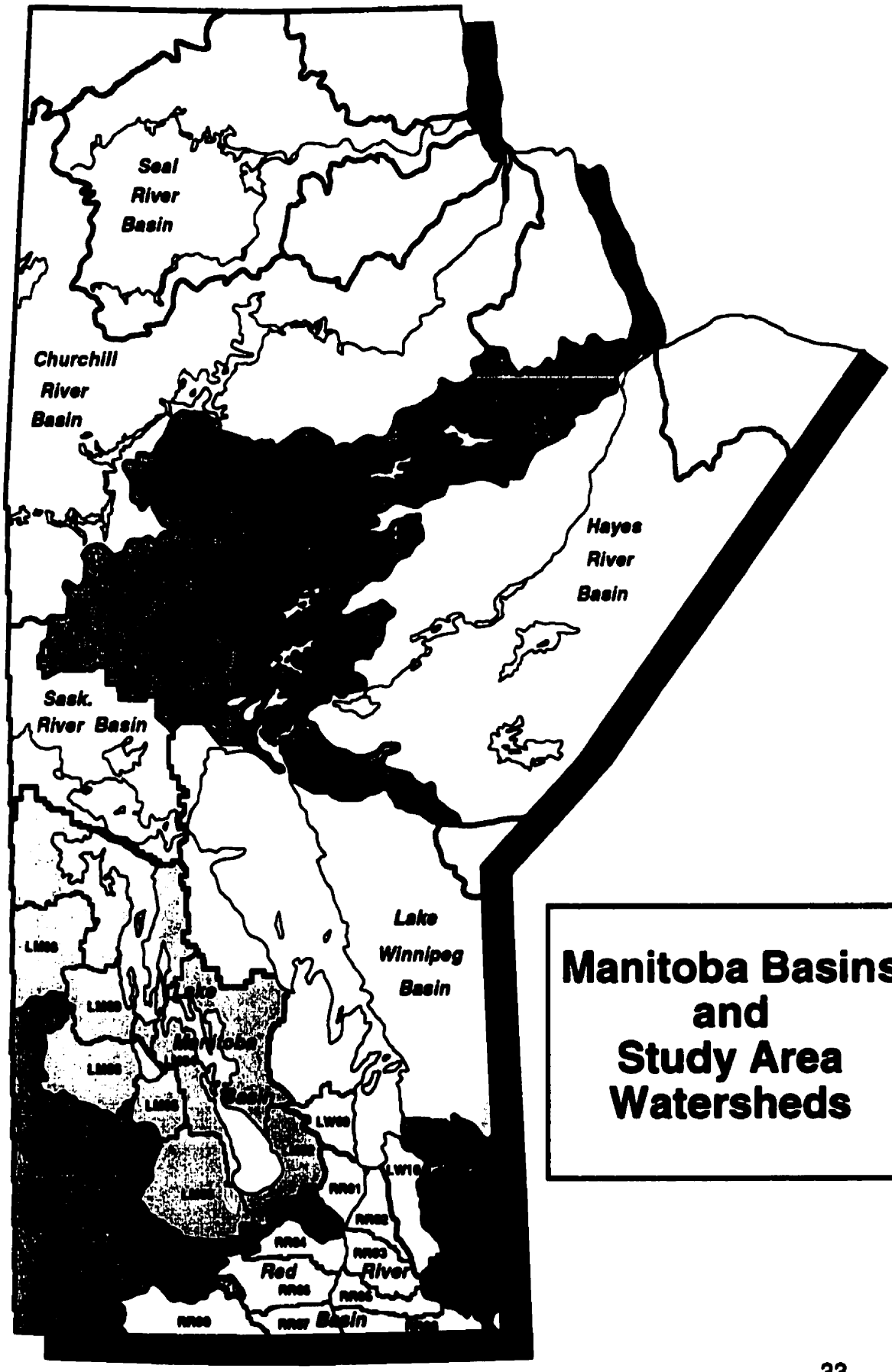
WETLANDS IN THE AGRICULTURAL PORTION OF MANITOBA

Introduction

A variety of environmental and social values are expressed in the wetland literature. Considering the large portion of wetland losses estimated due to agriculture and Canada's policy of no net loss of wetlands functions, it would be useful to have a comprehensive and more detailed inventory of wetlands in the agricultural portion of Manitoba. This inventory could be used in natural resource planning and management as an indicator of terrestrial and aquatic flora and fauna habitat and of local hydrology.

Part two describes the processes used to compile an inventory of wetland magnitude and distribution by basin and watershed and by cover type for the study area (See numbered watersheds in Figure 1). This inventory is presented in figure and table form. It was completed between 1993 and 1997. It adds to previous inventories in the agricultural portion of Manitoba in that it is comprehensive for the area, relatively current and more detailed.

The inventory is based on previous vegetation and water cover mapping. It identifies functioning wetland ecosystems larger than 0.3 hectares throughout the study area. They contain natural wetland terrestrial



Manitoba Basins and Study Area Watersheds

Figure 1

and aquatic flora and fauna by virtue of their uncultivated soils and unharvested vegetation.

The study area covers Manitoba's portion of Canada's Prairie wetland region and part of the Boreal wetland region (Pries, 1994). It also covers most of the portion of Manitoba where the risk of wetland loss is rated high and moderate (Rubec, 1994). Most of the wetlands in the inventory are mineral soil wetlands and all are freshwater wetlands. In terms of hydrologic origin they are palustrine, lacustrine or riverine.

Inventory Design

This project sought to improve on the currently available wetland inventory for the agricultural portion of Manitoba. Judicious wetlands planning requires an inventory of the resource including the identification of size, type and location of every wetland in the area. Ideally the determination of wetland type should include consideration of vegetation, soil and water factors as per the Canadian wetlands classification system. Such a detailed inventory would require a multi-disciplinary team at work for several years and was beyond the scope of this project.

Available Information Sources

Relatively detailed land and water cover information has been established for much of Manitoba. It was expected that a subgroup of this information could be selected and collated to represent a more detailed wetlands inventory. Two information sources were considered. One was based on thematic mapper imagery and the other on aerial photography.

A land cover database from thematic mapper imagery during the early 1990s was available for southern Manitoba from the Manitoba Surveys and Mapping Branch. The map database at a scale of 1:50,000 coded Land Cover / Land Use into the following 16 categories; Agricultural Cropland, Deciduous Forest, Water Bodies, Grassland/Rangeland, Mixedwood Forest,

Marsh and Fens, Treed and Open Bogs, Treed Rock, Coniferous Forest, Burnt Areas, Open Deciduous, Forage Crops, Cultural Features, Forest Cutovers, Bare Rock Gravel and Sand, and Roads and Trails.

Another potential information source considered was a forest inventory database established from aerial photography taken at a scale of 1:15,840 during the mid-1980s. Manitoba's surface was classified into land and water. Land area was classified into three cover groups, Forested Productive, Forested Non-Productive, and Non-Forested. Wetlands were contained within the land area groups classified as Non-Productive Forest, and Non-Forested and Water. These groups were further classified into 10 categories and into 51 cover types.

Forestry had established township hard copy land cover maps at a scale of 1:15,840 showing cover type boundaries. Cover types were coded with land ownership information in 10 categories. The ownership coded cover type areas had been digitized, measured and summed for each township mapsheet. This database was available for southern Manitoba courtesy of Manitoba Forestry.

Both information sources covered the agricultural portion of Manitoba. The remotely sensed database had the advantage of being more current and of being in map form and therefore able to display the location of selected wetland covers. Working with this database, however, would require external equipment support and expertise. On the other hand

working with the forest inventory database had the advantage of a more accurate determination of wetland covers, because it was based on larger scale mapping and three times as many land cover categories. It also included land ownership information which could be an asset to resource evaluation and to potential management considerations. In addition, area measurements had been done thereby allowing the remaining work to be completed in house. However, this database was nearly 20 years old and was in tabular form collated by township and range.

It was decided to use the forest inventory database and to evaluate the current accuracy of the data by conducting ground truthing. If little change was found in the mapped covers, the inventory could be considered a detailed representation of the current situation. If considerable change was found, the inventory would be an indicator of wetlands existing during the mid-1980s and of the magnitude of recent changes or losses and, when discounted for this change, a relatively detailed indicator of current wetland distribution and magnitude. It was also decided, for easier use, to present the wetland data in table and map formats.

Inventory Process

A set of potential wetland cover types was selected from the 51 land and water cover types based on the forest inventory cover descriptions (Manitoba, 1992) and on conversations with staff experts in the photo

interpretation section of the Forestry Branch. The forest inventory database including cover type area and ownership by township and range was loaded on a personal computer and searched using Paradox software. Area values were determined for each township of each potential wetland cover type and of wetlands privately-owned.

Ground truthing information, gathered as discussed in the following section, was used to select a final set of 16 cover types to represent wetlands. The area values for these covers were then summed for each watershed and basin within the study area. When watershed boundaries included only a portion of a township the area values for that portion were determined by area ratio. This information is presented in the following sections.

A review of cover types used in the forest inventory and identification of the cover types selected to represent wetlands is presented in Appendix A. The selected forest inventory cover types listed in order from the most to least permanently wet environments are: Water, Beaver Floods, Rivers, Marsh, String Bog, Mud/Salt Flats, Sand Beaches, Muskeg, Black Spruce Treed Muskeg, Tamarack Larch Treed Muskeg, Eastern Cedar Treed Muskeg, Dwarf Birch, Shrub, Alder, Willow, Wet Meadow. These cover types are compared to the Canadian Wetlands Classification System in Table 1.

Table 1

Wetland Cover Types Compared To
Canadian Wetlands Classification System

Wetland Cover Type*	Canadian Wetlands Classification System Class // Form // Type
Black Spruce Treed Muskeg Tamarack Larch Treed Muskeg Eastern Cedar Treed Muskeg	Swamp. // Discharge, Flat, Mineral-Rise, Riparian, Slope. // Treed Bog. // Basin, Flat, Riparian, Slope. // Treed.
Willow Alder Dwarf Birch Shrub	Swamp. // Flat, Riparian, Slope, Discharge, Mineral-Rise. // Shrub
Wet Meadow	Marsh. // Riparian, Lacustrine, Slope, Spring, Basin. // Graminoid.
Muskeg	Bog. // Basin, Domed, Flat, Riparian. // Graminoid, Moss.
String Bog	Bog. // String Bog. // Graminoid, Moss.
Marsh	Marsh. // Riparian, Basin, Spring, Slope, Lacustrine. // Graminoid, Aquatic.
Mud / Salt Flats Sand Beaches	Shallow Water. // Lacustrine, Riparian. // Non-Vegetated.
Beaver Floods	Shallow Water. // Riparian. // Non-Vegetated, Graminoid, Aquatic.
Water	Shallow Water. // Riparian, Basin, Lacustrine. // Non-Vegetated, Aquatic.
Rivers	Shallow Water. // Riparian. // Non-Vegetated, Aquatic

* Based on selected Manitoba forest inventory land and water cover type classifications.

Some of the uses of the selected wetland cover types are indicated in Table 2. Habitat use values arise because in some portions of agricultural Manitoba, wetland ecosystems comprise a significant portion, in some cases

the bulk, of the remaining natural environment and they are becoming increasingly rare. Surface water runoff use values arise because wetlands detain runoff and thereby increase infilltration and groundwater recharge, reduce downstream flow peaks and prolong streamflow.

Table 2

Wetland Cover Type Uses

Cover Type	Waterfowl Habitat	Aquatic Flora and Fauna Habitat	Terrestrial Flora and Fauna Habitat	Surface Water Runoff Detention
Black Spruce Treed Muskeg			x	x
Tamarack Larch Treed Muskeg			x	x
Eastern Cedar Treed Muskeg			x	x
Willow	x		x	x
Alder			x	x
Dwarf Birch			x	x
Shrub			x	x
Wet Meadow	x		x	x
Muskeg			x	x
String Bog		x	x	x
Marsh	x	x	x	x
Mud / Salt Flats	x	x	x	
Sand Beaches	x	x	x	
Beaver Floods	x	x	x	x
Water	x	x	x	x
Rivers	x	x	x	x

Ground Truthing

Ground truthing was undertaken to evaluate the current accuracy of the mid-1980s land cover mapping mainly with respect to the set of potential wetland cover types selected and to make a final determination of the cover types to be selected to represent wetlands in the inventory.

Ground truthing sites were chosen from 60 townships throughout the study area and were visited during the summers of 1995 and 1996. The distribution of the 825 ground truthing sites by basin and cover type is presented in Table 3. Sites were chosen to represent the range of potential wetland cover types and to focus on the most prevalent wetland types and on difficult wetland cover type selections. Ground truthing did not include the selected wetland cover types of: Eastern Cedar Treed Muskeg, Alder, String Bogs, Mud/Salt Flats, and River. These cover types were either not accessible or were considered not in need of ground truthing.

A significant choice was made between the two equally common potential wetland cover types of Wet Meadow and Moist Prairie which were often mapped in close proximity. Wet Meadow was included, Moist Prairie was excluded. On a soil moisture gradient Wet Meadow was selected to be the driest cover type to represent wetland. It was a more moist and natural environment than the next drier cover type Moist Prairie.

Table 3

Ground Truthing Sites by Cover Type and Basin

Site Cover Type	Basin					Number of Sites
	Red River (RRB)	Assiniboine River (ARB)	Lake Manitoba (LMB)	Lake Winnipeg (LWB)	Winnipeg River (WRB)	
Black Spruce Treed Muskeg			3	3	1	7
Tamarack Larch Treed Muskeg			1	1	2	4
Willow	52	21	67	13	10	163
Dwarf Birch	2	2	1		5	10
Shrub	13	3	15	1		32
Shrub/Prairie *	3		4			7
Hayland *	17		9			26
Cropland *	26	3	8			37
Pastureland *	20	7	17	7		51
Moist Prairie *	30	48	62	13	1	154
Wet Meadow	53	57	62	28		200
Muskeg	1			2		3
Marsh	10	29	23	4		66
Drainage Channels *	8					8
Sand Beaches			1			1
Water	4	35	14	1	1	55
Beaver Floods			1			1
Number of Sites	239	205	288	73	20	825

* These cover types were not selected to represent wetlands.

Forestry's classification distinction between these two cover types was that Wet Meadow vegetation was seldom harvested and that Moist Prairie vegetation was commonly harvested (Bell, 1995). Ground truthing of 154 Moist Prairie and 200 Wet Meadow sites throughout the study area revealed this distinction to be reliable. The Moist Prairie cover type was often found in topographic depressions functioning as natural grassed waterways or as an upper vegetation band around marsh, water or isolated shallow depressions. In addition, Moist Prairie typically displayed evidence of haying practices and appeared to contain a more homogenous vegetation cover. In contrast, Wet Meadow cover type was commonly found in topographic depressions isolated from the surface water drainage network or as a lower vegetation band around marsh or water. In addition, the vegetation cover typically appeared more diverse and showed no signs of haying practices.

Early wetland classification systems (Stewart and Kantrud, 1971; Millar, 1976) had prominent classes for wet meadow and low prairie. These classes were most susceptible to drainage activities and hence many have become farmland with sporadic wetness problems. Current classification systems eliminate or give less consideration to such areas (Prince, 1997). The Canadian wetland classification system includes wet meadow as a marsh class subform.

During ground truthing, the current land cover / land use for each site

was compared to the mid-1980s cover type classification. The accuracy of the wetlands inventory, as determined based only on sites from within the final set of wetland covers, is presented in Table 4. Over all the current accuracy of the inventory was determined to be 92 %. Most altered cover types were found to be drier environments than when originally mapped.

Some land clearing activities were observed during the ground truthing travels. The wetland cover type most commonly affected by these activities was Willow. Once drainage is provided to an area of willow vegetation the relatively level land is easily cleared, broken and cultivated.

Table 4

Current Accuracy of Wetland Cover Classifications

Basin	RRB[1]	RRB[2]	ARB	LMB	LWB	WRB	Total
All Sites Visited	196	43	205	288	73	20	825
Sites Drier Than Original Classification	24		16	24	11	2	
Sites Wetter Than Original Classification	8		11	1	2	1	
Sites Classified Wetland	135	43	147	188	53	19	585
Sites Still Wetland	118	35	142	175	48	17	535
Wetland Accuracy %	87	81	97	93	91	90	92

[1] Ground truthing course one was evenly distributed in the basin.

[2] Ground truthing course two focused on isolated wetlands in the Red River Valley.

Pastureland was identified as fenced and containing sign of domestic animals. It was not included as wetland. Some pastureland was observed to include small areas of the wetland covers; Wet Meadow, Marsh and Water. Drainage ditches were not included as wetlands. Most included empty waterway channels and adjacent channel slopes and dykes that were hayed annually. Some also included a pilot channel containing areas of standing water and narrow bands of bulrush vegetation on either side.

In the Red River basin two ground truthing courses were completed. An evenly distributed course as in the other basins and a course focused on isolated wetlands in the Red River valley. These wetlands were considered to be under the greatest conversion pressure due to the high land values and the ease of drainage activities in this low relief area. They therefore served as a rigorous check of the current accuracy of the inventory. It was determined that 81 % of these sites were still under wetland cover.

In an attempt to investigate the loss of wetlands over time the mid-1960s Canada Land Inventory (CLI) land cover/land use information was compared to the mid-1980s Forest Inventory (FI) land cover information. Five CLI categories were estimated to include FI vegetation covers considered to be wetlands. The CLI "Swamp, Marsh, or Bog" category included exclusively wetland area but the categories of, "Rough Grazing and Rangeland", "Unproductive Woodland", "Unvegetated Land" and "Water" included some non-wetland area.

One township was chosen at random from the ground truthing sites in each basin. The CLI land cover/land use and the FI land cover maps were obtained at a scale of 1:50,000 and the inventories were compared for each section in the selected townships. A section was noted to have lost wetlands if an area classified by the CLI as "Swamp, Marsh, or Bog" was classified by the FI as non-wetland. It was noted to possibly have lost wetlands if an area classified by the CLI as "Rough Grazing and Rangeland" or "Unproductive Woodland" was classified by the FI as non-wetland. It was also noted as having a drier water regime if it had lost wetlands, possibly lost wetlands or if for example an area classified by the CLI as "Woodland" was classified by the FI as cropland.

Land cover was compared between the 1960s and the 1980s on 174 sections. This information is displayed in Table 5 for each township compared. In total 126 sections (73%) displayed land cover changes indicative of drier water regimes, 85 sections (49%) displayed changes indicative of possible wetland loss and 17 (10%) changes indicative of wetland loss.

Comparing these two inventories was awkward because they were mapped at different scales and area measurements were available only for the FI. More significantly, however, the comparison is incomplete because the land cover categories are different.

Table 5

1960s - 1980s Land Cover Comparison

Selected township from	Sections with wetland loss	Sections with possible wetland loss	Sections with drier water regimes [1]
RRB	8	12	30
ARB	8	15	27
LMB	0	32	34
LWB	0	11	17
WRB [2]	1	15	18
Total	17	85	126

[1] This category includes the previous two.

[2] This township contains 30 sections.

Wetlands Magnitude and Distribution By Basin and Watershed

The study area includes 100,031 square kilometers. The inventory found 11,218 square kilometers of wetlands comprise 11 % of the entire study area. The magnitude of the wetland area within the basins of the study area ranges from 1,044 square kilometers in the Lake Winnipeg basin to 4,474 square kilometers in the Lake Manitoba basin. See Table 6.

Table 6

Wetland Area by Basin in Square Kilometers

Basin	RRB	ARB	LMB*	LWB*	WRB*	Total
Basin Area	25,587	32,808	31,490	5,974	4,172	100,031
Wetland Area	1,590	2,596	4,474	1,044	1,514	11,218
Private Wetland Area	663	1,255	1,104	193	75	3,290

* The study area includes only a portion of this basin.

The inventory found that 3,290 square kilometers or 29% of all wetlands were privately-owned. The basins with the highest portion of wetlands in private ownership are the Assiniboine River basin (48%) and the Red River basin (42%). The basin with the smallest portion of wetlands in private ownership is the Winnipeg River basin (5%).

The magnitude of wetlands in each of the study area basins, their distribution within the watersheds of the basin and their ownership is summarised in the following. The portion of the 28 watersheds of the study area with wetland covers ranges from 0.5 to 36 %. The portion of wetlands privately-owned ranges from five to 92 %.

For the duration of this report, wetland area values are in hectares. For reading convenience, the area values in the text have been expressed rounded to the nearest hundred or thousand. Corresponding area values in tables and figures are expressed accurate to the nearest unit.

Red River Basin

The study area includes all of the Manitoba portion of the Red River basin (RRB). It is divided into nine watersheds which drain a total area of 2,559,000 hectares. The inventory found 160,000 hectares of wetlands comprise six percent of this area. The area of wetlands in individual watersheds ranges from 1,000 to 37,000 hectares. See Table 7.

Table 7

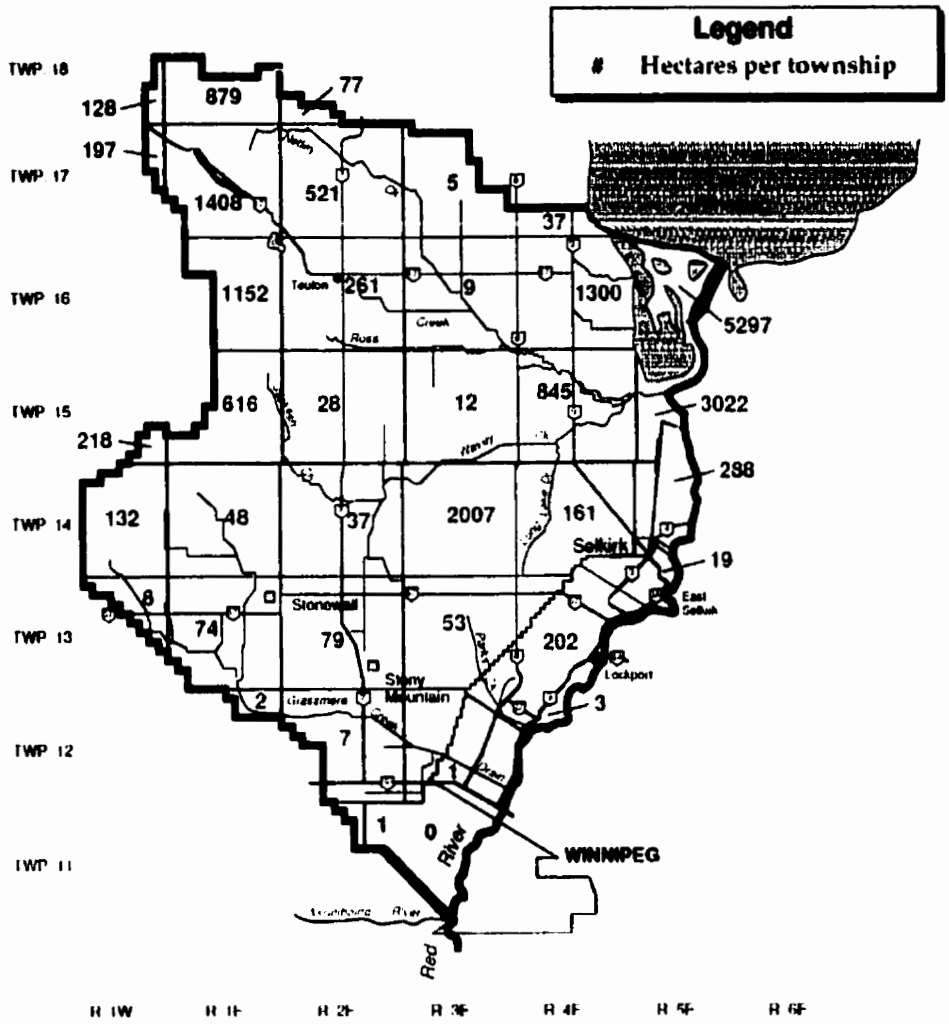
Red River Basin Wetland Area by Watershed in Hectares

Watershed	RR01	RR02	RR03	RR04	RR05
Watershed Area	227,300	193,000	262,100	258,400	214,800
Wetland Area	19,131	17,291	19,284	2,607	24,858
Private Wetland Area	5,656	5,273	8,548	2,074	8,702
Watershed	RR06	RR07	RR08	RR09	Total
Watershed Area	427,100	206,900	259,200	509,900	2,558,700
Wetland Area	5,588	983	36,882	32,344	158,968
Private Wetland Area	4,751	808	8,275	22,159	66,246

The portion of the individual watersheds in wetland cover ranges from 0.5 % to 14 %. In this basin 42 % of the wetlands are privately-owned. The portion of wetlands privately-owned in the individual watersheds ranges from 30 to 85 %.

