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Summary of Resources and Land Use Issues Related to Riparian Areas in the Lower Red River Watershed Study Area

Agriculture and Agri-Food Canada - Prairie Farm Rehabilitation Administration
(AAFC-PFRA)
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Manitoba Rural Adaptation Council Inc.
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Preface

This report is one of a series of watershed summary reports completed for the Agriculture Environmental Sustainable Initiative's Riparian Areas: Planning and Priority Setting project. Due to scale and data accuracy limitations, these reports do not replace the need for site-specific analysis; rather, they serve as a generalized guide for overall planning purposes on a watershed basis. These reports are available in .pdf format on the Manitoba Riparian Health Council's website (www.riparianhealth.ca), or can be obtained by contacting:

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Background

Riparian areas play an important role in surface water quality and their ability to carry out this function can be affected by anthropogenic activities on the landscape. Agriculture is only one component, with other human activities such as industry, recreation and residences contributing to degraded riparian areas. The intent of this report is to be a first step towards addressing the issue of riparian health, with respect to agriculture, in the watershed study area. By providing information on the land resources and the agricultural activities in the study area, a better understanding of the issue can be obtained which will assist towards better planning and priority setting by local decision makers, land use planners and policy decision-makers. While this reports studies the agricultural aspect of the watershed study area, in a true watershed study, all factors of activities of all sectors must be considered.

This project is a component of the Agriculture and Agri-Food Canada – Prairie Farm Rehabilitation Administration (AAFC-PFRA) Agricultural Riparian Areas: Planning and Performance Monitoring project. Funding was provided by the Manitoba Rural Adaptation Council (MRAC), through the Agricultural Environmental Stewardship Initiative (AESI). The purpose of this project is to provide a central source of riparian-related resource information in a format that is easily accessible to land use planners and policy decision-makers. The information provided can assist in strategic planning for riparian areas in Manitoba. Through the identification of potential problem areas, decision makers can make informed land use decisions that target priority areas.

As part of the Agricultural Riparian Areas: Planning and Performance Monitoring project, AAFC-PFRA has collected, analyzed, and displayed riparian-related data using an Internet Map Server (IMS). The IMS web server is designed to be a one-stop source of riparian-related data and information relevant for analysis, land-use planning, and program design. The IMS site is available under the tools menu on the Riparian Health Council website (*www.riparianhealth.ca*).

The Riparian Health Council (RHC) is comprised of government and non-government agencies with an interest in increasing producer involvement and improving the coordination of cooperative efforts among agencies that develop riparian projects with landowners throughout Manitoba. The Council has developed a vision for cooperative programming that enhances riparian areas and surface water quality across agro-Manitoba while also supporting landowner needs. This project will provide information which can assist the RHC in achieving its vision.

The boundaries used in this report are based on the watershed layer produced by a joint venture between Manitoba Conservation and AAFC-PFRA. For reporting purposes, water flow direction data was used to amalgamate individual sub-watershed units into larger sub-watershed and watershed groups (refer to Appendix D). Due to scale and data accuracy limitations, neither this report nor the information and data provided on the RHC website can replace the need for site-specific analysis. However, these information sources can serve as a guide for general watershed planning purposes.

Importance of Riparian Areas

Although riparian areas occupy only a small percentage of the area of a watershed, they represent an extremely important component of the overall landscape. They are the transitional areas between the aquatic and surrounding upland area. These "green zones" are one of the most ecologically diverse ecosystems. A healthy riparian area can perform a number of ecological functions, including trapping sediment, building and maintaining streambanks, storing floodwater and energy, recharging groundwater, filtering and buffering water, reducing and dissipating stream energy, maintaining biodiversity and creating primary productivity. These functions are essential for sustaining a majority of fish and wildlife species, maintaining functioning watersheds, providing good water quality, forage for livestock and supporting people on the landscape. Disturbance and alteration of a riparian area will impact its ability to carry out these ecological functions. Impacted riparian areas will have a reduced capacity to trap and store sediment and nutrients and stabilizing streambanks (important for surface water quality), provide fish and wildlife habitat, etc.