Figures 2 through 10 are maps for each watershed in the basin showing the wetland area in each township. These maps also tabulate for each watershed, the area, total wetland area, the portion of watershed in wetlands, the privately-owned wetland area and the portion of wetlands privately-owned.

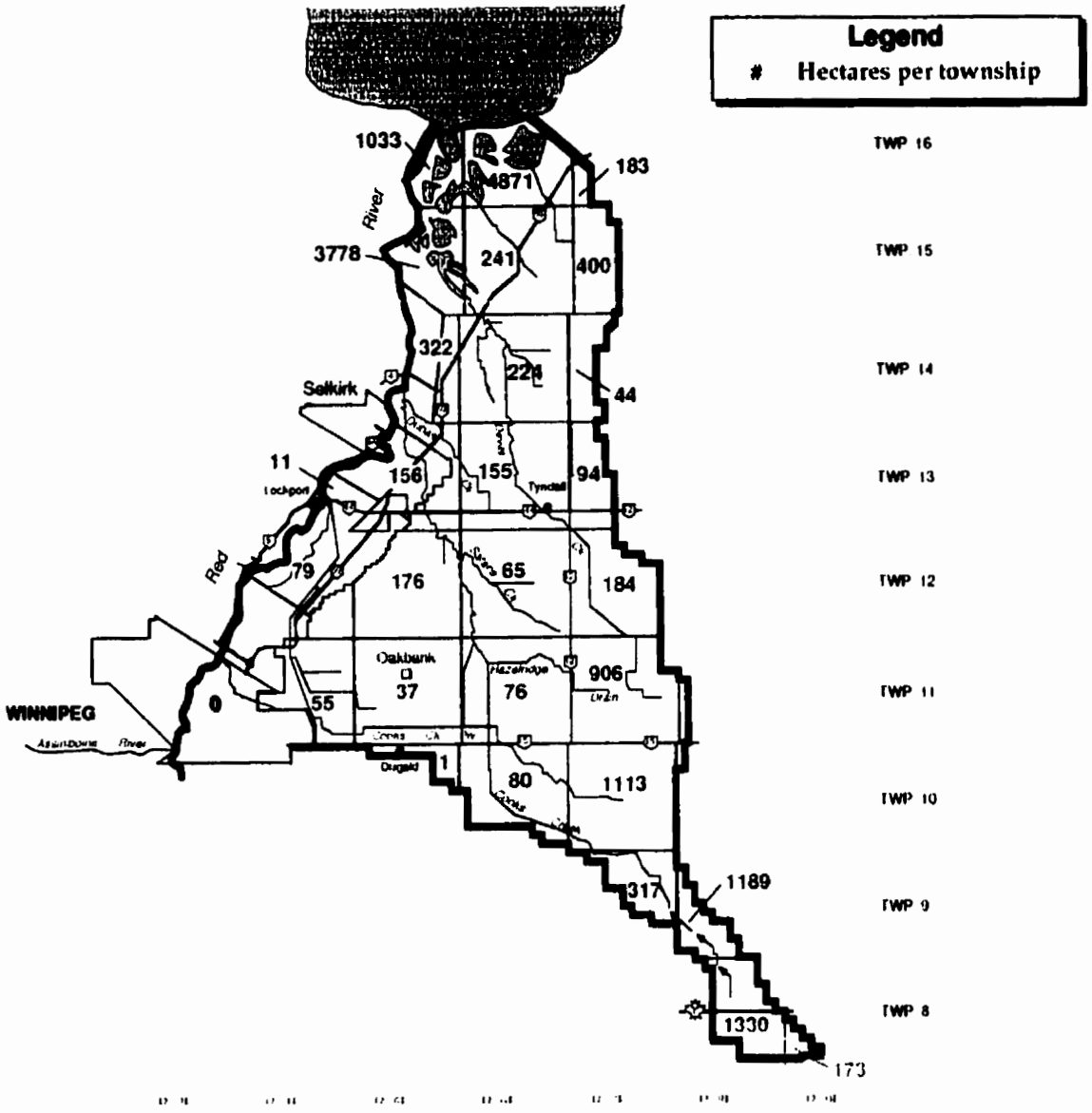
Red River Basin Wetlands
Netley Creek, Grassmere Creek Watershed
RR01



Total watershed area	227,300 ha.
Total wetland area	19,131 ha.
Portion of watershed in wetlands	8%
Privately owned wetland area	5,656 ha.
Portion of wetlands privately owned	30%

Figure 2

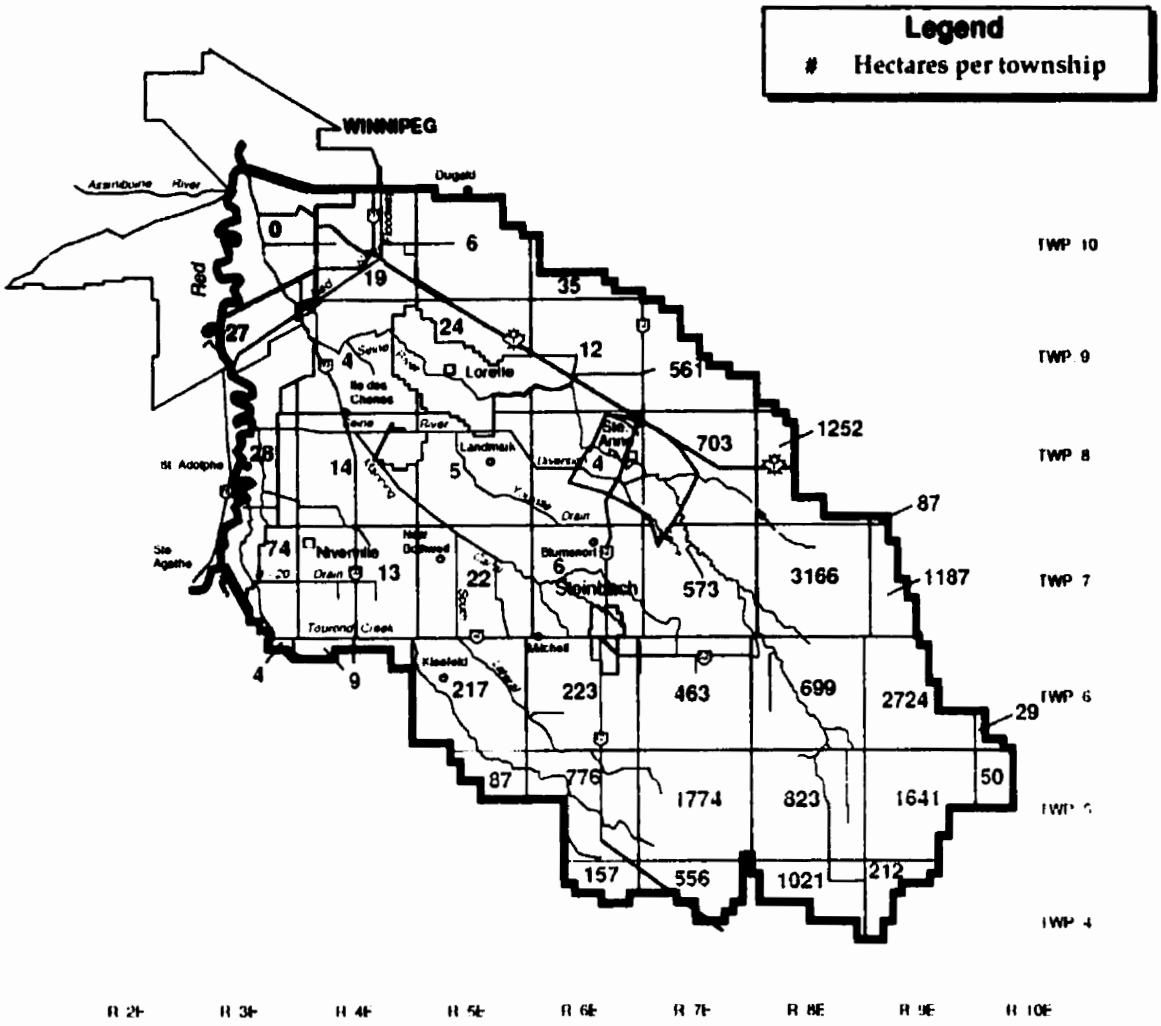
Red River Basin Wetlands
Cooks Creek, Devils Creek Watershed
RR02



Total watershed area	193,000 ha.
Total wetland area	17,290 ha.
Portion of watershed in wetlands	9%
Privately owned wetland area	5,273 ha.
Portion of wetlands privately owned	30%

Figure 3

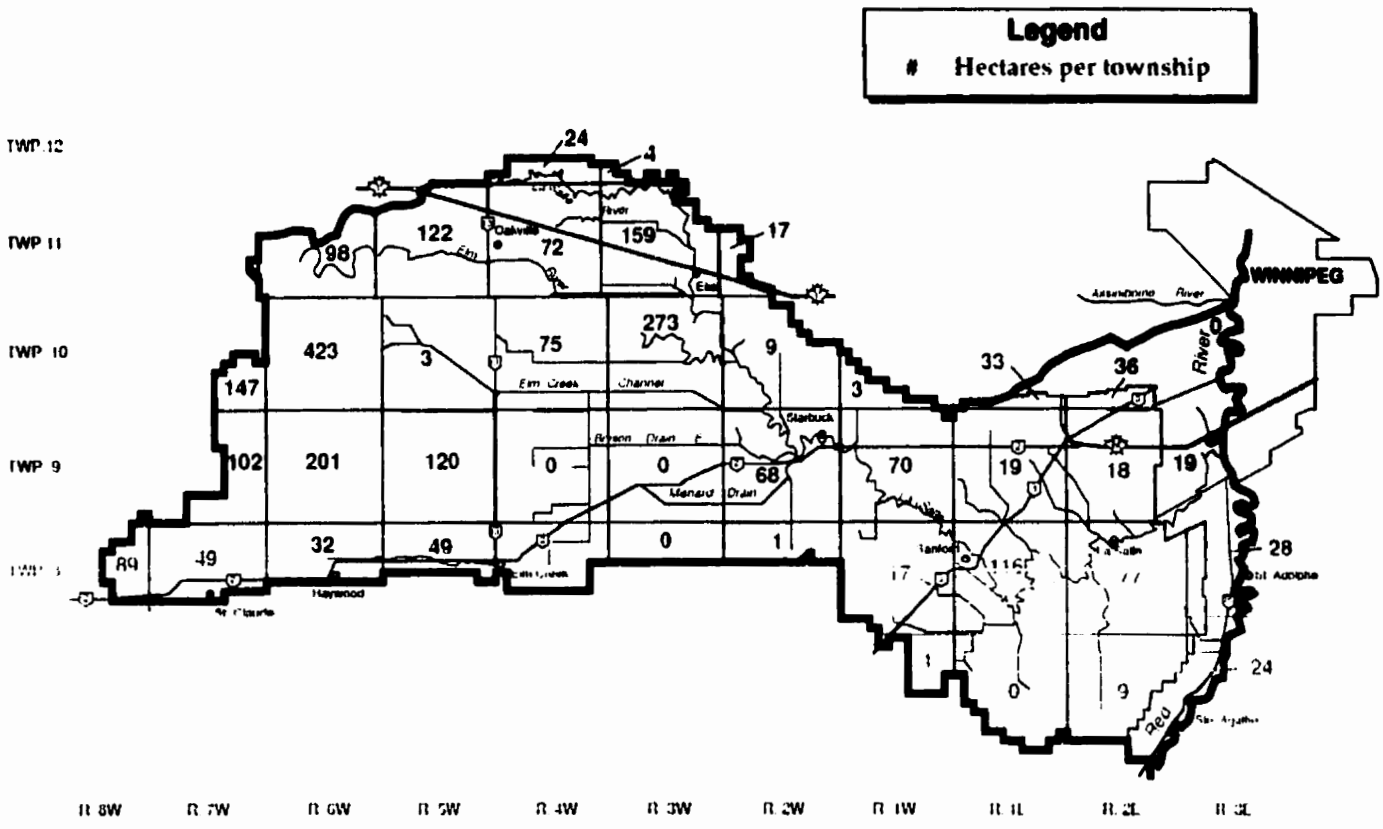
Red River Basin Wetlands
Seine River Watershed
RR03



Total watershed area	262,100 ha.
Total wetland area	19,284 ha.
Portion of watershed in wetlands	7%
Privately owned wetland area	8,548 ha.
Portion of wetlands privately owned	44%

Figure 4

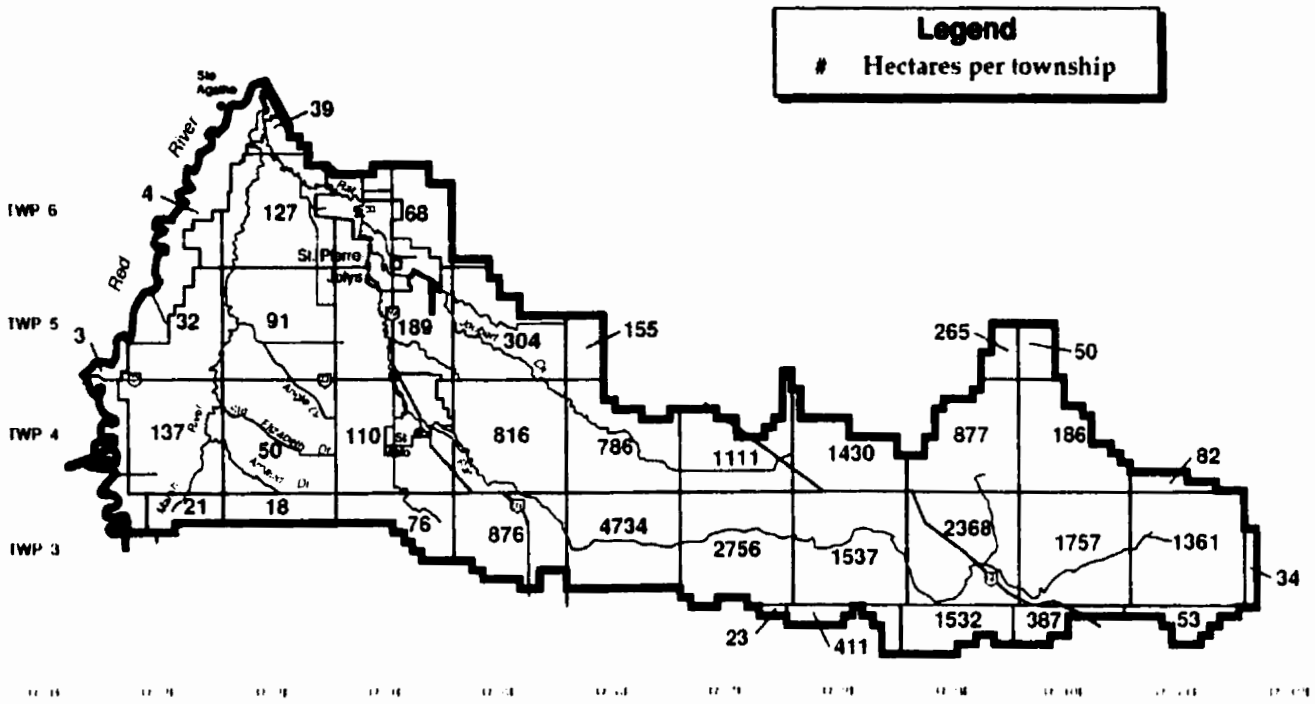
Red River Basin Wetlands
LaSalle River Watershed
RR04



Total watershed area	258,400 ha.
Total wetland area	2,607 ha.
Portion of watershed in wetlands	1%
Privately owned wetland area	2,074 ha.
Portion of wetlands privately owned	80%

Figure 5

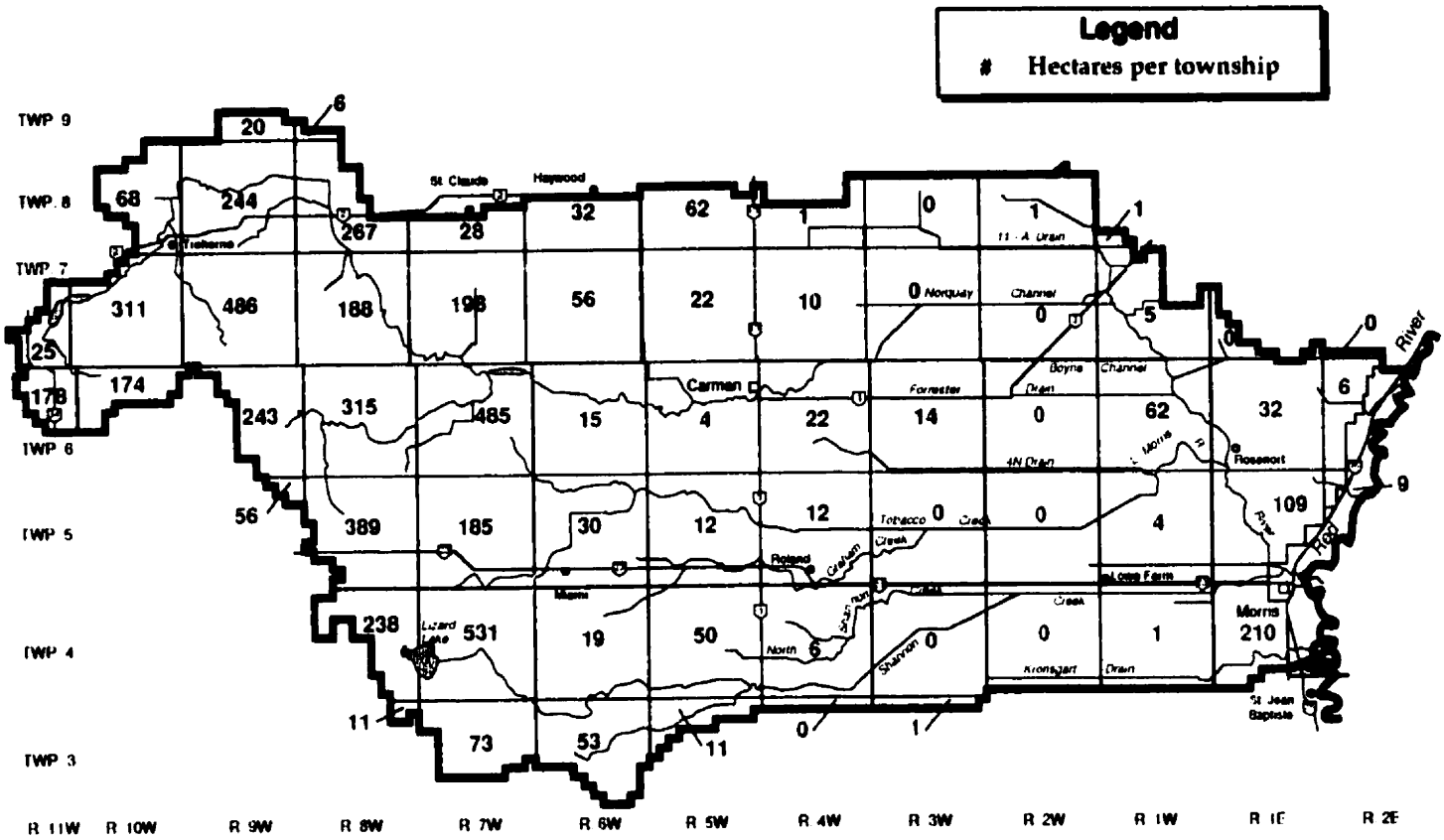
Red River Basin Wetlands
Rat River Watershed
RR05



Total watershed area	214,800 ha.
Total wetland area	24,855 ha.
Portion of watershed in wetlands	12%
Privately owned wetland area	8,702 ha.
Portion of wetlands privately owned	35%

Figure 6

Red River Basin Wetlands
Morris River Watershed
RR06

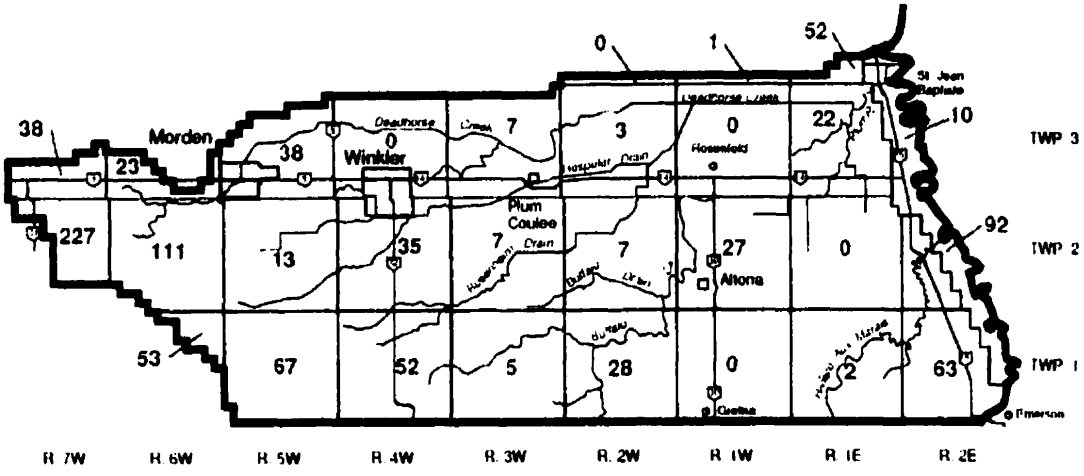


Total watershed area	427,100 ha.
Total wetland area	5,588 ha.
Portion of watershed in wetlands	1%
Privately owned wetland area	4,751 ha.
Portion of wetlands privately owned	85%

Figure 7

Red River Basin Wetlands
Riviere Aux Marais, Plum River Watershed
RR07

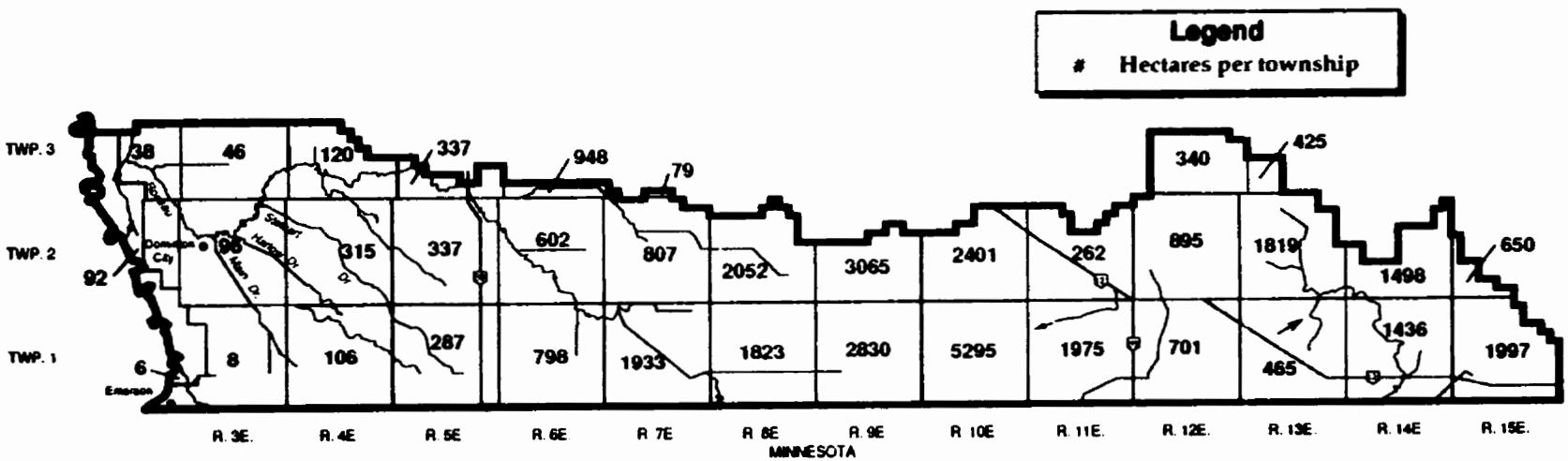
Legend
\# Hectares per township



Total watershed area	206,900 ha.
Total wetland area	983 ha.
Portion of watershed in wetlands	0.5%
Privately owned wetland area	808 ha.
Portion of wetlands privately owned	82%

Figure 8

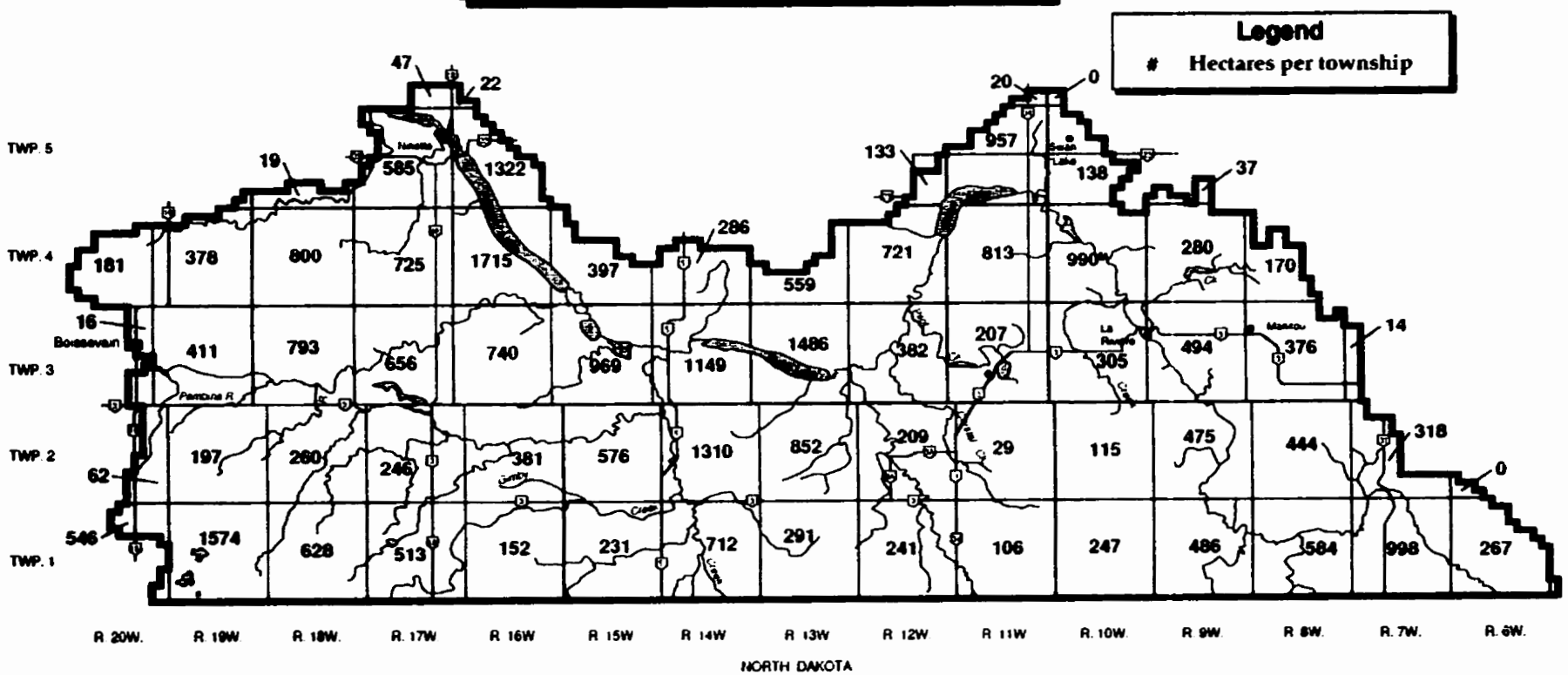
Red River Basin Wetlands
Roseau River Watershed
RR08



Total watershed area	259,200 ha.
Total wetland area	36,882 ha.
Portion of watershed in wetlands	14%
Privately owned wetland area	8,275 ha.
Portion of wetlands privately owned	22%

Figure 9

Red River Basin Wetlands
Pembina River Watershed
RR09



Total watershed area	509,900 ha.
Total wetland area	32,343 ha.
Portion of watershed in wetlands	6%
Privately owned wetland area	22,159 ha.
Portion of wetlands privately owned	69%

Figure 10

A large portion of the basin, mainly within the Red River Valley, contains one percent (94 hectares per township) wetlands or less (based on an average township including road allowances covering 9379 hectares of landscape). This area lies as far west as a line through Morden, St Claude, Portage La Prairie, Stonewall and Teulon and as far east as a line through, Hazelridge, Steinbach, St Pierre and Dominion City. It includes portions of Red River watersheds number RR01, RR02, RR03, RR04, RR05, RR06, and RR07. Within this area there are 29 townships with no wetland area.

In the Red River basin in Manitoba wetlands originally comprised more than half the area (Ellis, 1938). RR04 (La Salle River Watershed) is the most highly drained watershed in Manitoba. It contains on average 0.75 kilometres of drain for each square kilometre of area (Oswald, 1992).

In this basin townships with 15 % (1407 hectares) or more wetland cover exist only north of Teulon, around Oak Hammock Marsh (RR01), south of Lake Winnipeg (RR01, RR02) in the most easterly headwater areas of the watersheds east of the Red River (RR03, RR05, RR08) around Rock and Pelican Lakes and in the eastern portion of the Turtle Mountain provincial park (RR09).

Red River Basin Sections With Wetlands

Due to the lack of wetland cover in the Red River basin it was considered worth while to determine more precisely where wetlands existed. The forest inventory township maps were manually reviewed for the presence of wetland cover. Maps for each watershed in this basin showing the sections with wetland area are displayed in Figures 11 to 19.

Red River Basin Wetlands
Sections with Wetlands
RR01

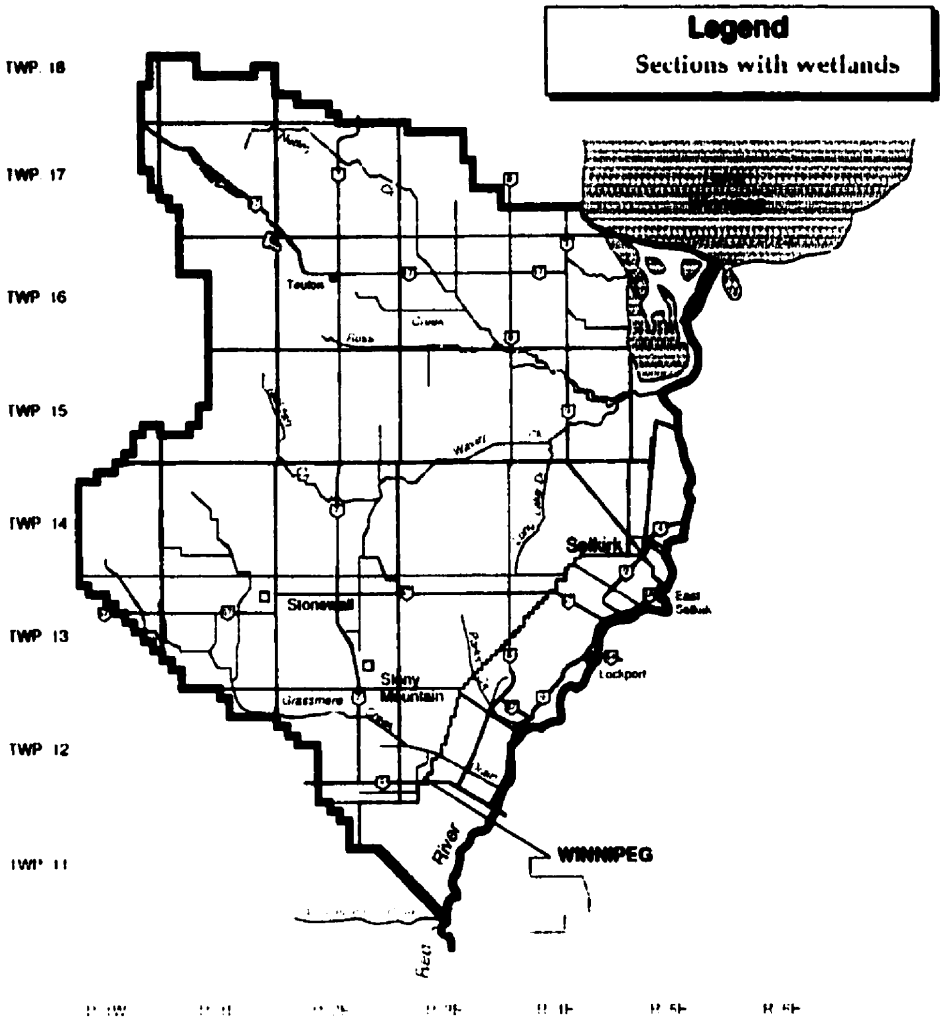


Figure 11

Red River Basin Wetlands
Sections with Wetlands
RR02

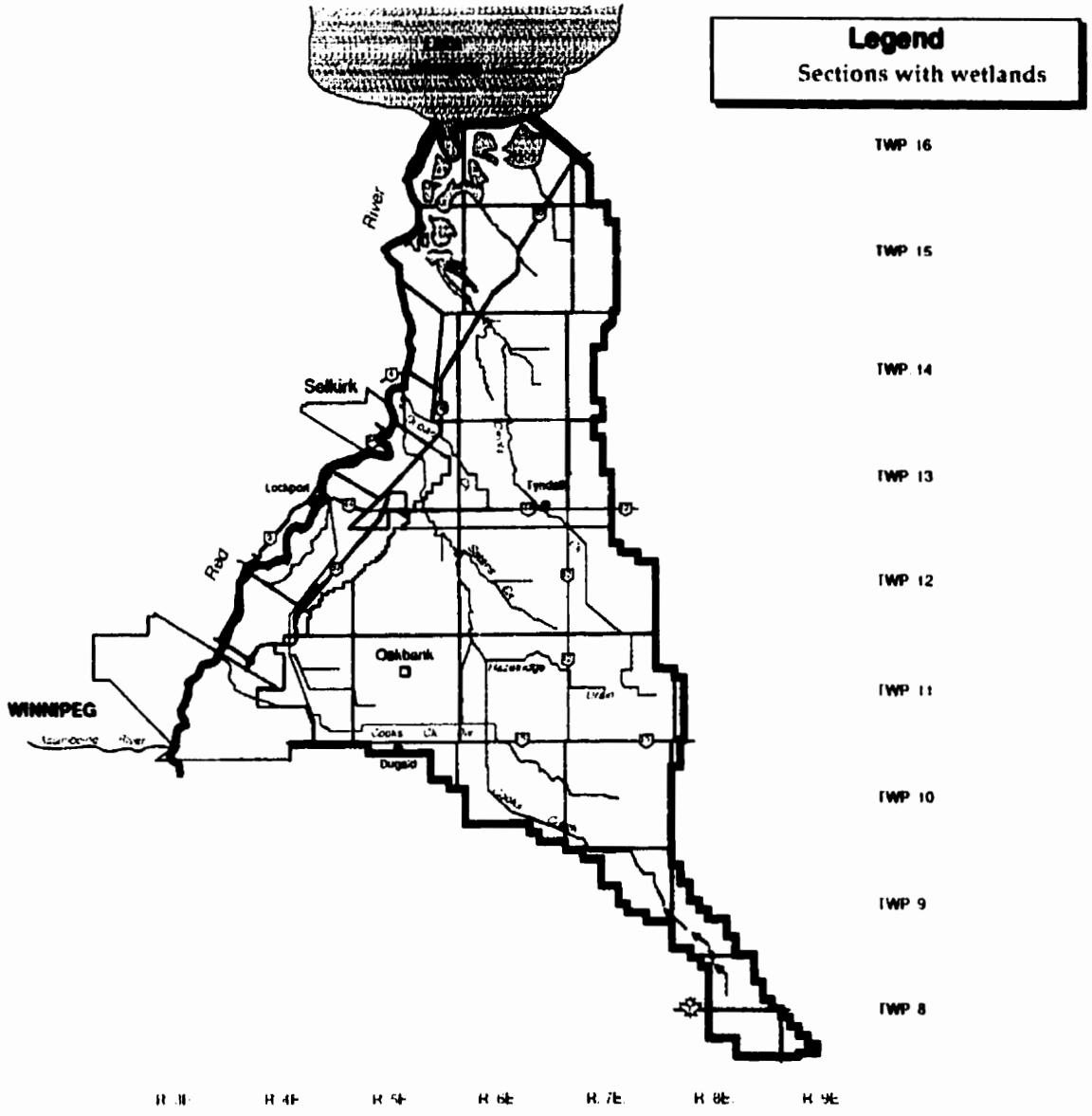


Figure 12

Red River Basin Wetlands
Sections with Wetlands
RR03

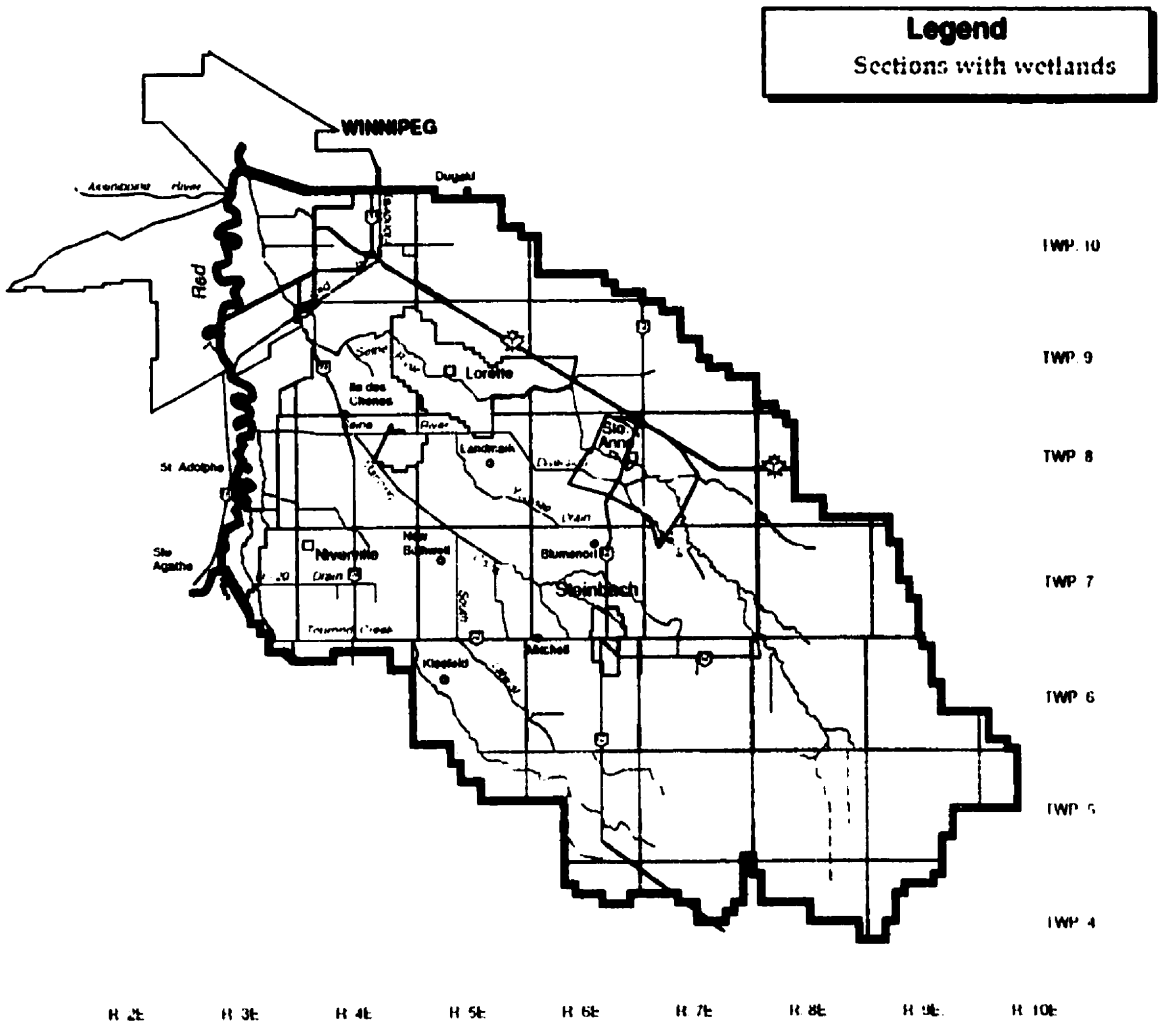


Figure 13

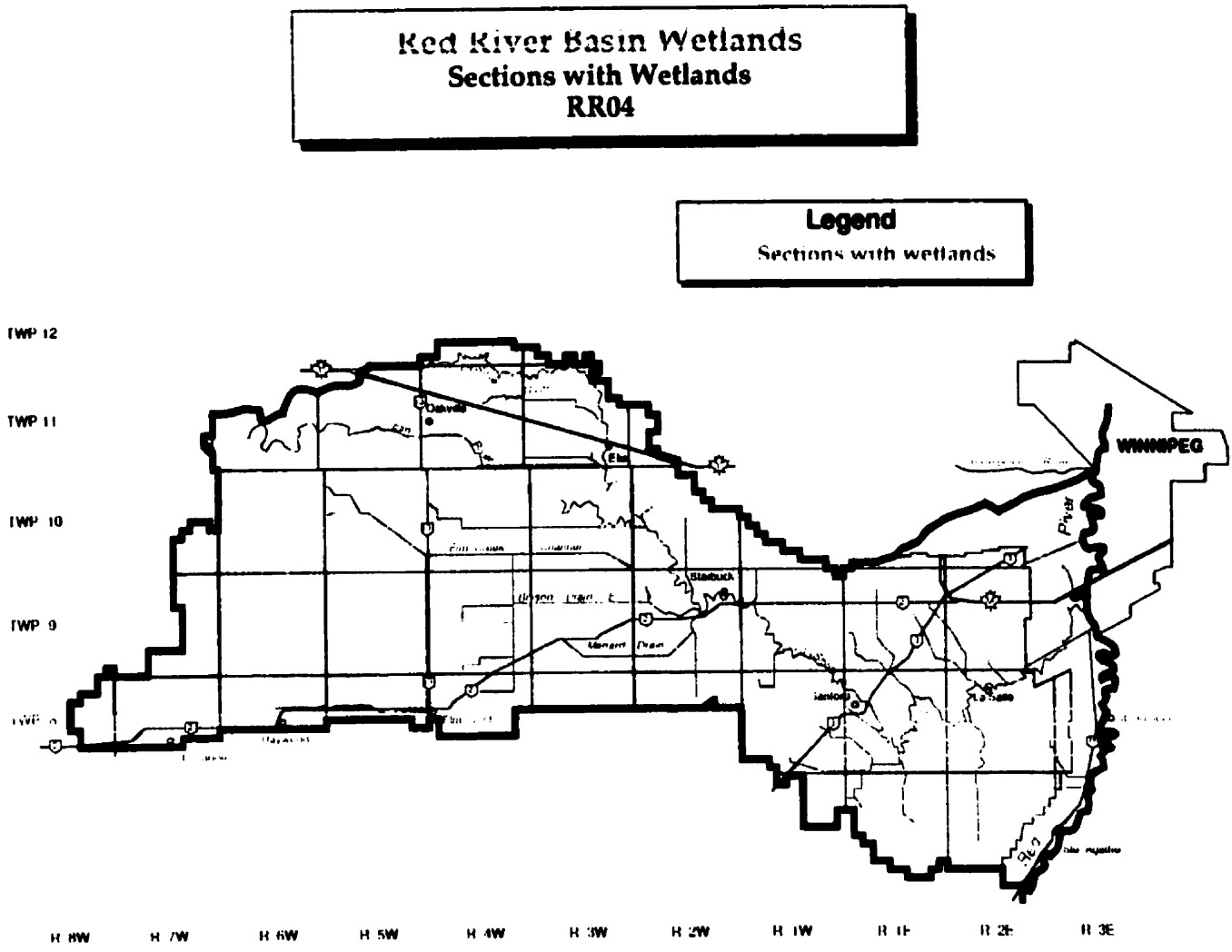

Red River Basin Wetlands
Sections with Wetlands
RR04
Legend
Sections with wetlands
TWP 12
TWP 11
TWP 10
TWP 9
WINNIPEG
R 8W
R 7W
R 6W
R 5W
R 4W
R 3W
R 2W
R 1W
R 1E
R 2E
R 3E