Recognizing that many sectors contribute to the alteration of riparian areas, including agriculture, recreation, urban and residential development, and forestry, this report will focus on the agricultural impacts to riparian areas in an attempt to provide information that can be used by the agricultural industry to begin to address the issue of riparian health.

Watershed Overview

The Red River is an international waterway, with its headwaters at the convergence of the Ottertail and Boise de Sioux Rivers near Wahpeton, North Dakota. From its origin the river flows north in a relatively straight line, emptying into Lake Winnipeg. The Red River Watershed occupies a large area, of which approximately 20% lies in Manitoba, with the remaining area shared by North Dakota, Minnesota and a small portion of South Dakota. This reports deals with the Manitoba portion. To make the Manitoba portion more manageable, and the analysis and reports more relevant to local landscape and land uses, the watershed was divided into two reporting areas: the Upper and Lower Red River Watershed study areas.

The Lower Red River Watershed study area is approximately 419,539 ha in size and is comprised of five sub-watershed units (refer to Figure 1.0). The watershed drains into the Red River, which enters this watershed area in the City of Winnipeg. The river meanders its way north to spill into Lake Winnipeg. Several lakes are located in the northern portion of this watershed area near the river convergence with Lake Winnipeg, and include Netley Lake, Lower and Upper Devils Lakes, Morrison, Poplar Point and Hardmans Lake. There are also many creeks draining the land in this watershed, including Devils, Netley and Cooks Creeks. Cooks Creek is considered a significant tributary and empties into the Red River at Selkirk. During periods of high water, the flow from its upper reaches is diverted west into the Red River Floodway via the Cooks Creek Diversion. Much of the creek has also been dredged for additional flood control and agricultural purposes. Other features include Oak Hammock Marsh, located northeast of Stonewall, and the Red River Floodway which diverts flood waters on the Red River around Winnipeg, meeting back up with the Red River at Lockport. In addition to the tributary creeks and lakes, this watershed contains some drainage ditches, and many lakes and intermittent waterbodies.

Being a main waterway in southern Manitoba, there are many rivers and their associated watershed areas, contributing to the Red River. Many of these major rivers converge with the Red upstream of this watershed, in the Upper Red River Watershed area, and include the Pembina, Morris, La Salle, Assiniboine and Seine Rivers. All of these rivers and their basins are considered in separate watershed reports.

Elevation in the study area ranges from 212 metres above sea level (masl) in the northern portion of the watershed, up to 316 masl at the eastern tip of the watershed (refer to Figure 2.0). This watershed has a higher elevation in the eastern and western regions, and forms a valley towards centre. The Birds Hill region, north of West Pine Ridge, contains gentle slopes and reaches an elevation of 274 masl, which is about 40 metres higher than the surrounding area. An area of lower elevation is also seen directly adjacent to the Red River.

At the time of this report, part of the watershed area was served by the Cooks Creek Conservation District. This conservation district is located in the south-eastern portion of the watershed and covers the drainage area of Cooks Creek. The remaining land base is not covered by any conservation districts. Fourteen Rural Municipalities (RMs) are contained within the watershed boundaries and include Rockwood, St. Andrews, Brokenhead, Tache, West and East St. Paul, Springfield, and St. Clements (refer to Figure 3). Birds Hill Provincial Park covers approximately 3,513 ha and is popular for biking, cross-country skiing, camping and the internationally known Winnipeg Folk Festival. Oak Hammock Marsh is popular for viewing waterfowl and natural landscapes, as well as hiking and biking. Although a large part of the population in the watershed is urban due to the presence of the City of Winnipeg, the land base in the study area is predominantly rural and farm-based; however, there is an influx of population, desiring larger living spaces, moving into the RM of West and East St. Paul. This is resulting in an increase in residential sub-divisions, the expansion of low density rural residences and urban settlements, and a rise in small farm holdings. This has shifted some land use in the area away from general agriculture. The RMs of St. Andrews and St. Clements experience a population increase during the summer months with the arrival of cottagers attracted to the water-based recreational activities associated with Lake Winnipeg and other lakes and rivers of the region. Larger towns/communities within the watershed include Teulon, Stonewall, Selkirk, Oakbank, Dugald and the City of Winnipeg. Some of the communities close to Winnipeg serve as bedroom communities to Winnipeg. River properties are common within this watershed, with a large number of residences present along the Red River.