Figure 14

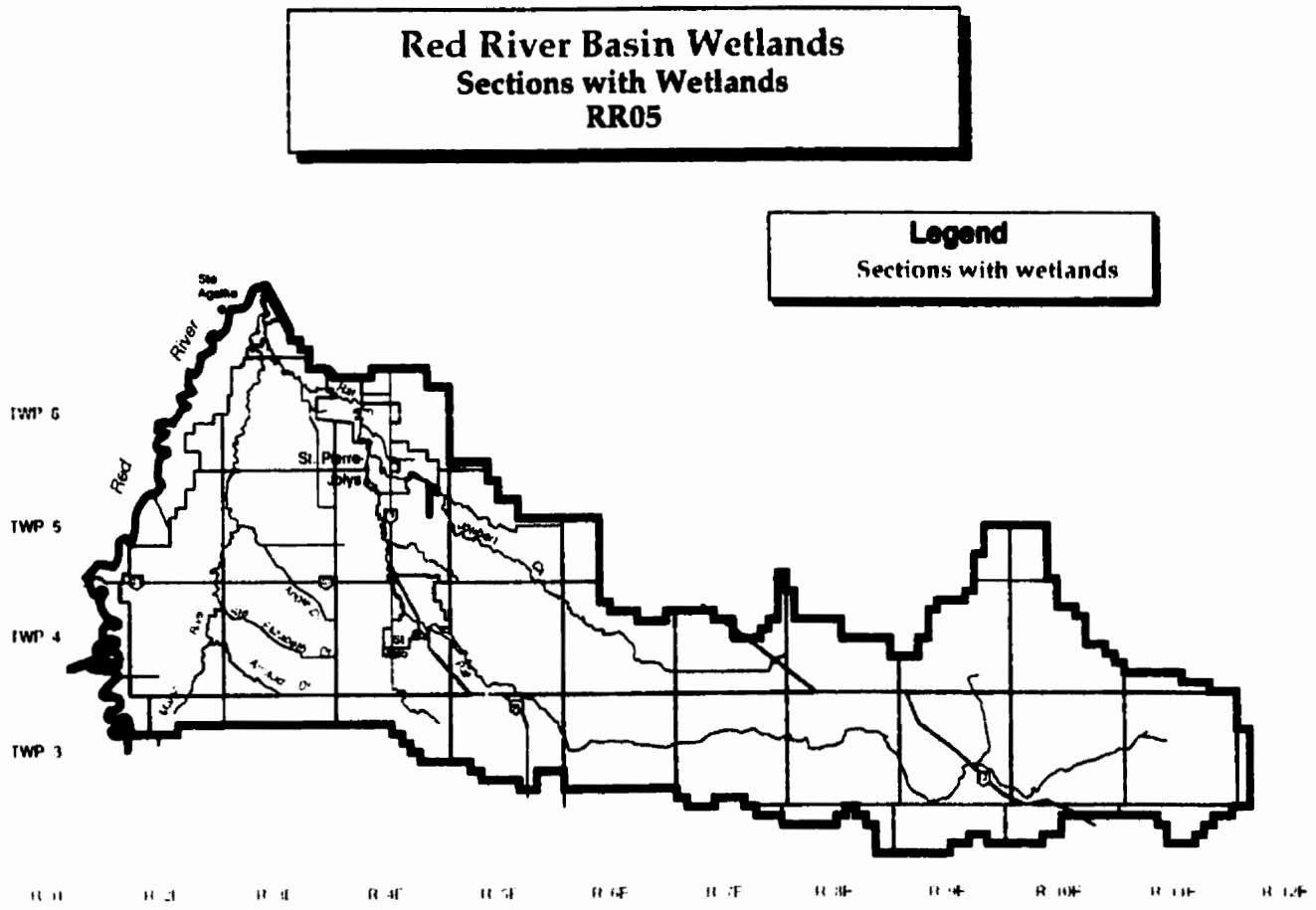

Red River Basin Wetlands
Sections with Wetlands
RR05
Legend
Sections with wetlands
TWP 6
TWP 5
TWP 4
TWP 3
Red River
St. Pierre-Jolys

Figure 15

Red River Basin Wetlands
Sections with Wetlands
RR06

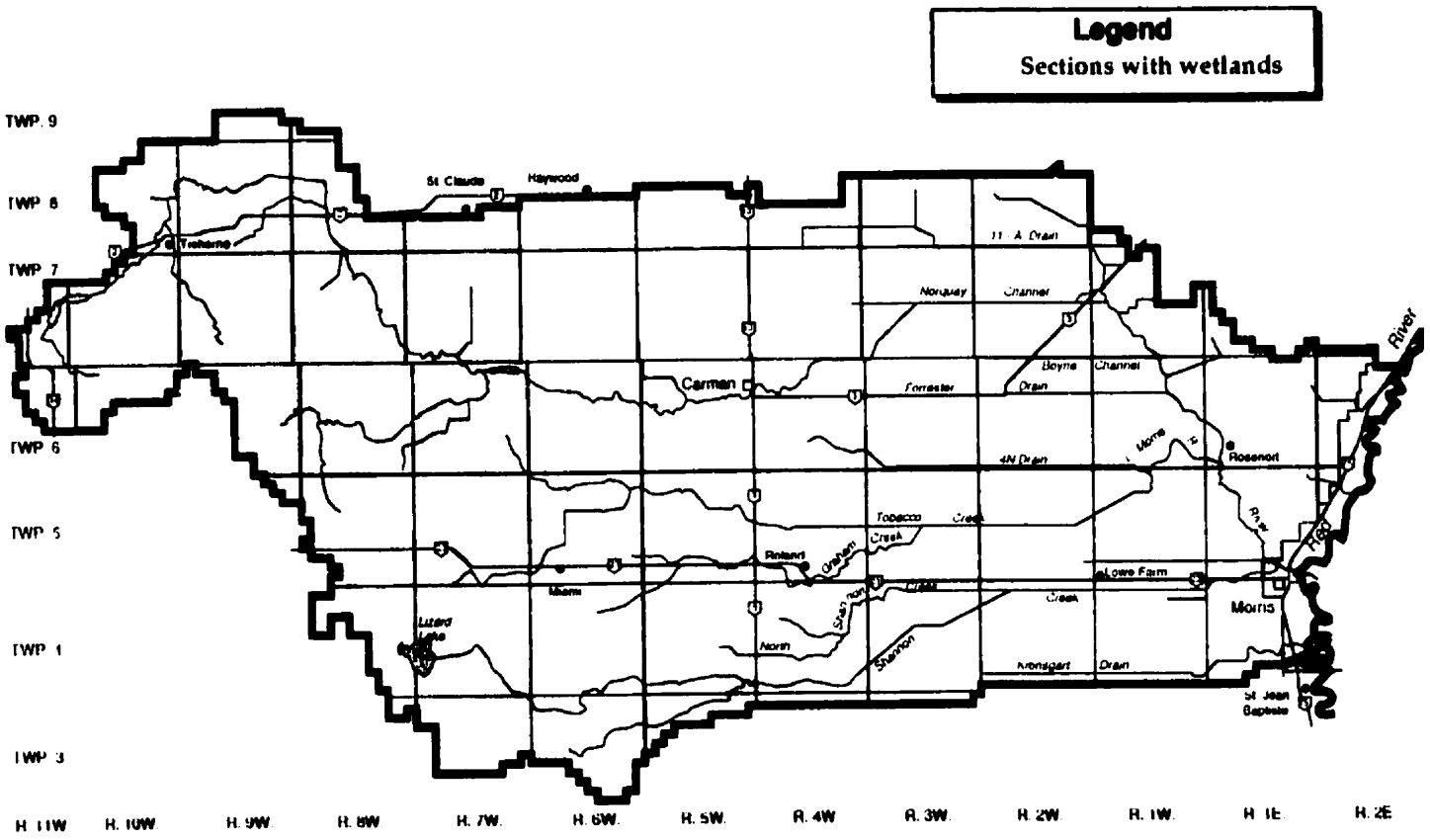


Figure 16

Red River Basin Wetlands
Sections with Wetlands
RR07

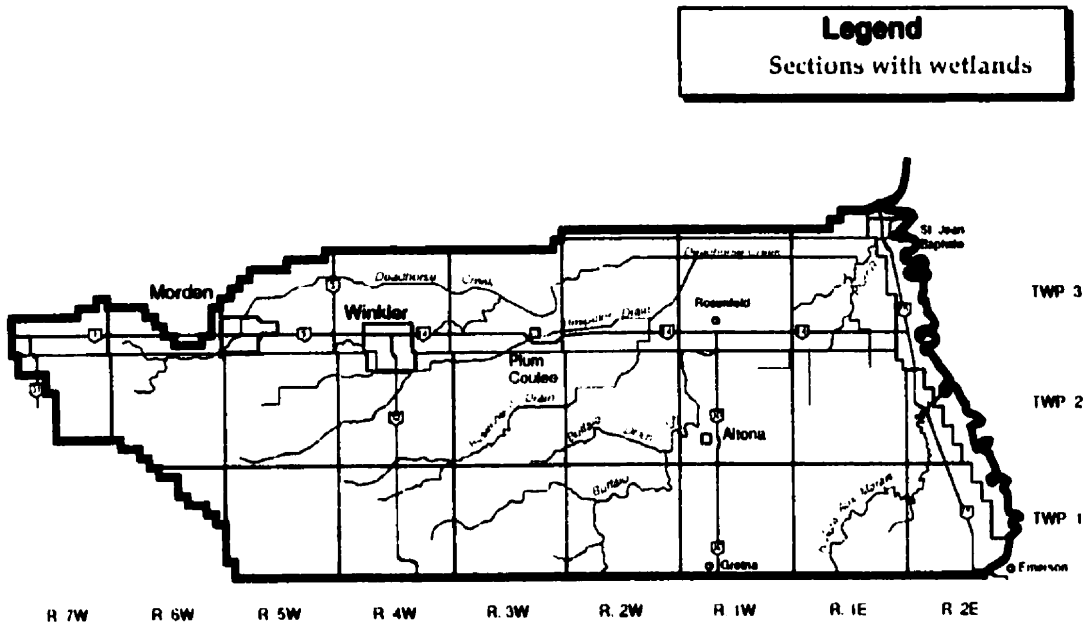


Figure 17

Red River Basin Wetlands
Sections with Wetlands
RR08

Legend
Sections with wetlands

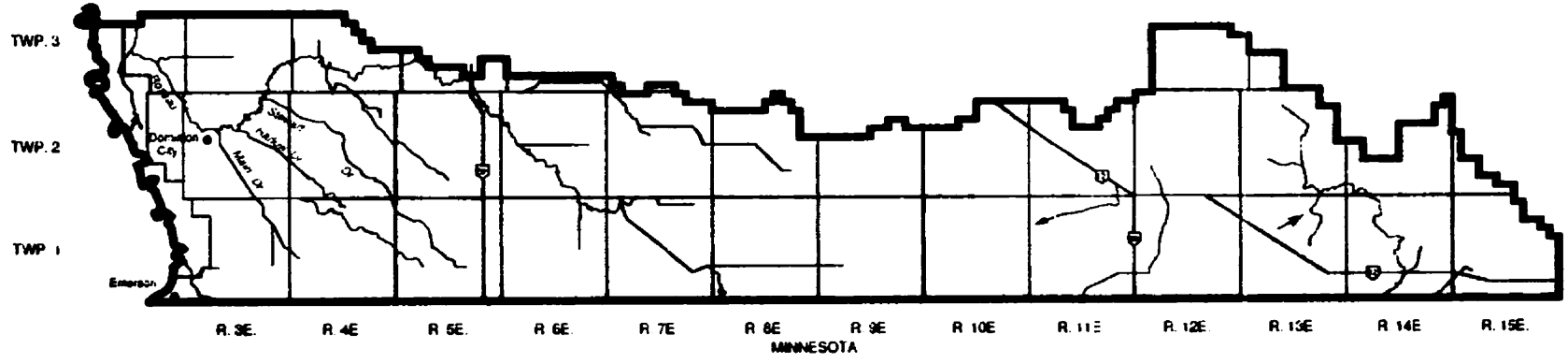


Figure 18

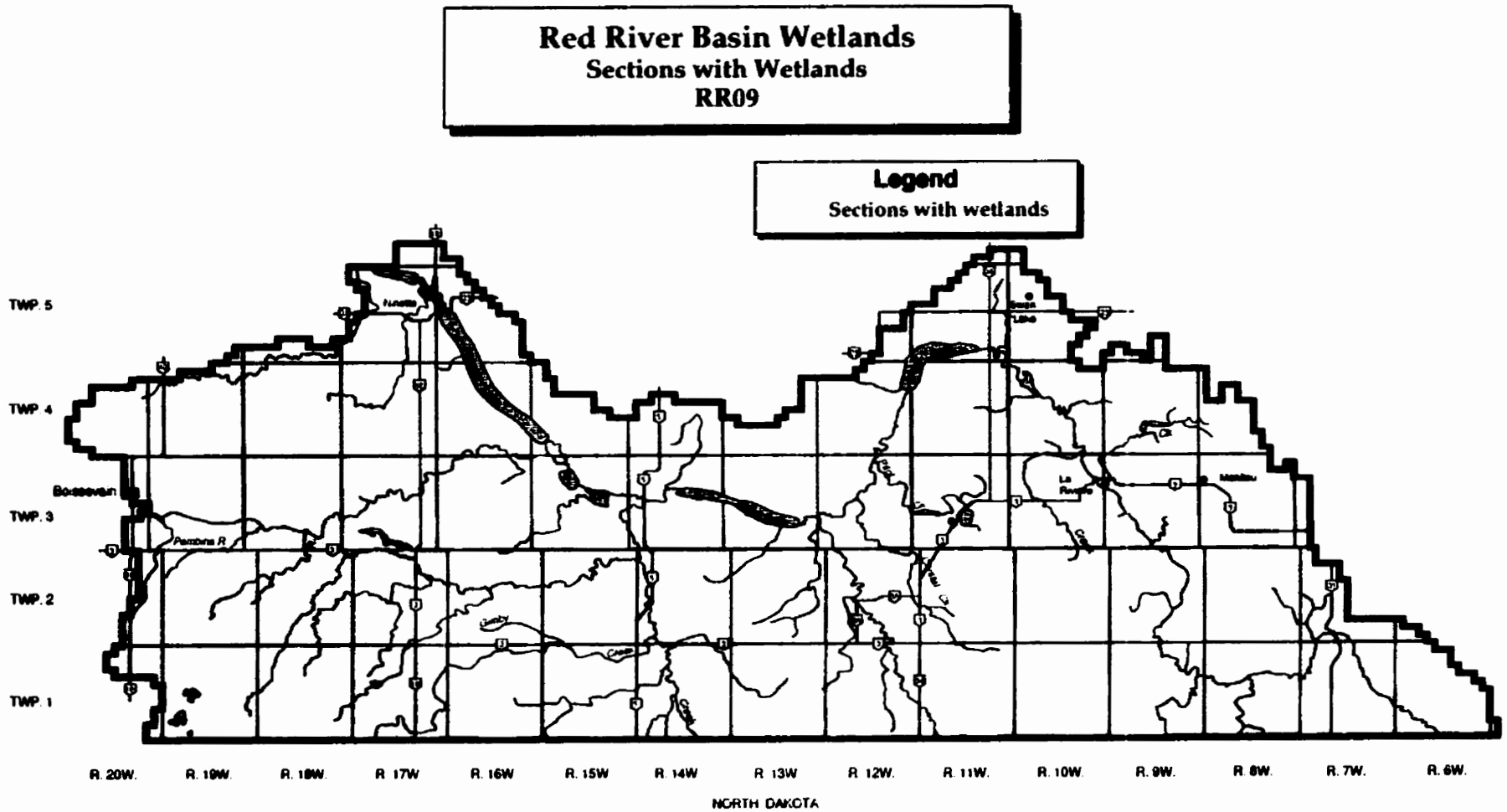

Red River Basin Wetlands
Sections with Wetlands
RR09
Legend
Sections with wetlands
TWP. 5
TWP. 4
TWP. 3
TWP. 2
TWP. 1
R. 20W.
R. 19W.
R. 18W.
R. 17W
R. 16W
R. 15W
R. 14W
R. 13W
R. 12W.
R. 11W.
R. 10W.
R. 9W.
R. 8W.
R. 7W.
R. 6W.
NORTH DAKOTA

Figure 19

Assiniboine River Basin

The study area includes all of the Manitoba portion of the Assiniboine River basin (ARB). It is divided into nine watersheds which drain a total area of 3,281,000 hectares. The inventory found 260,000 hectares of wetlands comprise eight percent of this area. The area of wetlands in individual watersheds ranges from 2,700 to 67,000 hectares. See Table 8.

Table 8

Assiniboine River Basin Wetland Area in Hectares by Watershed

Watershed	AR01	AR02	AR03	AR04	AR05
Watershed Area	175,100	510,400	546,900	266,200	152,700
Wetland Area	2,651	27,936	35,118	5,898	12,298
Private Wetland Area	2,067	18,997	16,920	5,404	6,213
Watershed	AR06	AR07	AR08	AR09	Total
Watershed Area	423,800	631,800	257,100	317,000	3,281,000
Wetland Area	66,853	50,261	9,596	48,997	259,608
Private Wetland Area	26,874	31,146	7,930	9,966	125,517

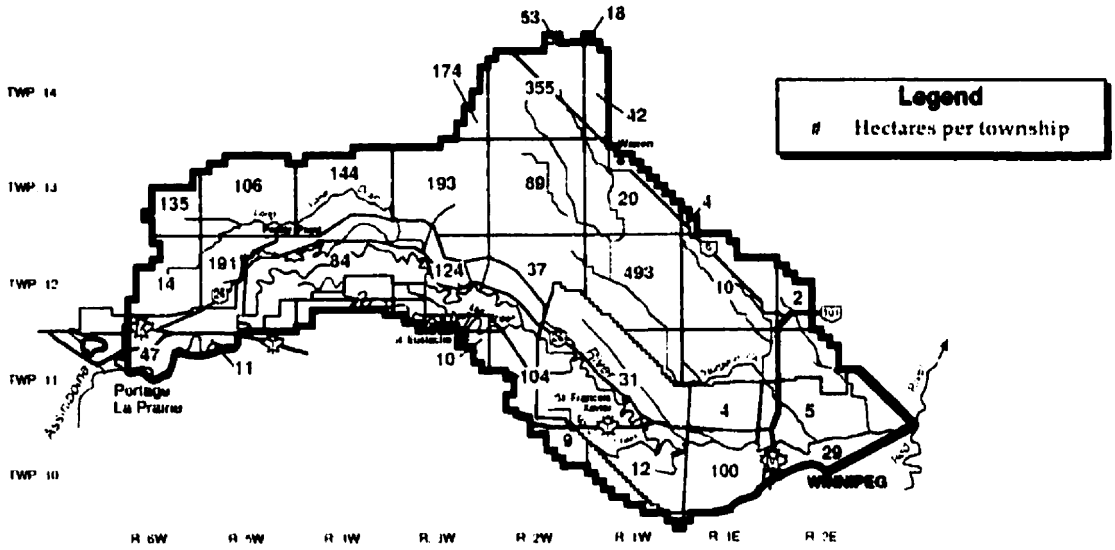
The portion of the individual watersheds in wetland cover ranges from two to 16 %. In this basin 48% of the wetlands are privately-owned. The portion of wetlands privately-owned in the individual watersheds ranges from

20 to 92 %.

Figures 20 through 28 are maps for each watershed in the basin showing the wetland area in each township. These maps also summarize for each watershed, the area, total wetland area, the portion of watershed in wetlands, the privately-owned wetland area and the portion of wetlands privately-owned.

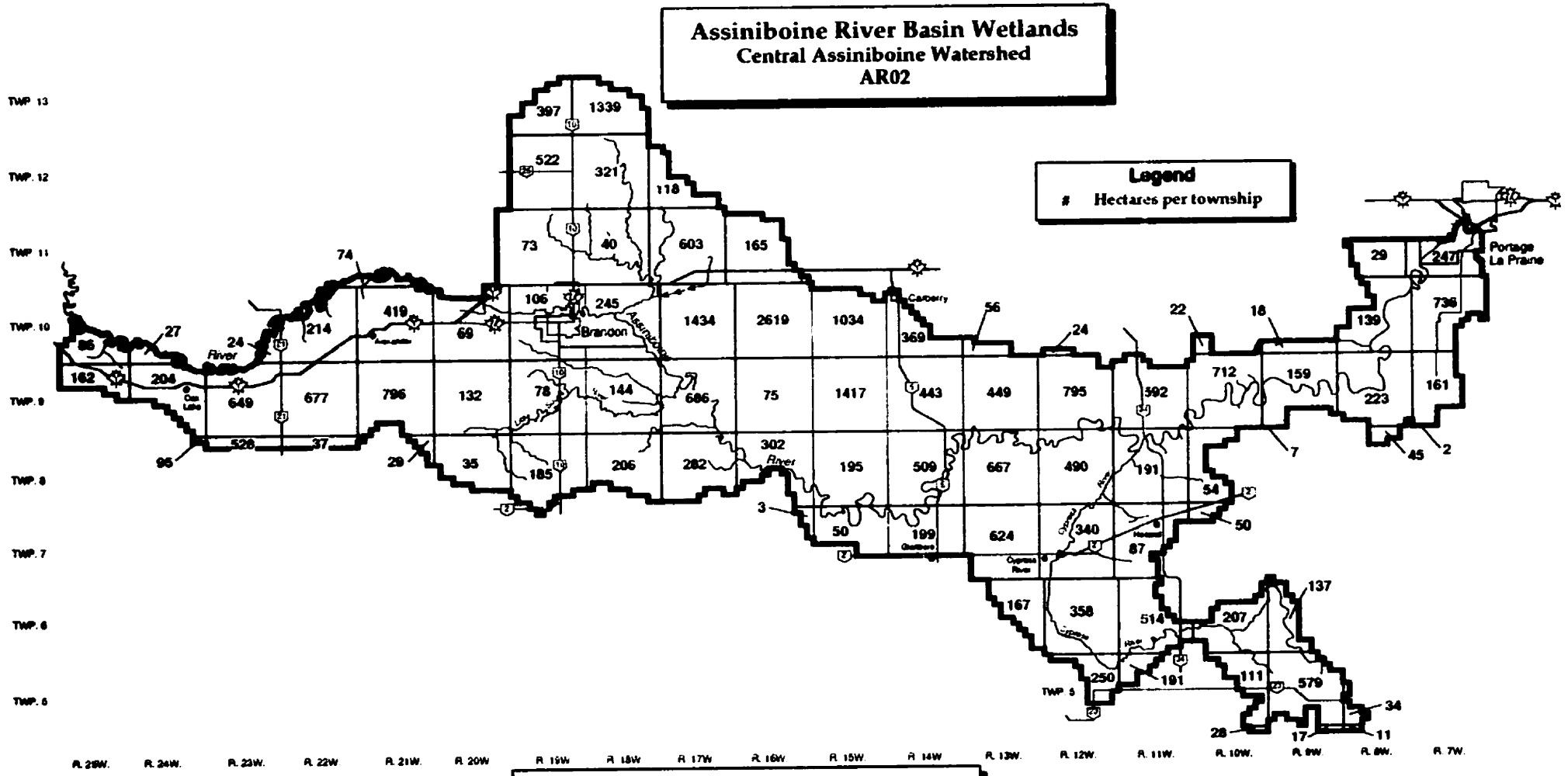
Most of watersheds AR01, AR04 and AR08 and significant portions of AR02, AR03, AR05 and AR07 contain five percent (469 hectares per township) or less wetland cover. Areas with 15 % (1407 hectares per township) or more wetland cover exist just east of Brandon (AR02), along the Manitoba-North Dakota border (in Turtle Mountain Provincial Park) and around Whitewater Lake (AR03), around Oak Lake (AR05), in the north half of AR06 (in Riding Mountain National Park and south of it in the pothole country), in the north edge of AR07 (in Riding Mountain National Park) and in the north portion of AR09 (in Duck Mountain Provincial Forest).