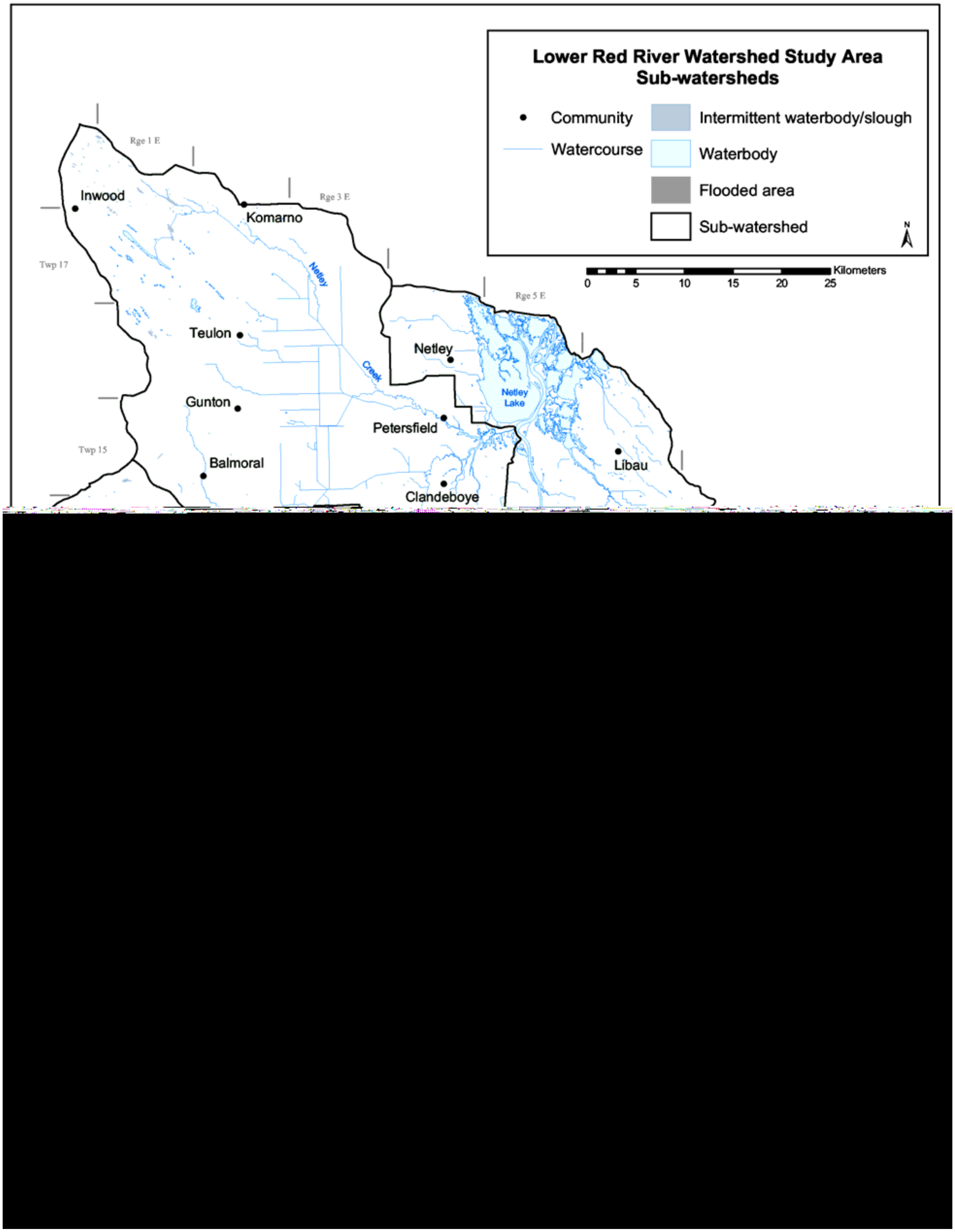

Figure 1.0 Sub-watersheds within the Lower Red River Watershed study area (water shown at 1:50,000 scale)

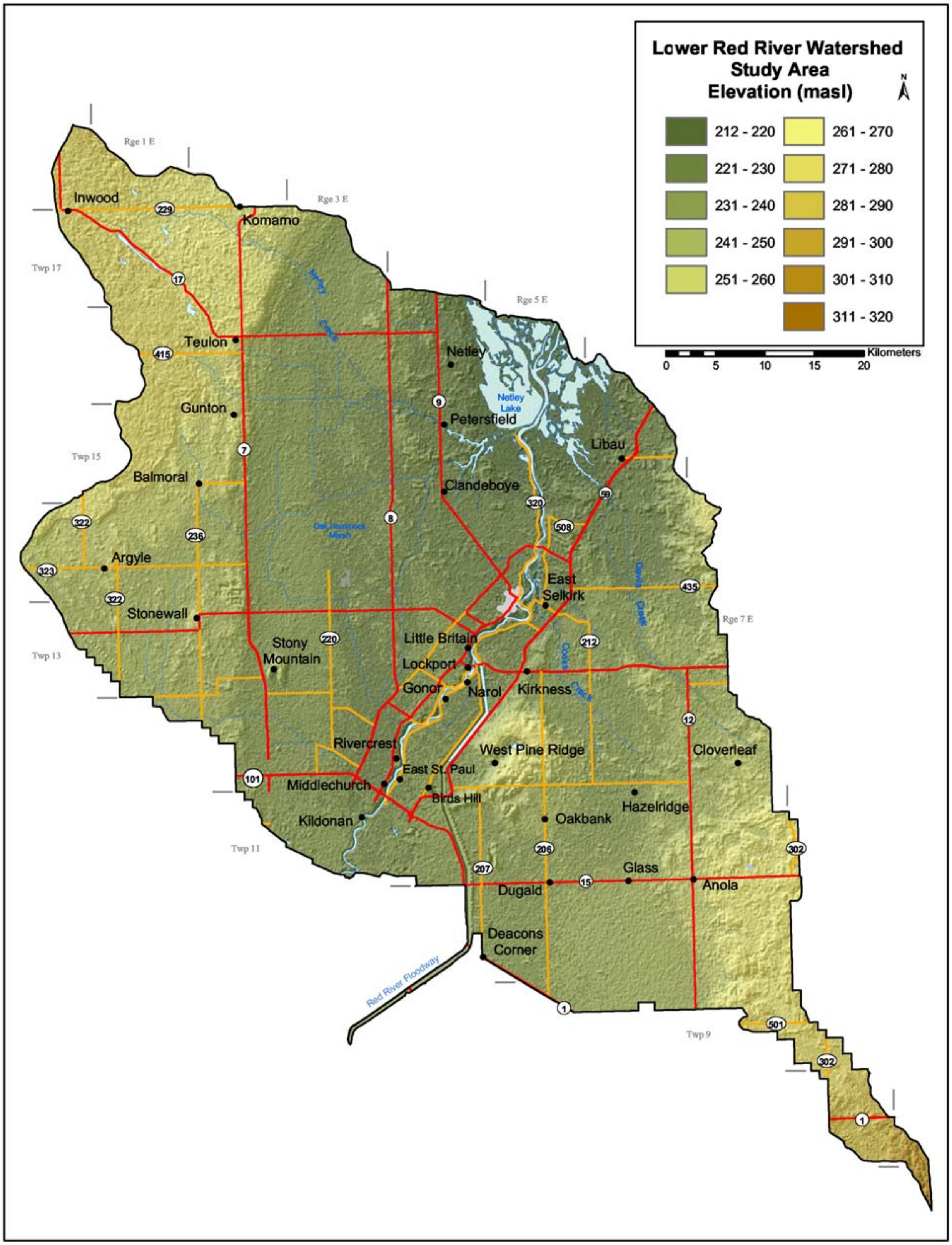

Figure 2.0 Digital elevation model of the Lower Red River Watershed study area (radar image was obtained by the Shuttle Radar Topography Mission, 2000)