Assiniboine River Basin Wetlands
Lower Assiniboine Watershed
AR01



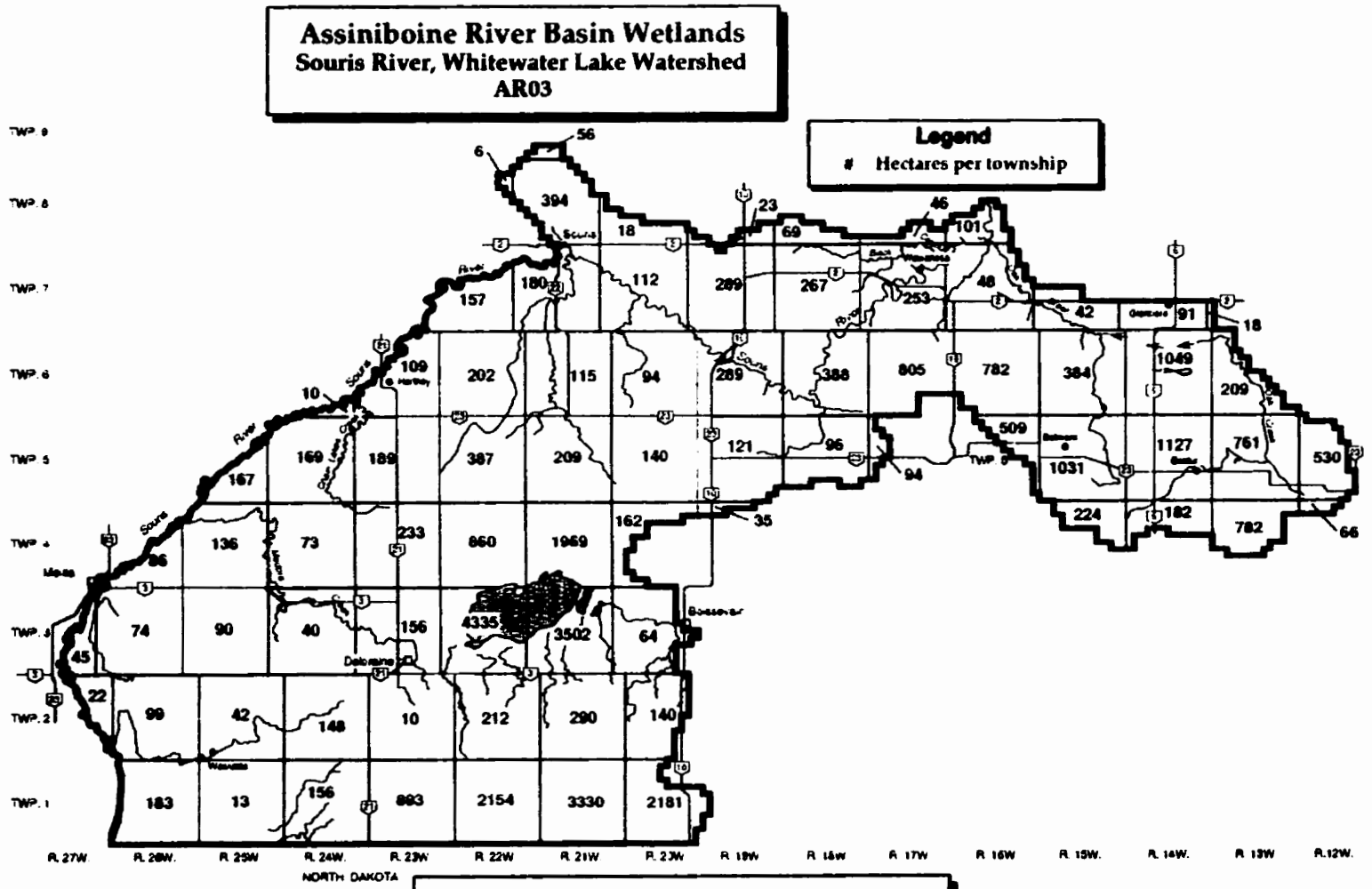
Total watershed area	175,100 ha.
Total wetland area	2,651 ha.
Portion of watershed in wetlands	2%
Privately owned wetland area	2,067 ha.
Portion of wetlands privately owned	78%

Figure 20



Total watershed area	510,400 ha.
Total wetland area	27,936 ha.
Portion of watershed in wetlands	5%
Privately owned wetland area	18,997 ha.
Portion of wetlands privately owned	68%

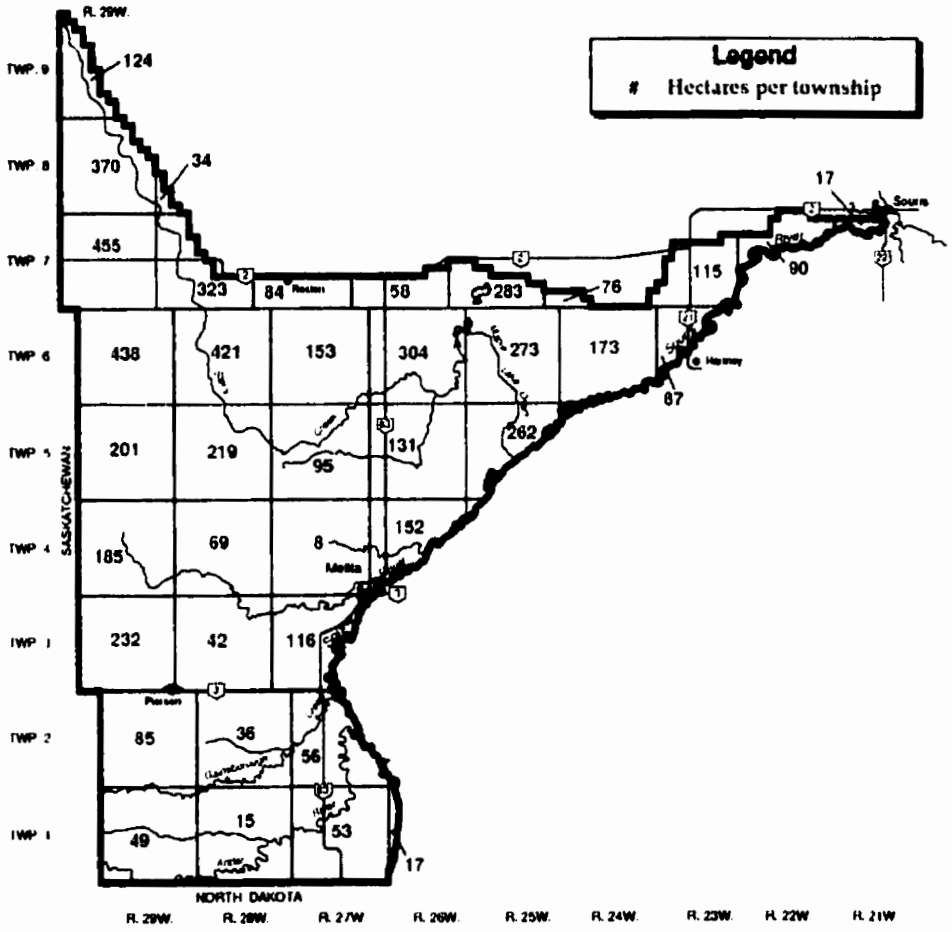
Figure 21



Total watershed area	546,900 ha.
Total wetland area	35,118 ha.
Portion of watershed in wetlands	6%
Privately owned wetland area	16,920 ha.
Portion of wetlands privately owned	48%

Figure 22

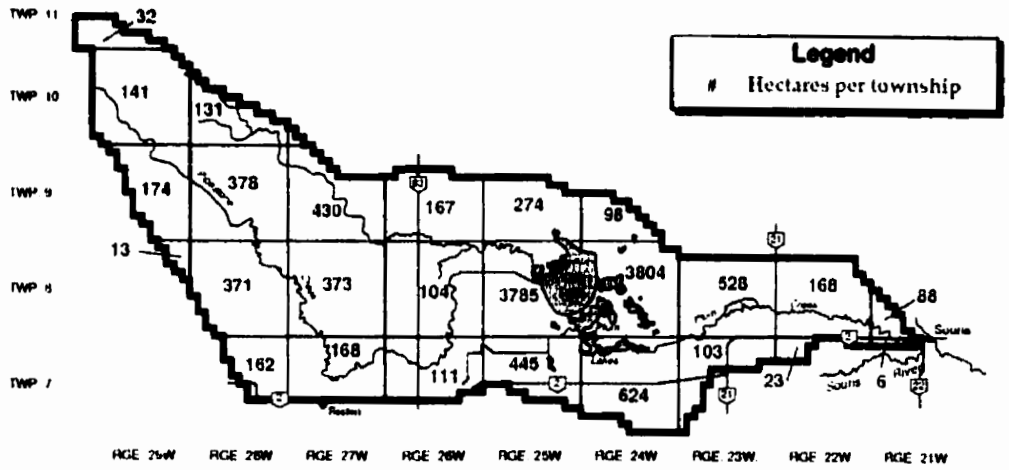
Assiniboine River Basin Wetlands
Souris River West Watershed
AR04



Total watershed area	266,200 ha.
Total wetland area	5,898 ha.
Portion of watershed in wetlands	2%
Privately owned wetland area	5,404 ha.
Portion of wetlands privately owned	92%

Figure 23

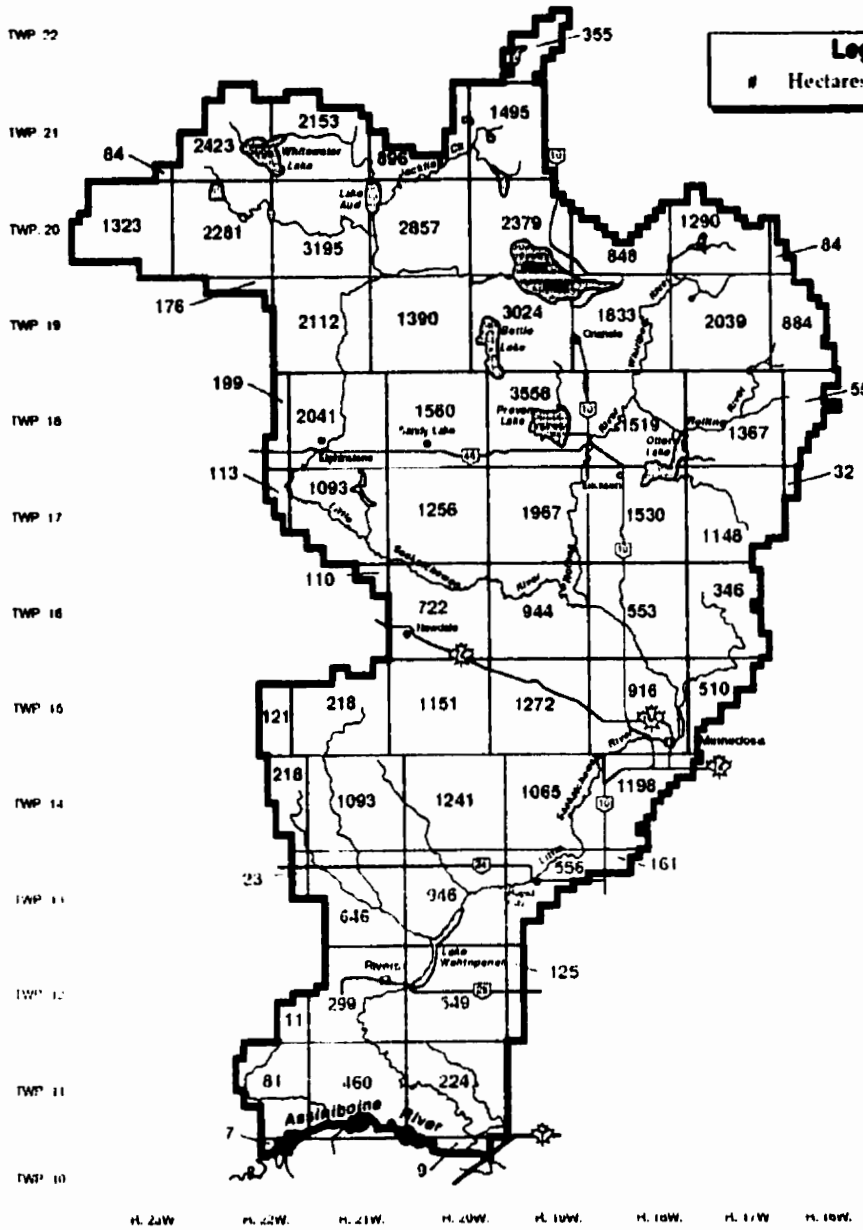
Assiniboine River Basin Wetlands
Oak Lake Watershed
AR05



Total watershed area	152,700 ha.
Total wetland area	12,298 ha.
Portion of watershed in wetlands	8%
Privately owned wetland area	6,213 ha.
Portion of wetlands privately owned	51%

Figure 24

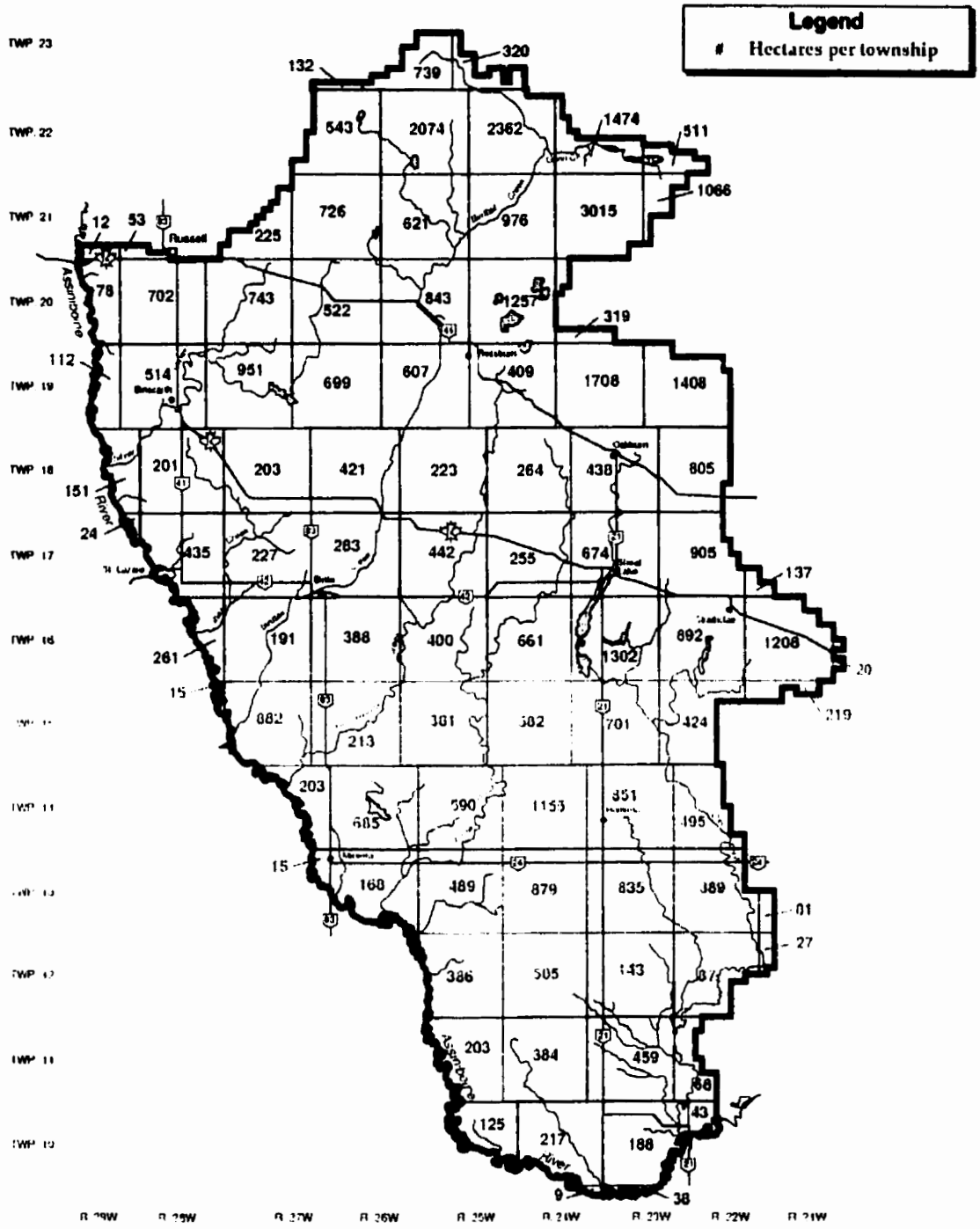
Assiniboine River Basin Wetlands
Little Saskatchewan River Watershed
AR06



Total watershed area	423,800 ha.
Total wetland area	66,853 ha.
Portion of watershed in wetlands	16%
Privately owned wetland area	26,874 ha.
Portion of wetlands privately owned	40%

Figure 25

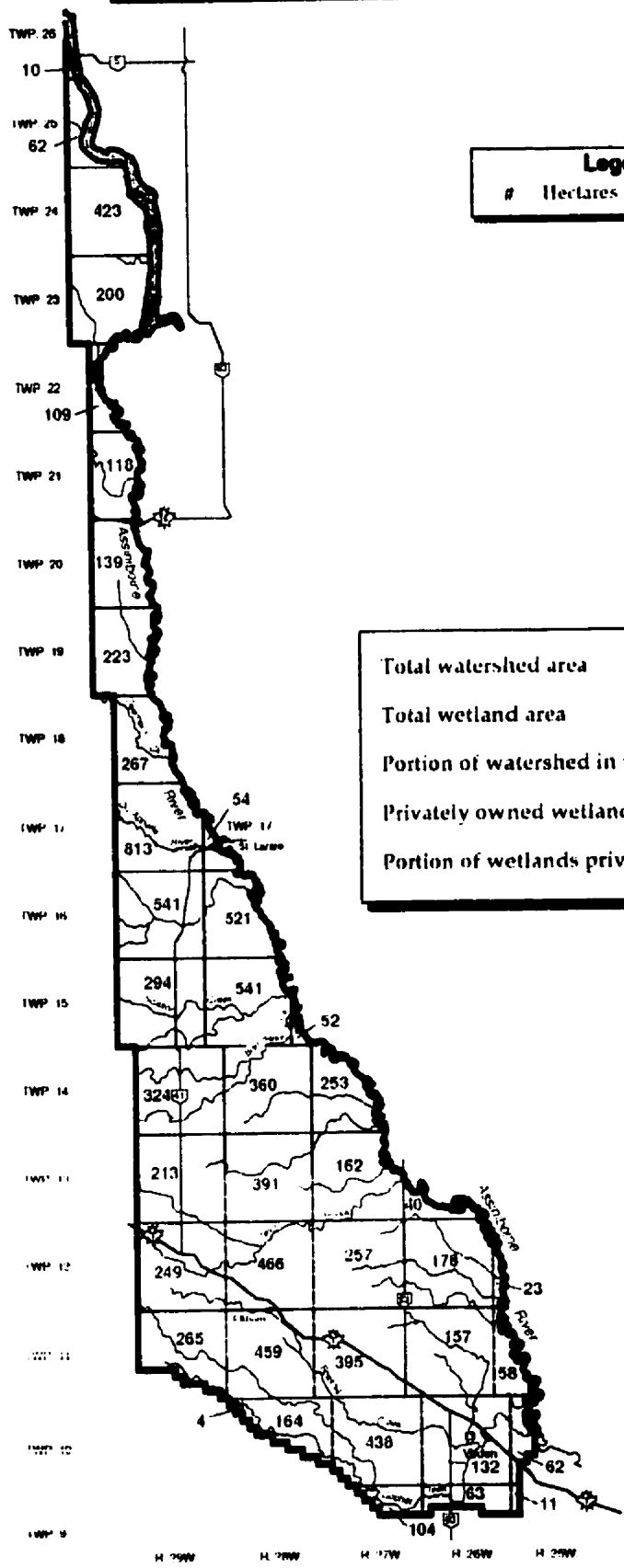
Assiniboine River Basin Wetlands
Birdtail Creek, Oak River Watershed
AR07



Total watershed area	631,800 ha.
Total wetland area	50,261 ha.
Portion of watershed in wetlands	8%
Privately owned wetland area	31,146 ha.
Portion of wetlands privately owned	62%

Figure 26

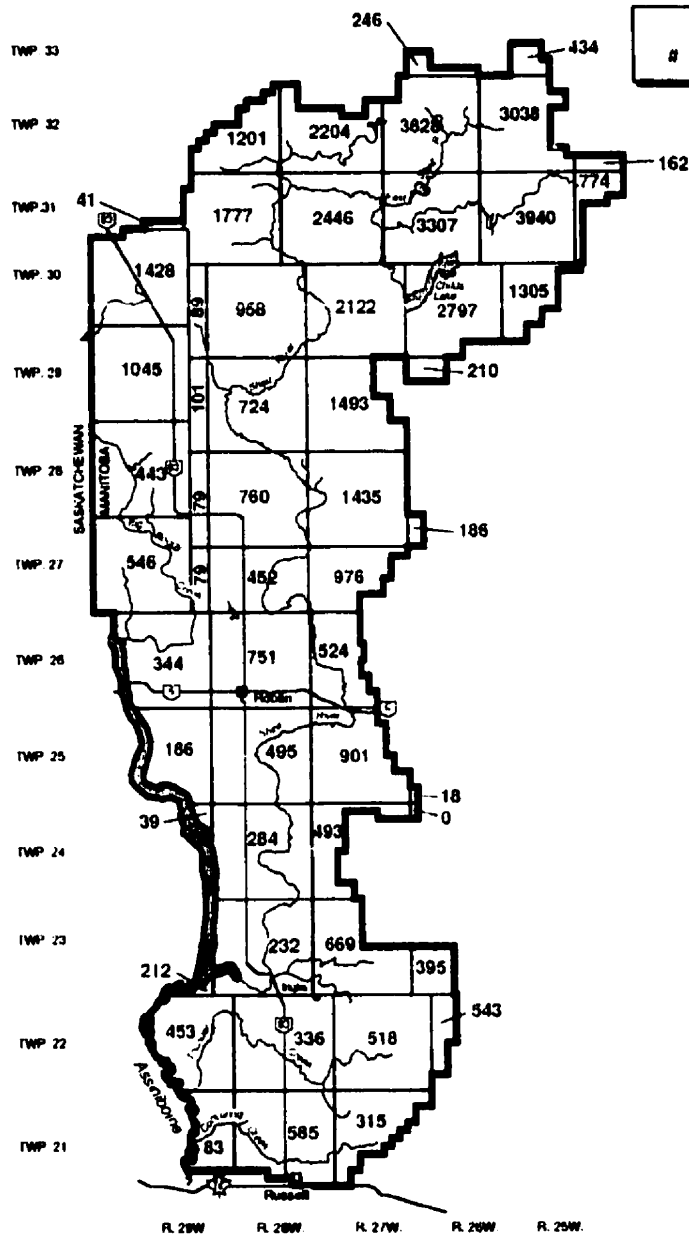
Assiniboine River Basin Wetlands
Assiniboine West Watershed
AR08



Total watershed area	257,100 ha.
Total wetland area	9,596 ha.
Portion of watershed in wetlands	4%
Privately owned wetland area	7,930 ha.
Portion of wetlands privately owned	83%

Figure 27

Assiniboine River Basin Wetlands
Shell River Watershed
AR09



Total watershed area	317,000 ha.
Total wetland area	48,997 ha.
Portion of watershed in wetlands	16%
Privately owned wetland area	9,966 ha.
Portion of wetlands privately owned	20%

Figure 28

Lake Manitoba Basin

The study area includes approximately two thirds of the Manitoba portion of the Lake Manitoba basin (LMB). This portion of the basin is divided into seven watersheds which drain a total area of 3,149,000 hectares. The inventory found 447,000 hectares of wetlands comprise 14 % of this area. The area of wetlands in individual watersheds ranges from 23,000 to 90,000 hectares. See Table 9.