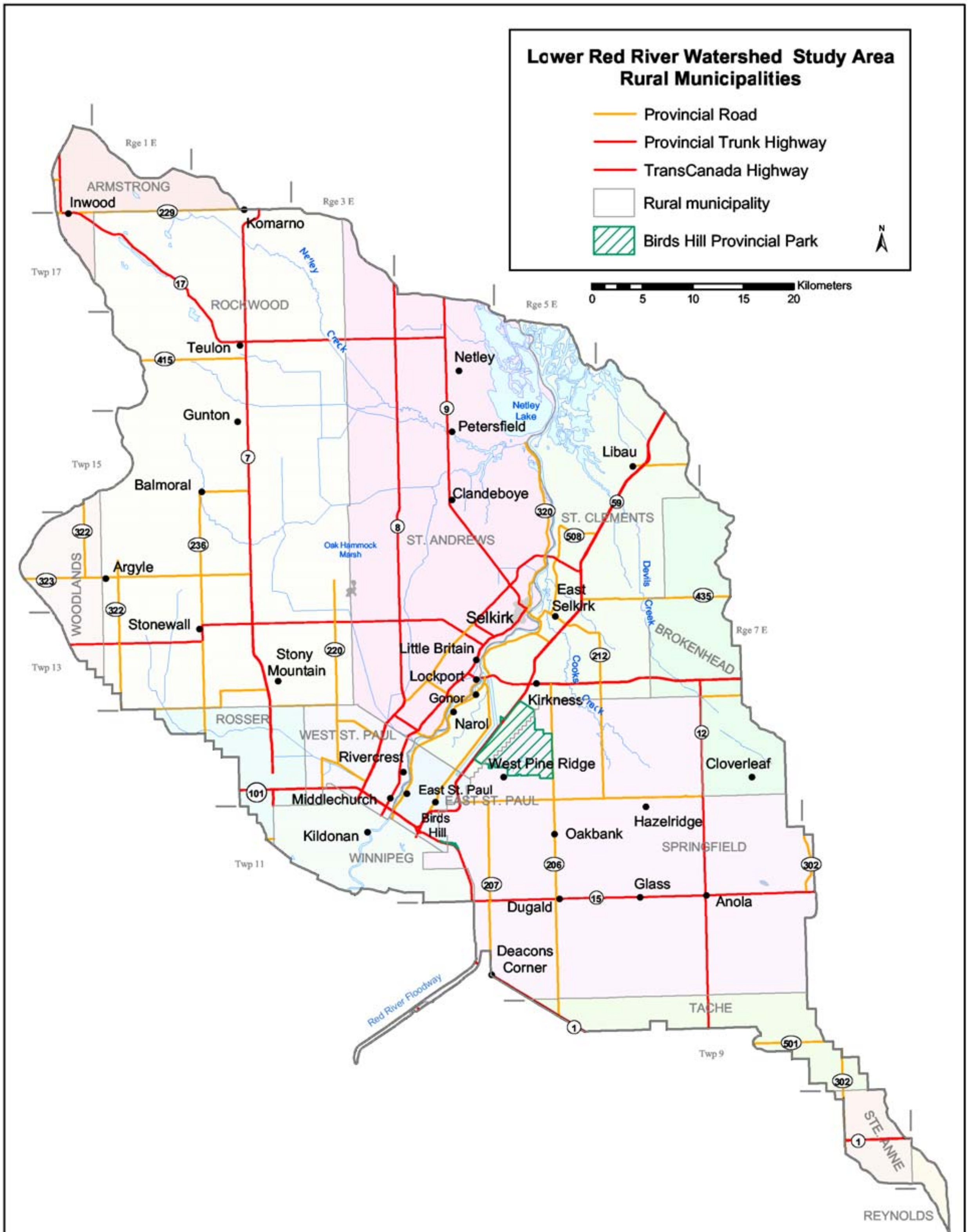

Figure 3.0 Rural municipalities in the Lower Red River Watershed study area

Climate and Ecology

The Canadian Ecological Land Classification System divides Canada's natural landscapes into terrestrial ecozones, which are further sub-divided into ecoregions and ecodistricts. The classification system was developed by integrating surface vegetation cover, underlying geology, physiography, soils, and climate data (Smith et al. 1998).

Ecozones, the most generalized level in Environment Canada's ecological land classification system, are defined by Smith et al. (1998) as "areas of the earth's surface representative of very generalized ecological units that consist of a distinctive assemblage of physical and biological characteristics". Ecoregions are broad, integrated map units characterized by a unique combination of landscape physiography and ecoclimate. Ecodistricts are integrated map units characterized by relatively homogeneous physical landscape and climatic conditions and they contain Soil Landscapes of Canada polygons nested within them (Smith et al. 1998).

Based on the Terrestrial Ecozones of Canada (Smith et al. 1998), the southern and south-western part of the Lower Red River Watershed study area falls within the Prairies Ecozone, and contains the Lake Manitoba Plain Ecoregion (which further contains the Winnipeg and Lundar Ecodistricts) (refer to Table 1.0, Figure 4.0). Moving from the north-western region to the north-eastern region, the watershed falls within the Boreal Plains Ecozone, and contains the Interlake Plain Ecoregion (which is further subdivided into the Ashern, Gimli and Steinbach Ecodistricts). A small portion of the Boreal Shield Ecozone, containing the Lake of the Woods Ecoregion (further containing the Stead Ecodistrict) is found in the south-eastern tip of the study area.

The vegetation of the area varies based on moisture and elevation, as well as other ecoregion characteristics. Much of the natural vegetation has been cleared for agriculture and development of drainage ditches, however some has survived in poorly-drained depressions and on yet to be broken land (Smith et al. 1998). Some areas of the Ashern Ecodistrict have also reverted to their original shrub vegetation. The Interlake Plain Ecoregion consists of forest stands dominated by trembling aspen, with some balsam poplar and white spruce interspersed. White spruce distribution is greatly affected by forest fires. Poorly drained areas contain willow, sedge and meadow grass vegetation. The Ashern Ecodistrict contains black spruce, tamarack, swamp birch, willow, sedge, mosses, herbs and forbs in its bogs and peatlands; while the Gimli Ecodistrict contains marshes characterized by reeds, cattails and sedges. The vegetation of the Birds Hill region reflects a somewhat higher elevation, where deciduous trees are still present; however more white spruce, tamarack, white cedar, and peatlands with black spruce are present. The Steinbach Ecodistrict contains forest species such as willow, red-osier dogwood and jack pine on well-drained sties. Tree cover has survived better in the Winnipeg Ecodistrict, and grows naturally as a fringe along stream channels. Better drained sites of this ecodistrict contain bur oak, trembling aspen, and an undergrowth of snowberry, hazelnut, and red-osier dogwood while shrubs such as saskatoon and high bush cranberry are found on floodplains and in high areas. Along rivers, especially the Red River, and alluvial flood plain deposits are Manitoba maple, green ash, basswood, elm and cottonwood, with an undergrowth of willows and ferns dominate, indicating periodic inundation.

Despite weather similarities within the watershed, localized temperature and precipitation variations exist. Based on climate data for the ecoregions within the Lower Red River Watershed study area, mean annual precipitation ranges from 485 to 530 mm, while mean annual temperature ranges from 1.2 to 2. °C (refer to Table 1.0). The average number of growing season days ranges from 175 to 184 and the average number of growing degree days from 1500 to 1720. Mean annual moisture deficit ranges between 90 to 250 mm (Ecoregions Working Group 1989). These parameters provide an indication of moisture and heat energy available for crop and vegetation growth and generally are sufficient for good growth of a wide range of crops adapted to the prairies.