Table 9

Lake Manitoba Basin Wetland Area by Watershed in Hectares

Watershed	LM02	LM03	LM04	LM05
Watershed Area	359,900	720,800	394,600	233,400
Wetland Area	88,845	42,617	89,514	23,422
Private Wetland Area	34,774	27,960	12,156	8,598
Watershed	**LM06**	**LM08**	**LM09**	**Total**
Watershed Area	536,000	532,800	371,500	3,149,000
Wetland Area	57,321	77,099	68,573	447,390
Private Wetland Area	12,035	7,091	7,754	110,369

The portion of the individual watersheds in wetland cover ranges from six to 25 %. In this basin 25% of the wetlands are privately-owned. The

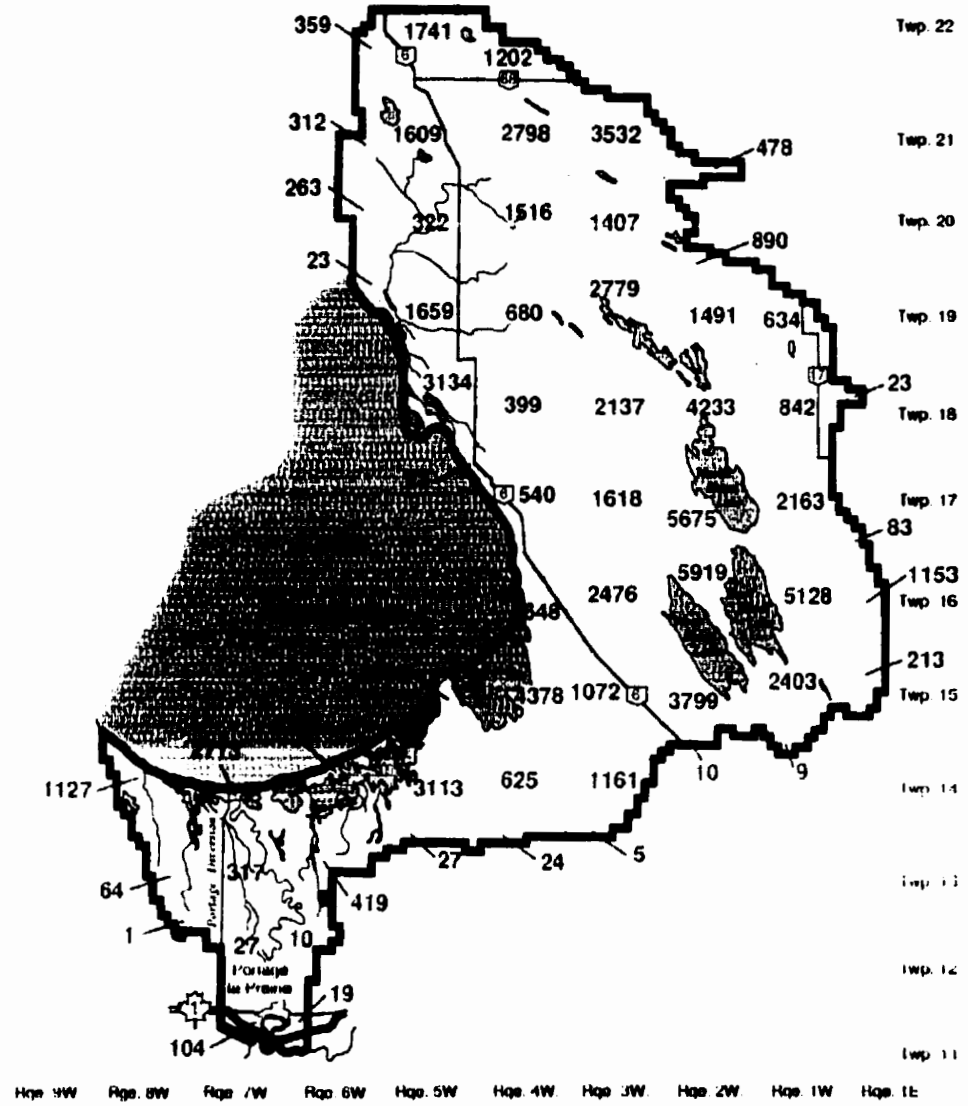
portion of wetlands privately-owned in the individual watersheds ranges from nine to 66 %.

Figures 29 through 35 are maps for each watershed in the basin showing the wetland area in each township. These maps also summarize for each watershed, the area, total wetland area, the portion of watershed in wetlands, the privately-owned wetland area and the portion of wetlands privately-owned.

Significant portions of watersheds LM02, LM06 and LM08 contain less than five percent (469 hectares per) wetland cover. Areas with 15 % (1407 hectares per township) or more wetland cover exist east and south of Lake Manitoba (LM02), west of Lake Manitoba (LM03, LM04 and LM09), along the south and north-west edges of LM06 (in Riding Mountain National Park and in Duck Mountain Provincial Forest), along the south edge and the north-east corner of LM08 (in Duck Mountain Provincial Forest and around Swan Lake).

Lake Manitoba Basin Wetlands
Shoal Lakes, Delta Marsh Watershed
LM02

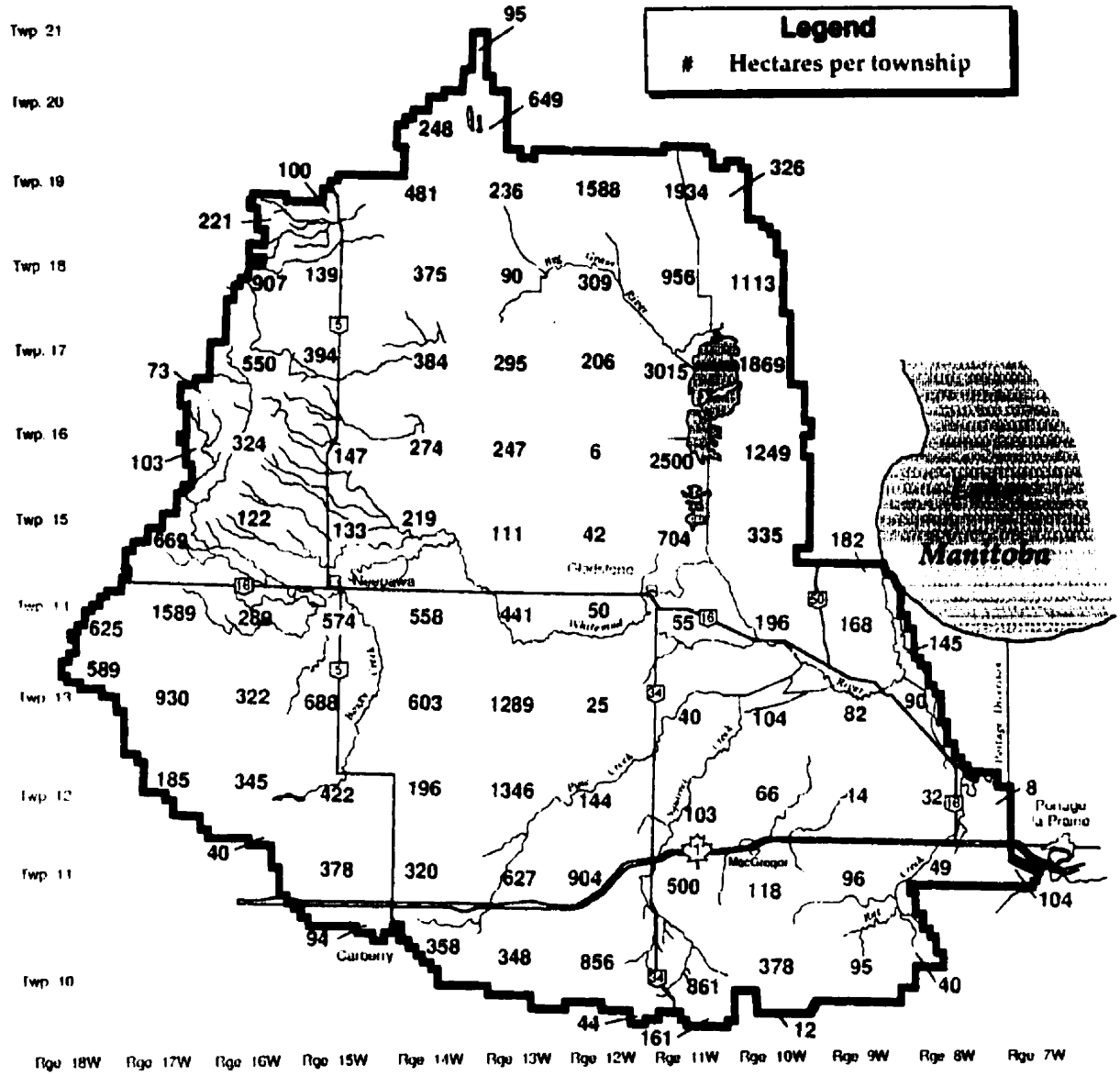
Legend
\# Hectares per township



Total watershed area	359,900 ha.
Total wetland area	88,845 ha.
Portion of watershed in wetlands	25%
Privately owned wetland area	34,774 ha.
Portion of wetlands privately owned	39%

Figure 29

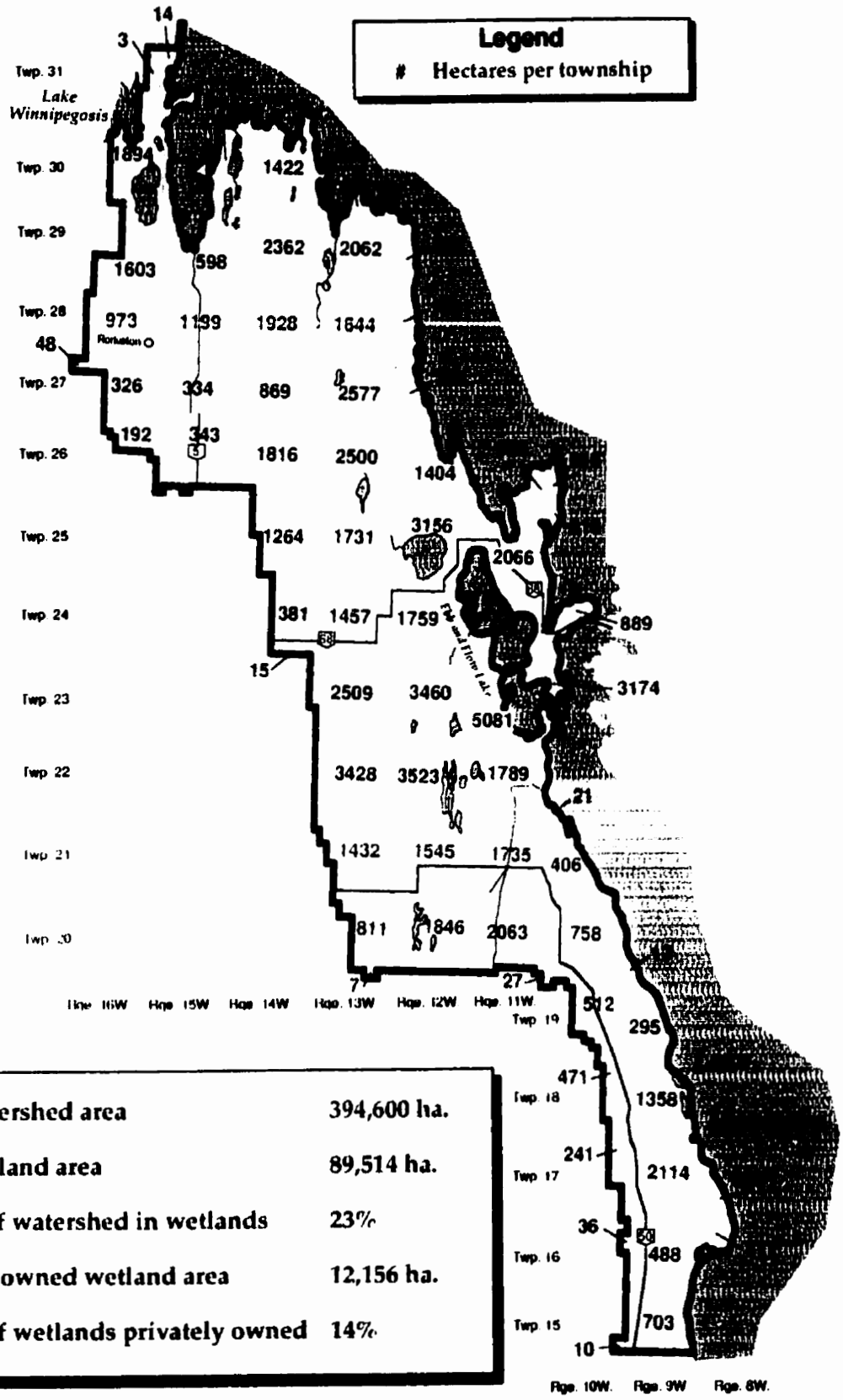
Lake Manitoba Basin Wetlands
Whitemud River Watershed
LM03



Total watershed area	720,800 ha.
Total wetland area	42,617 ha.
Portion of watershed in wetlands	6%
Privately owned wetland area	27,960 ha.
Portion of wetlands privately owned	66%

Figure 30

Lake Manitoba West Watershed
LM04

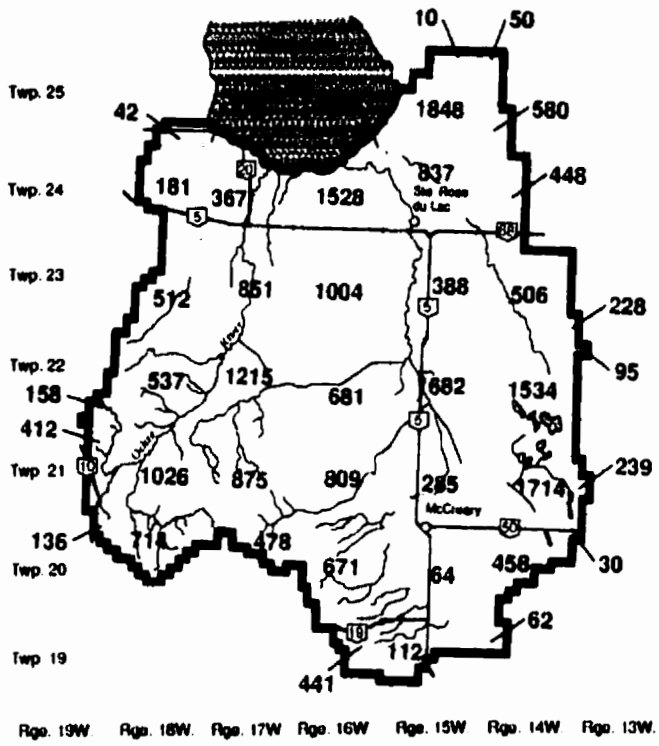


Total watershed area	394,600 ha.
Total wetland area	89,514 ha.
Portion of watershed in wetlands	23%
Privately owned wetland area	12,156 ha.
Portion of wetlands privately owned	14%

Figure 31

Lake Manitoba Basin Wetlands
Turtle River Watershed
LM05

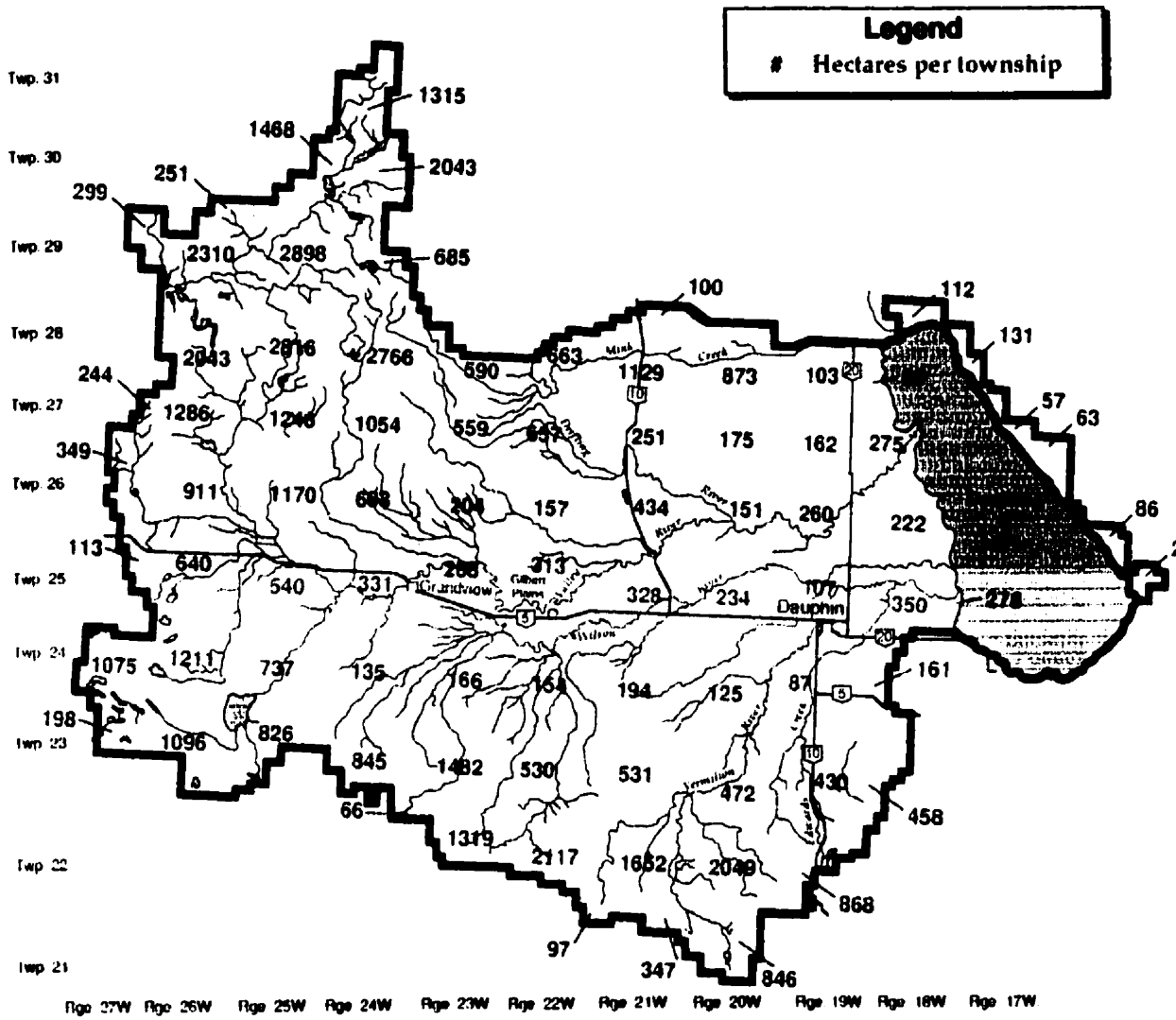
Legend
\# Hectares per township



Total watershed area	233,400 ha.
Total wetland area	23,422 ha.
Portion of watershed in wetlands	10%
Privately owned wetland area	8,598 ha.
Portion of wetlands privately owned	37%

Figure 32

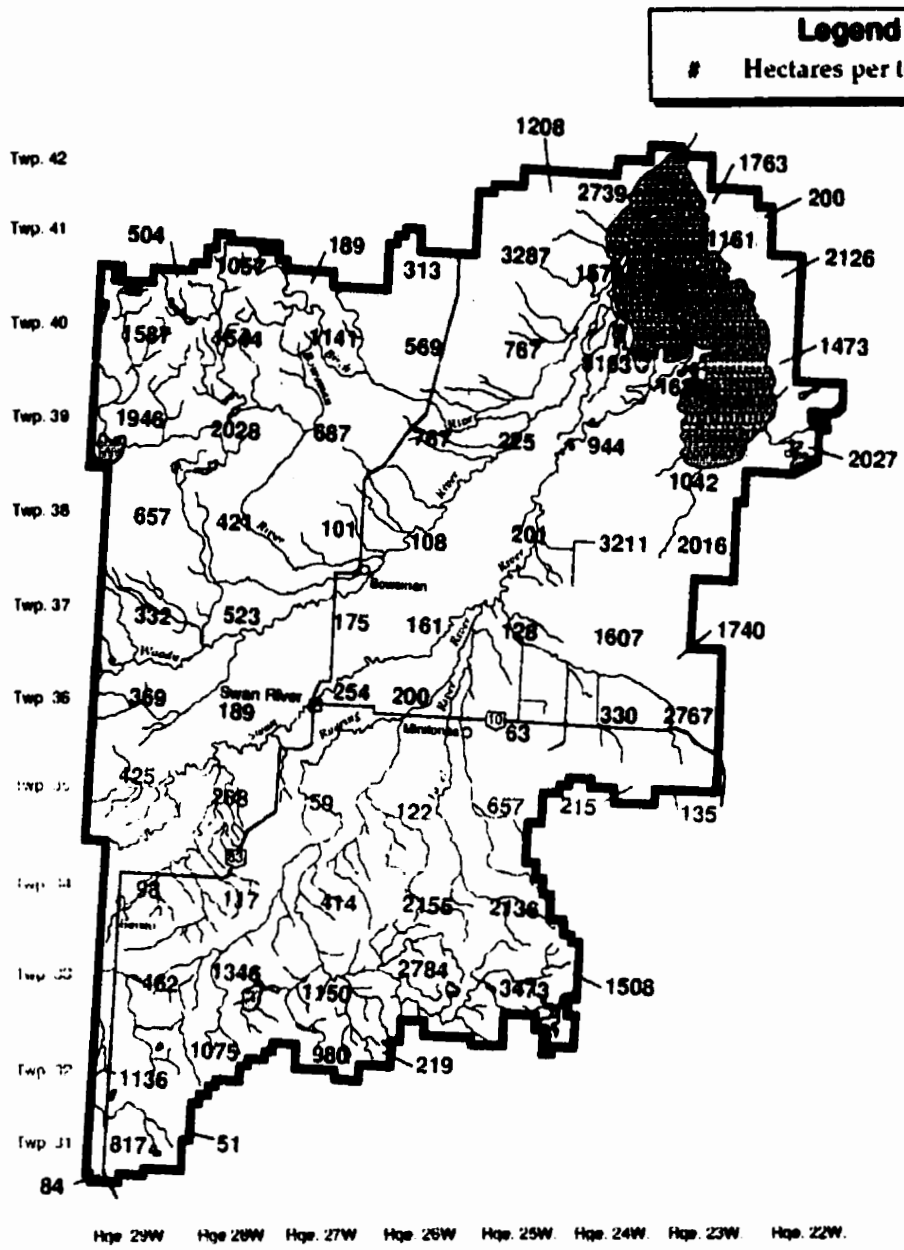
Lake Manitoba Basin Wetlands
Valley River Watershed
LM06



Total watershed area	536,000 ha.
Total wetland area	57,321 ha.
Portion of watershed in wetlands	11%
Privately owned wetland area	12,035 ha.
Portion of wetlands privately owned	21%

Figure 33

Lake Manitoba Basin Wetlands
Swan Lake Watershed
LM08

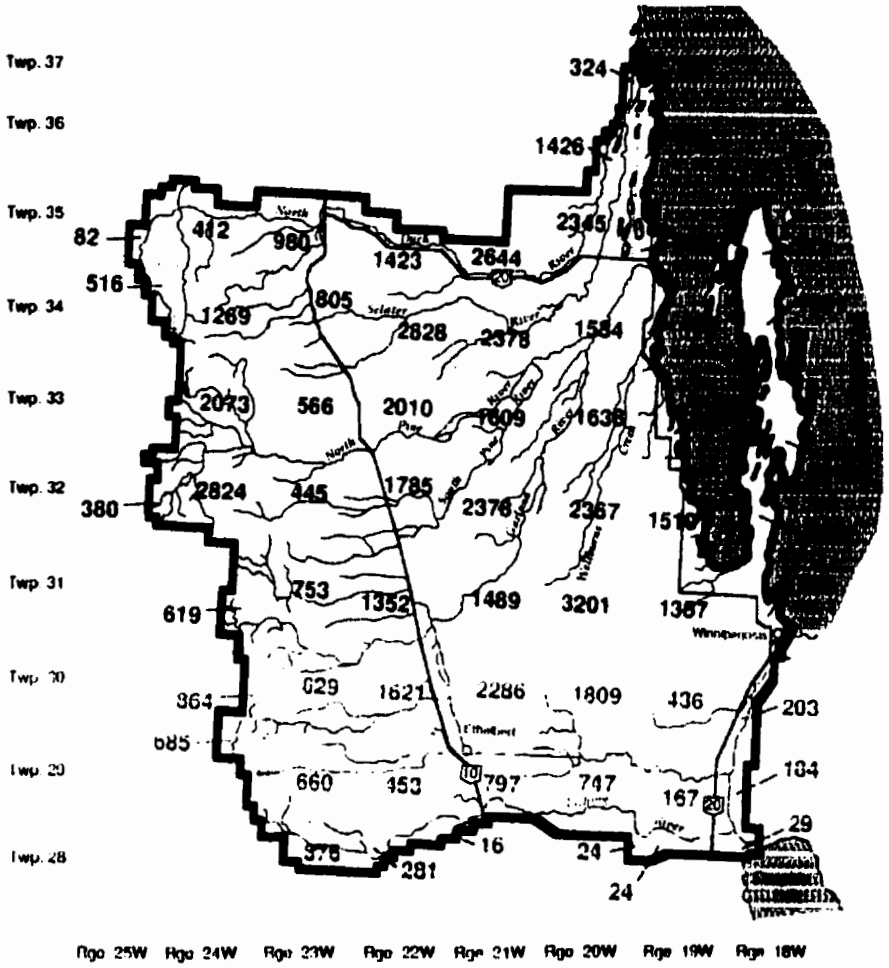


Total watershed area	532,800 ha.
Total wetland area	77,099 ha.
Portion of watershed in wetlands	15%
Privately owned wetland area	7,091 ha.
Portion of wetlands privately owned	9%

Figure 34

Lake Manitoba Basin Wetlands
Duck Mountain East Watershed
LM09

Legend
\# Hectares per township



Total watershed area	371,500 ha.
Total wetland area	68,573 ha.
Portion of watershed in wetlands	19%
Privately owned wetland area	7,754 ha.
Portion of wetlands privately owned	11%

Figure 35

Lake Winnipeg Basin

The study area includes approximately one sixth of the Manitoba portion of the Lake Winnipeg basin (LWB). This portion of the basin is divided into two watersheds which drain a total area of 598,000 hectares. The inventory found 104,000 hectares of wetlands comprise 18 % of this area. See Table 10. In this basin 19 % of the wetlands are privately-owned. The portion of wetlands privately-owned in the two watersheds is 13 and 33 %.