Table 1.0 Climate data for ecoregions within the Lower Red River Watershed study area

Ecozone	Ecoregion	Mean Annual Air Temp (°C)	Mean Growing Season (days)	Mean Growing Degree Days	Mean Annual Precipitation (mm)	Mean Annual Moisture Deficit (mm)
Boreal Plains	***Interlake Plain***	1.2-2.4	175-184	1500-1700	510-520	100-250
Boreal Shield	***Lake of the Woods***	1.9	180	1600	530	90
Prairies	***Lake Manitoba Plain***	2.2-2.4	181-183	1670-1720	485-515	190-200

Note: Climate data is based on eco-climatic data (Ecoregions Working Group, 1989)

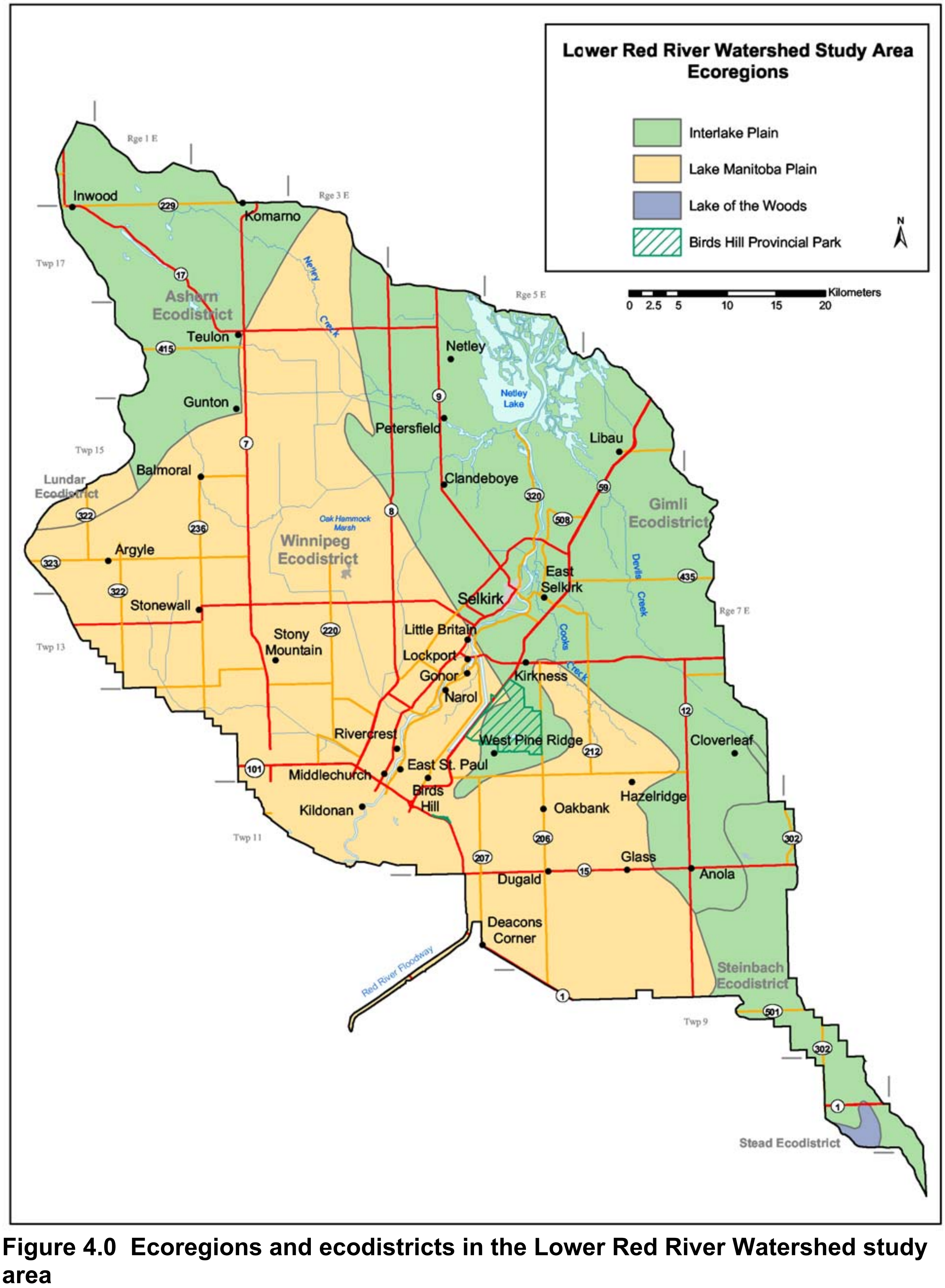

Figure 4.0 Ecoregions and ecodistricts in the Lower Red River Watershed study area

Water Resources

Hydrology

The Lower Red River Watershed study area is part of the larger Red River Basin. Water within this study area drains into the Red River and is fed by numerous rivers (draining other watershed areas), creeks, lakes, ditches, and sloughs. The river meanders north from central Winnipeg, through small communities, agricultural land, and residential and cottage areas. Based on the 1:50,000 National Topographic Series (NTS) data sheets, this watershed contains approximately 2,749 km of river and stream shoreline (both sides of the waterways are included in the calculation), and 1,034 km of waterbody shoreline.

Hydrometric gauging stations within the province provide surface water level and stream-flow data used for the operation of water control works, flood forecasting, water management investigations, and hydrologic studies (Manitoba Conservation 2003). A network of seventeen hydrometric gauging stations have been installed within this watershed (refer to Figure 5.0). For the purpose of this report, mean annual flow rate out of the watershed has been examined, as measured by three gauging stations. The three stations used were: gauging station 05OJ010, located 9 km upstream of Lockport, station 05OJ019, located below the Cooks Creek Diversion, and station 05OJ020, located in the Cooks Creek Diversion channel. Table 2.0 depicts the mean annual monthly flows from these stations over the years. Spring discharge, along with spring and summer rain events, create higher flow rates from April through to August, with the peak flow generally occurring in April.