Figures 36 and 37 are maps for each watershed in the basin showing the wetland area in each township. These maps also summarize for each watershed, the area, total wetland area, the portion of watershed in wetlands, the privately-owned wetland area and the portion of wetlands privately-owned.

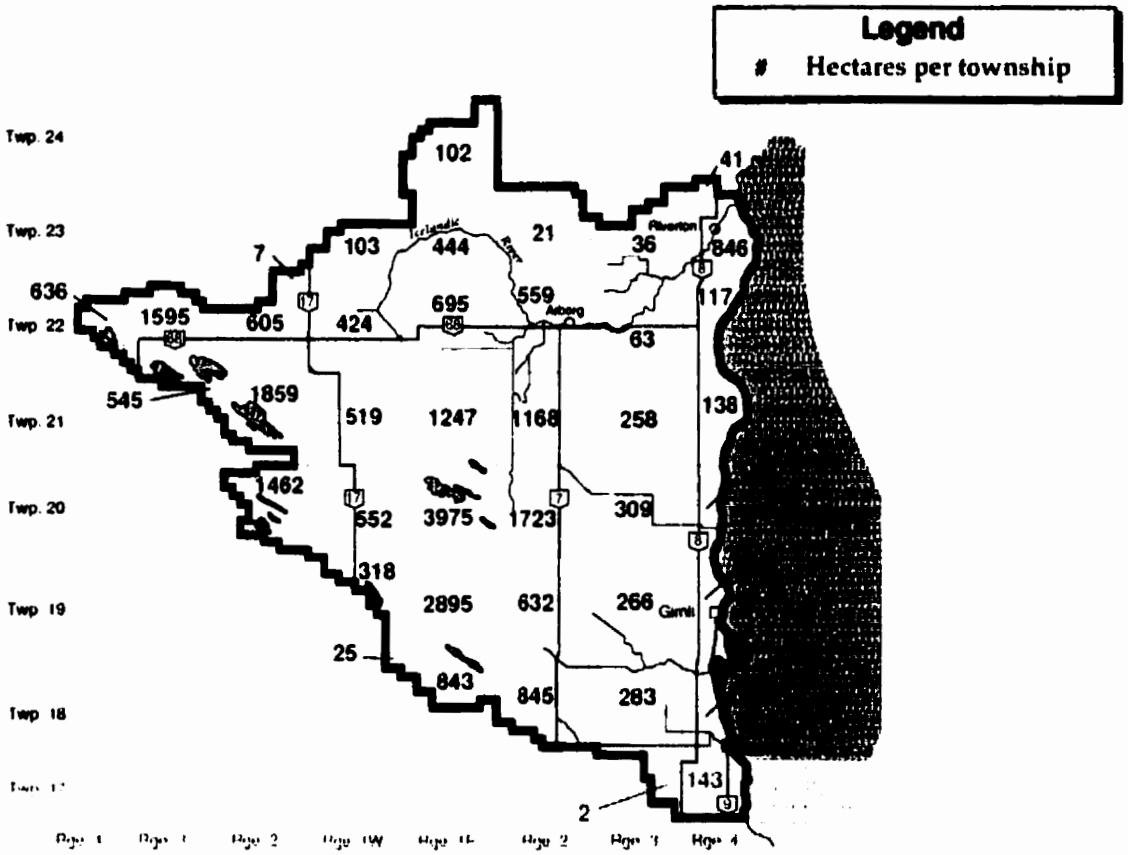
Areas with five percent (469 hectares per township) or less wetland cover exist along the west edge of Lake Winnipeg and north of Arborg (LW09) and north of Beausejour (LW10). Areas with 15 % (1407 hectares per township) or more wetland cover exist along the west edge of LW09 around the small lakes and marshes and over most of LW10.

Table 10

Lake Winnipeg Basin Wetland Area by Watershed in Hectares

Watershed	LW09	LW10	Total
Watershed Area	275,000	322,400	597,400
Wetland Area	26,972	77,442	104,414
Private Wetland Area	8,940	10,389	19,329

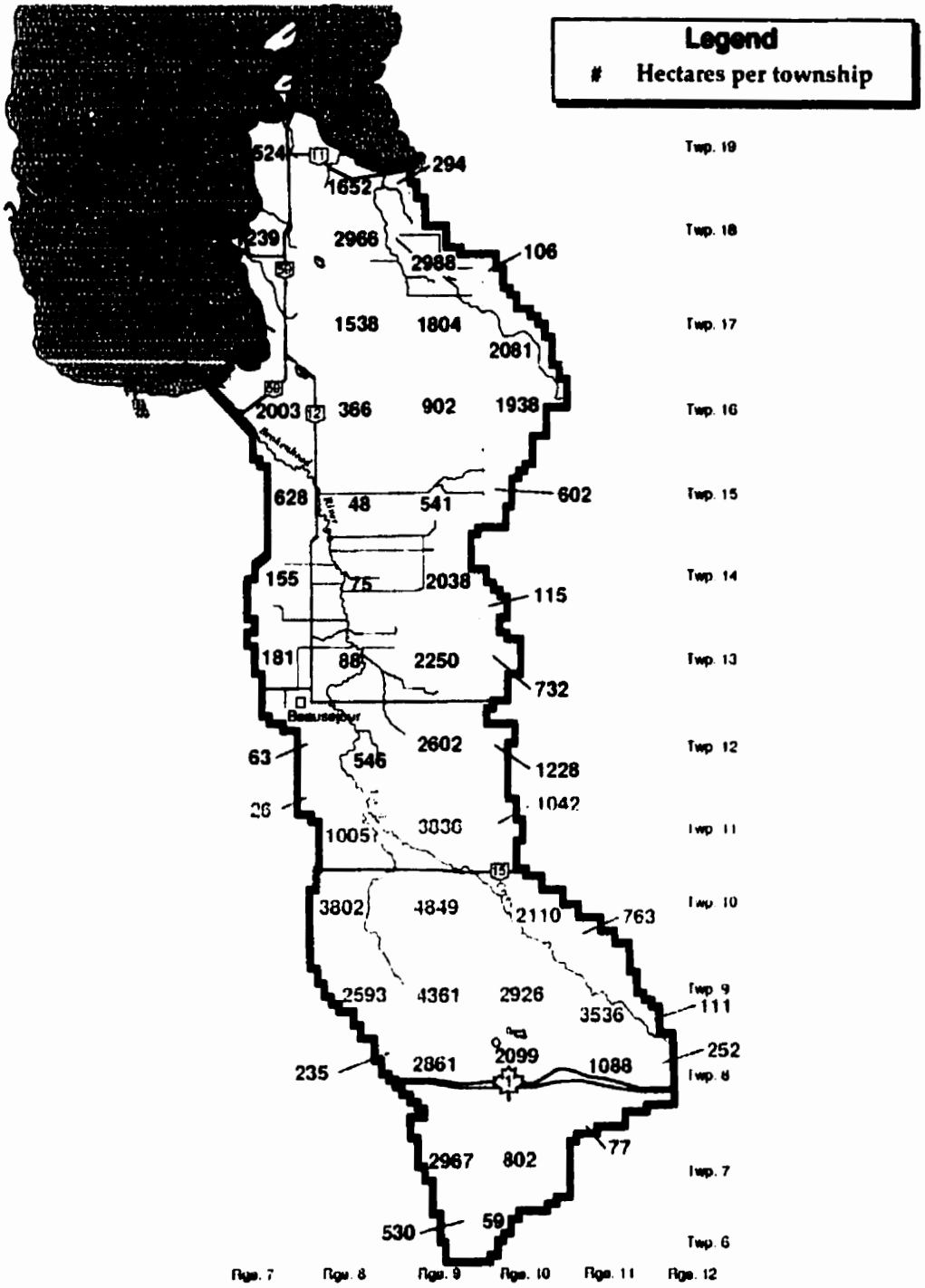
Lake Winnipeg Basin Wetlands
Icelandic River, Willow Creek Watershed
LW09



Total watershed area	275,000 ha.
Total wetland area	26,972 ha.
Portion of watershed in wetlands	10%
Privately owned wetland area	8,940 ha.
Portion of wetlands privately owned	33%

Figure 36

Lake Winnipeg Basin Wetlands
Brokenhead River Watershed
LW10



Total watershed area	322,400 ha.
Total wetland area	77,442 ha.
Portion of watershed in wetlands	24%
Privately owned wetland area	10,398 ha.
Portion of wetlands privately owned	13%

Figure 37

Winnipeg River Basin

The study area includes approximately one third of the Manitoba portion of the Winnipeg River basin (WRB). This portion of the basin is drained by one watershed covering 417,000 hectares. The inventory found 151,000 hectares of wetlands comprise 36 % of this area. See Table 11. In this watershed five percent of the wetlands are privately-owned.

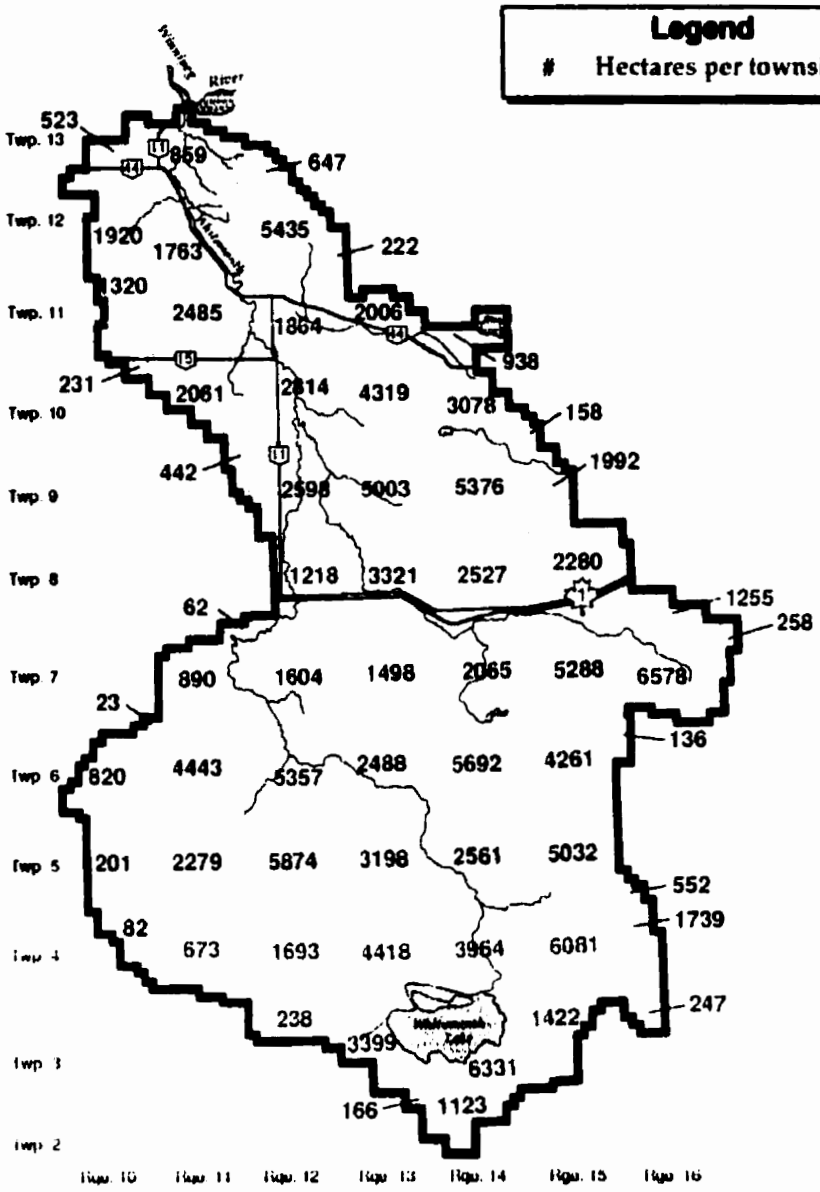
Table 11

Winnipeg River Basin Wetland Area by Watershed in Hectares

Watershed	WR02
Watershed Area	417,200
Wetland Area	151,387
Private Wetland Area	7,520

Figure 38 is a map for the watershed in the basin showing the wetland area in each township. This maps also summarizes for the watershed, the area, total wetland area, the portion of watershed in wetlands, the privately-owned wetland area and the portion of wetlands privately-owned.

Winnipeg River Basin Wetlands
Whitemouth River Watershed
WR02



Total watershed area	417,200 ha.
Total wetland area	151,387 ha.
Portion of watershed in wetlands	36%
Privately owned wetland area	7,520 ha.
Portion of wetlands privately owned	5%

Figure 38

Wetlands By Cover Type

The three most common wetland cover types in the study area are Willow (227,000 hectares comprise 20 % of the wetland area), Wet Meadow (200,000 hectares comprise 18 % of the wetland area), and Water (176,000 hectares comprise 16 % of the wetland area). Data on wetland area cover types by basin and by watershed are presented in tables 12 to 17.

In the Red River basin the three most common wetland cover types are Willow (42,000 hectares comprises 26% of the basin wetland area), Wet Meadow (32,000 hectares comprises 20%) and Marsh (22,000 hectares comprises 14%).

In the Assiniboine River basin the three most common wetland cover types are Water (69,000 hectares comprises 27% of the wetlands in the basin), Willow (56,000 hectares comprises 21%) and Wet Meadow (50,000 hectares comprises 19%).

In the Lake Manitoba basin the four most common wetland cover types are Wet Meadow (99,000 hectares comprises 23% of the wetlands in the basin), Willow (94,000 hectares comprises 21%) Water (72,000 hectares comprises 16%) and Marsh (62,000 hectares comprises 14%).

In the Lake Winnipeg basin the four most common wetland cover types are; Black Spruce Treed Muskeg (21,000 hectares comprises 20 % of the wetlands in the basin), Willow (20,000 hectares comprises 19%), Wet

Meadow (17,000 hectares comprises 16%) and Muskeg(16,000 hectares comprises 16%).

In the Winnipeg River basin the three most common wetland cover types are; Tamarack Larch Treed Muskeg (56,000 hectares comprises 37% of the wetlands in the basin), Muskeg (37,000 hectares comprises 25%) and Black Spruce Treed Muskeg (23,000 hectares comprises 15%).

Information regarding the distribution of wetland cover types within a section is available on four inch to a mile scale maps available from Manitoba Conservation, Forestry Branch.

Table 12

Study Area Wetlands in Hectares by Cover Type

Wetland Cover Type	RRB	ARB	LMB	LWB	WRB	TOTAL
Black Spruce Treed Muskeg	3,510	13,801	41,301	20,604	22,582	101,798
Tamarack Larch Treed Muskeg	4,555	1,854	5,437	9,284	56,483	77,614
Eastern Cedar Treed Muskeg	0	0	0	0	49	49
Willow	41,606	55,728	93,711	20,062	15,495	226,601
Alder	8	54	212	20	11	305
Dwarf Birch	2,105	1,226	3,305	3,109	3,717	13,463
Shrub	14,156	5,295	14,880	641	98	35,070
Wet Meadow	32,187	49,693	99,495	17,104	1,729	200,208
Muskeg	16,792	3,822	8,803	16,182	37,480	83,079
String Bogs	373	95	84	337	1,304	2,192
Marsh	22,100	29,591	61,969	10,360	289	124,309
Mud/Salt Flats	8	298	872	3	0	1,181
Sand Beaches	121	322	520	521	1	1,485
Beaver Floods	1,289	27,972	41,133	338	2,605	73,337
Water	20,117	69,163	72,425	5,295	8,953	175,952
Rivers	41	698	3,245	555	591	5,129
Total Wetland Area	158,968	259,608	447,390	104,414	151,387	1,121,767

Table 13

Red River Basin Wetlands in Hectares by Cover Type

Wetland Cover Type	RR01	RR02	RR03	RR04	RR05	RR06	RR07	RR08	RR09	RRB
Black Spruce Treed Muskeg	1	390	711	0	164	0	0	2,244	0	3,510
Tamarack Larch Treed Muskeg	0	78	1,196	0	419	0	0	2,862	0	4,555
Eastern Cedar Treed Muskeg	0	0	0	0	0	0	0	0	0	0
Willow	1,354	3,041	8,115	959	9,844	2,243	167	11,328	4,554	41,606
Alder	0	0	4	0	4	0	0	0	0	8
Dwarf Birch	0	267	466	1	622	6	0	743	0	2,105
Shrub	234	347	968	320	5,950	874	364	1,488	3,611	14,156
Wet Meadow	4,030	2,939	3,576	643	3,435	1,130	177	5,259	10,999	32,187
Muskeg	23	972	3,876	14	1,761	4	0	10,143	0	16,792
String Bogs	0	0	134	0	4	147	37	50	1	373
Marsh	8,584	6,114	92	116	1,848	566	38	1,542	3,200	22,100
Mud/Salt Flats	8	0	0	0	0	0	0	0	0	8
Sand Beaches	32	15	0	6	0	6	12	0	50	121
Beaver Floods	5	4	36	0	358	10	0	465	411	1,289
Water	4,860	3,124	110	548	414	602	188	753	9,518	20,117
Rivers	0	0	0	0	35	0	0	6	0	41
Total Wetland Area	19,131	17,291	19,284	2,607	24,858	5,588	983	36,682	32,344	159,968

Table14

Assiniboine River Basin Wetlands in Hectares by Cover Type

Wetland Cover Type	AR01	AR02	AR03	AR04	AR05	AR06	AR07	AR08	AR09	ARB
Black Spruce Treed Muskeg	0	490	4	0	0	1,623	415	0	11,269	13,801
Tamarack Larch Treed Muskeg	0	1,072	0	0	0	493	184	0	105	1,854
Eastern Cedar Treed Muskeg	0	0	0	0	0	0	0	0	0	0
Willow	629	10,042	3,508	1,936	1,726	11,992	14,294	4,334	7,267	55,728
Alder	0	0	0	3	0	0	51	0	0	54
Dwarf Birch	0	766	169	2	0	258	28	0	3	1,226
Shrub	415	1,740	347	27	65	674	1,048	734	245	5,295
Wet Meadow	744	5,673	9,892	2,844	2,539	12,062	10,076	2,911	2,952	49,693
Muskeg	0	1,533	8	0	0	1,536	268	2	475	3,822
String Bogs	0	63	5	3	0	22	2	0	0	95
Marsh	445	3,090	5,488	626	3,312	5,121	7,374	984	3,152	29,591
Mud/Salt Flats	3	15	131	0	10	11	36	1	91	298
Sand Beaches	2	247	49	0	7	4	5	6	2	322
Beaver Floods	0	162	174	0	31	9,086	5,994	130	12,395	27,972
Water	413	3,045	15,345	457	4,608	23,971	10,486	439	10,399	69,163
Rivers	0	0	0	0	0	0	0	55	643	698
Total Wetland Area	2,651	27,936	35,118	5,898	12,298	66,853	50,261	9,596	48,997	259,608

Table 15

Lake Manitoba Basin Wetlands in Hectares by Cover Type

Wetland Cover Type	LM02	LM03	LM04	LM05	LM06	LM08	LM09	LMB
Black Spruce Treed Muskeg	1	188	305	180	8,555	23,294	8,779	41,301
Tamarack Larch Treed Muskeg	0	147	28	217	387	3,326	1,333	5,437
Eastern Cedar Treed Muskeg	0	0	0	0	0	0	0	0
Willow	4,636	13,244	16,103	7,330	12,144	14,943	25,310	93,711
Alder	6	0	0	0	207	0	0	212
Dwarf Birch	4	321	597	233	202	1,110	838	3,305
Shrub	2,579	2,778	3,115	1,058	884	852	3,614	14,880
Wet Meadow	28,354	13,454	32,748	4,826	4,632	4,014	11,467	99,495
Muskeg	205	38	367	440	909	3,686	3,158	8,803
String Bogs	2	5	0	6	5	2	64	84
Marsh	26,942	7,075	14,714	3,764	2,552	3,838	3,084	61,969
Mud/Salt Flats	145	0	285	28	156	10	247	872
Sand Beaches	68	7	226	18	38	3	160	520
Beaver Floods	0	1,564	47	3,348	17,148	12,299	6,728	41,133
Water	25,901	3,644	20,951	1,678	8,511	8,553	3,186	72,425
Rivers	0	153	29	295	993	1,170	606	3,245
Total Wetland Area	88,845	42,617	89,514	23,422	57,321	77,099	68,573	447,390

Table 16

Lake Winnipeg Basin Wetlands in Hectares by Cover type

Wetland Cover Type	LW09	LW10	LWB
Black Spruce Treed Muskeg	359	20,245	20,604
Tamarack Larch Treed Muskeg	393	8,891	9,284
Eastern Cedar Treed Muskeg	0	0	0
Willow	2,410	17,652	20,062
Alder	0	20	20
Dwarf Birch	111	2,998	3,109
Shrub	226	415	641
Wet Meadow	11,438	5,666	17,104
Muskeg	516	15,666	16,182
String Bogs	0	337	337
Marsh	7,950	2,410	10,360
Mud/Salt Flats	0	3	3
Sand Beaches	294	227	520
Beaver Floods	14	324	338
Water	3,261	2,034	5,295
Rivers	0	555	555
Total Wetland Area	26,972	77,442	104,414

Table 17

Winnipeg River Basin Wetlands in Hectarea by Cover Type

Wetland Cover Type	WR02
Black Spruce Treed Muskeg	22,582
Tamarack Larch Treed Muskeg	56,483
Eastern Cedar Treed Muskeg	49
Willow	15,495
Alder	11
Dwarf Birch	3,717
Shrub	98
Wet Meadow	1,729
Muskeg	37,480
String Bogs	1,304
Marsh	289
Mud/Salt Flats	0
Sand Beaches	1
Beaver Floods	2,605
Water	8,953
Rivers	591
Total Wetland Area	151,387

Cover Type Concentrations and Shortages

The magnitude of each of the 16 wetland cover types in the study area and some notes on their distribution within the basins and watersheds of the study area follow.

Black Spruce Treed Muskeg - 102,000 hectares of this cover type comprise nine percent of the wetlands in the entire study area.

Concentrations	Shortages
41,000 hectares in the LMB. 23,000 in LM08.	3,500 hectares in the RRB. Less than 10 hectares in; RR01, RR04, RR06, RR07 and RR09.
23,000 hectares in the WRB. All in WR02.	Less than five hectares in; AR01, AR03, AR04, AR05, AR08.
21,000 hectares in the LWB. 20,000 in LW10.	One hectare in LM02.
14,000 hectares in the ARB. 11,000 in AR09.	

Tamarack Larch Treed Muskeg - 78,000 hectares of this cover type comprise seven percent of the wetlands in the entire study area.

Concentrations	Shortages
56,000 hectares in the WRB. All in WR02. 9,000 hectares in LW10.	1,800 hectares in the ARB. Zero hectares in; AR01, AR03, AR04, AR05, AR08.

Eastern Cedar Treed Muskeg - 50 hectares of this cover type comprise less than one percent of the wetlands in the entire study area. This cover type was found only in the WRB, WR02.

Willow - 227,000 hectares of this cover type comprise 20 % of the wetlands in the entire study area. This was found to be the most common type of wetland cover.

Concentrations	Shortages
94,000 hectares in the LMB. 25,000 hectares in LM09. 56,000 hectares in the ARB. Most in; AR02, AR06 and AR07. 42,000 hectares in the RRB. Most in; RR03, RR05 and RR08. 20,000 hectares in the LWB. 18,000 hectares in LW10.	200 hectares in RR07.

Alder - 300 hectares of this cover type comprise less than one percent of the wetlands in the entire study area.

Concentrations	Shortages
200 hectares in the LMB. Most in LM06.	

Dwarf Birch - 13,000 hectares of this cover type comprise less than one percent of the wetlands in the entire study area.

Concentrations	Shortages
4,000 hectares in WR02.	
3,000 hectares in LW10.	

Shrub - 35,000 hectares of this cover type comprise three percent of the wetlands in the entire study area.

Concentrations	Shortages
15,000 hectares in the LMB.	600 hectares in the LWB.
14,000 hectares in the RRB.	100 hectares in the WRB.
6,000 hectares in RR05.	
4,000 hectares in RR09.	Less than 100 hectares in AR04 and AR05.

Wet Meadow - 200,000 hectares of this cover type comprise 18 % of the wetlands in the study area. This was the second most common type of wetland cover.

Concentrations	Shortages
99,000 hectares in the LMB. 33,000 in LM04. 28,000 in LM02. 50,000 hectares in the ARB. 12,000 hectares in AR06. 10,000 hectares in AR07. 10,000 hectares in AR03. 32,000 hectares in the RRB. 11,000 hectares in RR09.	200 hectares in RR07.

Muskeg - 83,000 hectares of this cover type comprise seven percent of the wetlands in the entire study area.

Concentrations	Shortages
37,000 hectares in the WRB. All in WR02. 17,000 hectares in the RRB. 10,000 hectares in RR08. 16,000 hectares in the LWB. Most in LW10.	3,800 hectares in the ARB. Less than 10 hectares in; AR01, AR03, AR04, AR05 and AR08. Less than 10 hectares in; RR04, RR06, RR07 and RR09.

String Bogs - 2,000 hectares of this cover type comprise less than one percent of the wetlands in the entire study area.

Concentrations	Shortages
1,300 hectares in the WRB. All in WR02. 400 hectares in the RRB. Most in RR03 and RR06. 300 hectares in the LWB. All in LW10.	

Marsh - 124,000 hectares of this cover type comprise 11 % of the wetlands in the entire study area.

Concentrations	Shortages
62,000 hectares in the LMB. 27,000 hectares in LM02. 15,000 hectares in LM04. 30,000 in the ARB. 7,000 in AR07. 22,000 hectares in the RRB. 9,000 hectares in RR01.	Less than 100 hectares in RR03 and RR07.

Mud/Salt Flats - 1,200 hectares of this cover type comprise less than one percent of the wetlands in the entire study area.

Concentrations	Shortages
900 hectares in the LMB. 300 hectares in LM04. 200 hectares in LM09.	Zero in the WRB. Less than 10 in the WRB.
300 hectares in the ARB. 100 hectares in AR03. 100 hectares in AR09.	Less than 10 in the LWB.

Sand Beaches - 1,500 hectares of this cover type comprise less than one percent of the wetlands in the entire study area.

Concentrations	Shortages
500 hectares in the LMB. 200 in LM04. 200 in LM09.	One hectare in the WRB.
500 hectares in the LWB.	
300 hectares in the ARB. 200 in AR02.	

Beaver Floods - 73,000 hectares of this cover type comprise seven percent of the wetlands in the entire study area.

Concentrations	Shortages
41,000 hectares in the LMB. 17,000 hectares in LM06. 12,000 hectares in LM08.	1300 hectares in the RRB. Less than 10 hectares in RR01, RR02, RR04 and RR07.
28,000 hectares in the ARB. 12,000 hectares in AR09. 9,000 hectares in AR06.	Less than 10 hectares in AR01 and AR04.
	Less than 10 hectares in LM02.
	Less than 20 hectares in LW09.

Water - 176,000 hectares of this cover type comprise 16 % of the wetlands in the entire study area. This was the third most common type of wetland cover.

Concentrations	Shortages
72,000 hectares in the LMB. 27,000 in LM02. 21,000 in LM04.	5,000 hectares in the LWB.
	Less than 500 hectares in RR03, RR05 and RR07.
69,000 in the ARB. 24,000 in AR06.	Less than 500 hectares in AR01, AR04 and AR08.

Rivers - 5,000 hectares of this cover type comprise less than one percent of the wetlands in the entire study area.

Concentrations	Shortages
3,000 hectares in the LMB. 1,000 in LM08. 1,000 in LM06.	40 hectares in the RRB. Zero hectares in; RR01, RR02, RR03, RR04, RR06, RR07 and RR09. Zero hectares in AR01, AR02, AR03, AR04, AR05, AR06 and AR07. Zero hectares in LM02. Zero hectares in LW09.

Conclusions

The term, "wetlands" is a relatively recent one but since 1970 society and the science community have written extensively on the uses and values of these mainly natural areas.

Wetlands contain valuable natural flora and fauna habitat. They are acknowledged to be among the most prolific natural producers per unit area of plants and animals. They purify and store water and play a prominent role in the control of atmospheric gas budgets and possibly in the control of global climate. They are also prized environments for research and recreation.

A variety of previous wetland inventory information is available in Manitoba but most are for isolated areas and all utilise different classification systems. Two of the inventories cover all Manitoba. One is the very generalised distribution map by Zoltai in 1988 that shows for all of Canada five categories of percentage wetland cover. The other is the 1:250,000 scale mapping by Halsey *et al.* in 1997 that shows for all of Manitoba wetlands complexes classified as per the National Wetlands working group.

During the development of North America, laws and government policies facilitated the destruction of wetlands. As wetland numbers decreased, the knowledge of their uses increased and recently governments have been espousing their values. Canada has a policy of no net loss of

wetlands functions, however with a lack of detailed wetlands inventory it is very difficult to quantitatively assess status. Considerable qualitative information claims extensive wetland losses have occurred in most developed parts of Canada.

Canadian legislation provides limited direct protection to wetlands and that only to crown-owned, mainly northern, ones. On private property, there is little opportunity to prevent wetland destruction. The provinces have jurisdiction over wetlands, but Manitoba and other provinces, are not active in exercising that jurisdiction. With the exception of wetland areas pursued by the few agencies with a waterfowl habitat protection mandate and with economic resources, there seems little will to protect wetlands.

Nomenclature and language development may have facilitated wetland losses. In North America, as in other places, the evolution of resource law has resulted in land being considered a private resource and water a public or crown resource. Most natural wetland environments are areas of water. The name wetland, however, is suggestive of a land resource.

Had wetlands been given a name more suggestive of a water resource, perhaps "shallow water", they may have been more readily considered a public resource and their losses reduced. If the original name had been coined by an ecologist it may have focused more on their water aspects. Most recent wetland definitions make it clear that the controlling

factor in wetland soil and plant development is water permanence. Ecologists view the landscape from the perspective of habitat potential to support flora and fauna populations. The name wetland was coined by the hydrologists Shaw and Fredine. Hydrologists view the landscape from the perspective of water runoff potential, commonly for the sake of quantifying drainage requirements to support land development.

The 1980's forest inventory mapping is a good source of wetland information. It covers the entirety of the study area and ground truthing found the selected wetland covers to be, with few exceptions, still accurately classified. Its large scale mapping (1:15,840), detailed classification system and large number of cover types allowed for the selection of 16 covers that, in most circumstances, accurately describe wetland areas and exclude non-wetland areas. The identified wetlands contain natural terrestrial flora and fauna by virtue of their uncultivated soils and unharvested vegetation. The maps are available for viewing at Manitoba Forestry or in digital format to determine the locations of wetlands within each section.

Province wide generalisations of the percentage of wetland cover in Manitoba are not representative of southern Manitoba. It was estimated in 1997, based on small scale mapping (1:250,000) that 43% of Manitoba's territory is covered with wetlands complexes (Halsey *et al.*, 1997). This inventory found that the portion of wetland cover in the 28 watersheds of the study area ranged from 0.5 % to 36 %. Overall, excluding the major lakes

and rivers, only 11 % of the landscape in this area is wetlands.

Wetlands have been almost eliminated in some of the intensively drained and farmed watersheds. Seven watersheds in the Red and Assiniboine River basins contain less than five percent wetland cover and four of them (RR04, RR06, RR07 and AR01) have one percent wetland cover or less. Within watersheds RR04, RR06 and RR07 there are 13 townships that contain wetland cover in only one section and 15 townships that contain no wetland cover in patches larger than 0.3 hectares.

In the study area 29 % of the wetlands were found to be privately-owned. In the watersheds of the study area, the percentage of wetlands privately-owned ranged from five to 92 %. Generally, the lesser the wetland cover in the watershed the greater the percentage of their private ownership.

The most common wetland covers in the study area were found to be Willow, Wet Meadow and Water. In similar portions these three covers comprise a total of 54 % of the study area wetlands.

Future wetland loss in the agricultural portion of Manitoba will likely be focused on willow and wet meadow cover types. Where land clearing activities were noted during ground truthing, they were often focused on Willow cover. Wet Meadow cover was commonly noted to exist in shallow topographic depressions isolated from the waterway network and surrounded by agricultural activities.

Wetland magnitude and distribution within the study area is likely

controlled, most significantly, by the capability of the soils for agriculture. Wetland distribution in natural environments is often related to allogenic factors of climate and physiographic factors (Halsey *et al.*, 1997). In the agricultural portion of Manitoba, however, it is more likely related to the anthropogenic factors of agricultural and drainage practices.

A visual comparison of Canada land inventory 1:1,000,000 scale map of soil capability for agriculture (Canada, 1974) to this inventory confirms that areas mapped as soil capability for agriculture classes one, two or three contain less than five percent wetland cover except if they carry a topographic (T) limitation, then they contain less than 15 % wetland cover. Areas mapped as class four, five, six, seven or organic contain more than 15 % wetland cover except if either class carries a moisture (M) limitation, then they contain less than 15 % wetland cover.

The few places in the study area where soil capability is not the main factor in the remaining wetland magnitude are areas where agricultural activities are prohibited or areas where current drainage technology is prohibitively expensive. In the study area these include;

- Riding Mountain National Park and provincial parks and forest reserves and wildlife management areas.
- Low lying areas adjacent to lakes or large waterbodies where a high water table is maintained by the waterbody.
- Groundwater discharge areas where a high water table is maintained by

an ongoing water supply. An example of this circumstance is the Plum Lakes and Plum Creek area in watershed AR05.

- Hilly topography where the relief would require the excavation of large amounts of earth for gravity driven drainage to function. Notable examples of this circumstance exist in the "pothole country" in the northerly portions of watersheds AR06 and AR07 and to a lesser degree in the westerly portion of LM03. These areas are currently the focus of North American Waterfowl Management Plan expenditures in Manitoba.

Contrary to the extensive values society professes to attribute to wetlands it continues to allow them to be destroyed. This seems to be so because wetlands also have space values for urban, industrial and agricultural developers. Their development of these spaces, by filling or draining, involves the destruction of the wetland values. In Canada, particularly in the Prairies, wetlands are developed mainly for their space values to agriculture. It is a curious contradiction to destroy valued wetlands to produce agricultural products that are currently valued so low.

Canada and some of the Provinces devote resources to compiling and distributing wetlands educational materials. Educated, willing and financially able landowners can voluntarily set aside wetlands on their property. However, few incentives are available to encourage the private landowner to protect these societal resources. To a large degree they must do so at their own inconvenience and expense.

In some intensively farmed watersheds few wetlands remain and most of them are privately-owned. In these watersheds protection efforts based on government wetland conservation policies and on voluntary participation in incentive based preservation programs have not been successful.

Farming pressures, to increase cultivated area and to reduce travel obstacles in conjunction with improvements in drainage technology, will facilitate the additional loss of wetlands. Wetlands and their functions will become completely removed from ever larger portions of Manitoba's intensively used agricultural area.

If representative wetland environments, and their flora and fauna, are to be saved in all portions of Manitoba a more active approach to their preservation is required in Agro-Manitoba.

Wetlands may be the last preserve of some natural species in extensively developed areas where the most isolated ones remain. Flora and fauna inventories should be completed in these areas to ensure full knowledge of their worth before they are lost completely.

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APPENDIX "A"

Forest Inventory and Selected Wetland Cover Types

Forest Inventory and Selected Wetland Cover Types

The following reviews the description of the forest inventory land and water cover types and identifies the 16 covers selected to represent wetlands in this inventory. The forest inventory classified land and water cover throughout the province. The classification system was designed to focus on the evaluation of forestry production potential. All land area was classified into three groups; productive forest, non-productive forest and non-forested. Wetland covers were selected from the 44 cover types in the later two groups and from the water covered area which was classified into 7 types. Table 1 displays the classification used in the forest inventory.

The Forested Productive land group was defined as "all forest land capable of producing merchantable wood regardless of the existing stage of productivity". This group was further classified based on stand species, composition, age, size, etc.. No forested productive land was considered wetland.

The Forested Non-Productive land group was defined as "all forest land not capable of producing merchantable timber due to very low productivity". This group was classified into four categories; Treed Muskeg, Treed Rock, Wilow/Alder and Protection Forest which were subdivided into 16 cover types. Wetland covers were selected from the Treed Muskeg and the Willow/Alder categories as itemized in the following.

Table 1
Forest Inventory Land and Water Classification

Area	Group	Category	Type
Land	Forested Productive	Softwood Softwood-Hardwood Mixedwood Hardwood-Softwood Mixedwood Hardwood	
	Forested Non-Productive	Treed Muskeg	Black Spruce Treed Muskeg Tamarack Larch Treed Muskeg Eastern Cedar Treed Muskeg Taiga (Northern Transition Forest)
		Treed Rock	Jack Pine Treed Rock Black Spruce Treed Rock Hardwood Treed Rock
		Willow/Alder	Willow Alder Dwarf Birch Shrub Shrub/Prairie
		Protection Forest	Recreational Sites Small Islands Precipitous Slopes/Fragile Sites Shelter Belts
	Non-Forested	Barren-Bare Rock	Barren-Tundra Bare Rock-Igneous Bare Rock-Sedimentary Open Sand Dunes
		Fields (Agriculture)	Hayland Cropland Pastureland Land Clearing Abandon Land
		Meadow	Dry Upland Ridge Prairie Moist Prairie Wet Meadow Sand Prairie
		Marsh Muskeg	Muskeg String Bogs Marsh Mud/Salt Flats Sand Beaches
		Unclassified	Townsites/Residential Sites Airstrips Roads/Railroads Transmission Lines/ Pipelines Gravel Pits/Mine Sites Fence Lines (Community Pastures) Drainage Ditches Beaver Flood Dugouts/Water Holes Oil Fields
Water			Water Rivers Lake Winnipeg Lake Manitoba Lake Winnipegosis Red River Assiniboine River

The Treed Muskeg category was defined as "similar to open muskeg, except that the area is supporting semi-stagnated or stagnated trees. Some of the trees will produce "Christmas" trees or fence posts, but will not produce pulpwood size trees within a rotation age of 140 years (9.0+ cm d.b.h., height over 10.0m and 20 m^3 of net merchantable volume per hectare). At least 10 % of the area will be tree covered". This category was classified into four cover types based on tree species; Black Spruce Treed Muskeg, Tamarack Larch Treed Muskeg, Eastern Cedar Treed Muskeg and Taiga (Northern Transition Forest). Only Black Spruce, Tamarack Larch and Eastern Cedar cover types are found in the study area and they were considered wetlands.

The Treed Rock category was defined as "Rock with a very shallow soil, supporting semi-stagnated or stagnated trees. At least 26 % of the area will be tree covered. These sites do not produce merchantable stands". This category was classified into three cover types based on tree species; Jack Pine Treed Rock, Black Spruce Treed Rock and Hardwood Treed Rock. None of these cover types were considered wetlands.

The Willow/Alder category was defined as "Low lying area with a saturated water table presently supporting willow or alder growth. Without improvements these sites are not capable of producing merchantable timber stands. A least 51 % of the area must be shrub covered". This category was

classified into five cover types based on type of shrub cover; Willow, Alder, Dwarf Birch, Shrub and Shrub/Prairie. Initially all five types were considered wetland but ground truthing found the Shrub/Prairie cover type to be a relatively dry environment and it was not included. Willow, Alder, Dwarf Birch and Shrub cover types were considered wetlands.

The Protection Forest category was defined as "presently developed or preserved recreational areas and small islands less than two hectares". This category was classified into four types; Recreational sites, Small Islands, Precipitous slopes/ Fragile sites and Shelter Belts. None of this category was considered wetland.

The Non-Forested land group was defined as "includes areas withdrawn from timber production for a long period of time, such as cultivated fields, hay meadows, pastures, settlements, rights of way, gravel pits, beaches, wide ditches, summer resorts, bare rock, barren, mines, marsh and muskeg". This group was classified into five categories; Barren-Bare Rock, Fields (agriculture), Meadow, Marsh Muskeg and Unclassified which were subdivided into 28 cover types. Wetland covers were selected from the Meadow, Marsh Muskeg and Unclassified categories as itemized in the following.

The Barren-Bare Rock category was defined as "Tundra and rock with less than 25 % tree cover". This category was classified into four cover types; Barren-Tundra, Bare Rock-Igneous, Bare Rock-Sedimentary and

Open Sand Dunes. None of these cover types were considered wetlands.

The Fields (Agriculture) category was defined as "Areas of private and leased land cleared of tree cover and presently under an agriculture use. Less than 10 % of the area will be tree covered". This category was classified into five cover types; Hayland (cultivated), Cropland (cultivated), Pastureland (Domestic animals), Land clearing in progress and Abandoned cultivated land. None of these cover types were considered wetlands.

The Meadow category was defined as "Moist to wet grassland suitable for hay production (natural hay land), at least 51 % of the area is covered by grass". This category was classified into four cover types; Dry Upland Ridge Prairie, Moist Prairie, Wet Meadow and Sand Prairie. Only the Wet Meadow cover type was considered wetland.

The Marsh-Muskeg category was not defined. This category was classified into five cover types; Muskeg, String Bogs, Marsh, Mud/Salt Flats and Sand Beaches. The Muskeg cover type was defined as "Wetland which has a vegetative cover consisting mainly of sphagnum moss and heath plants with very scattered brush. Black Spruce, Tamarack or Cedar cover does not exceed 10 %". The Marsh cover type was defined as "Wetland completely or partially covered with tall grass, rushes or sedges, unsuitable for hay but can be used as a habitat for furbearing animals". All five of the cover types in this category were considered wetlands.

The Unclassified category was not defined. This category was

classified into ten cover types; Townsites/Residential Sites, Airstrips, Roads/Railroads, Transmission Lines/Pipelines, Gravel Pits/Mine Sites, Fence Lines (Community Pastures) fireguards, Drainage Ditches, Beaver Flood, Dugouts/Water holes and Oil Fields (oil wells, all structures pertaining to). Only the Beaver Flood cover type was considered wetland area.

Water was defined as "Includes Lakes and Rivers, measured at the high water mark, able to be delineated with a double line on the aerial photographs. Narrow rivers and creeks marked by a single line are not to be considered as separate types, nor as type boundaries". This category was classified into seven cover types; Water, Rivers, Lake Winnipeg, Lake Manitoba, Lake Winnipegosis, Red River and Assiniboine River. In practice rivers less than 10 meters wide were to narrow to register on the origonal 1:15,840 scale mapping as river cover type. Areas of open water, often found within marsh or wet meadow cover types, absent of grass, rushes or sedges and with a minimum dimension greater than 40 meters were also classified as water. The Water and Rivers cover types were considered wetlands.

The large lakes in the study area were identified separately by the forest inventory and were not selected to represent wetlands (Lake Winnipeg, Lake Manitoba and Lake Winnipegosis). Dauphin Lake and Swan Lake and Lake of the Prairies were removed separately from the township data. All other smaller and shallower lakes and waterbodies are included

within the water cover type. Some examples of the larger of such included lakes are; Clear Lake in watershed AR06, Oak Lake in AR05, Whitewater Lake in AR03, Rock Lake in RR09, the Shoal Lakes in LM02 and Whitemouth Lake in WR02.