Table 2.0 Mean stream flow on the Lower Red River Watershed study area as recorded by hydrometric station 05OJ010, located 9 km upstream of Lockport, MB (1962-2002), station 05OJ019, below the Cooks Creek Diversion (1990-2003), and station 05OJ020, in the Cooks Creek Diversion (1990-2003).

Monthly Discharge (m^3/s)													
Station No.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan-Dec
05OJ010	57	53.9	147	778	666	361	297	158	116	107	102	69.5	242
05OJ019	--	--	0.28	1.38	1.12	0.43	0.30	0.32	0.15	0.17	--	--	0.92
05OJ020	--	--	0.43	1.55	1.05	0.14	0.22	0.56	0.20	0.22	--	--	1.01

Water Quality

Nutrient loading is an important concern with many large and small streams throughout Manitoba. As a result, Manitoba Conservation has developed a long-term nutrient management strategy for surface waters in Manitoba. A comprehensive trend analysis using existing water quality data has been done to detect temporal trends in nutrient concentrations in the streams and rivers in Manitoba (Jones and Armstrong 2001). Along with this, studies by Bourne et al. (2002) reveal trends and concerns in nutrient loading along the Red River.

Long term water quality monitoring data are available from various sampling stations in this watershed, and for this report, stations on the Red River and on Cooks Creek will be analyzed. The water quality stations on the tributary of Cooks Creek, together with summed flow data from hydrometric stations 05OJ019 and 05OJ020, found some notable results. From station WQ0644, Jones and Armstrong (2001) found a significant trend of decreasing Total Nitrogen (TN) concentrations during the 1990s, while Total Phosphorus (TP) fluctuated but did not exhibit any significant trend. Station WQ0643, in the downstream portion of the creek, did not detect significant trends in either nutrient. The decreasing trend at the upstream site with no detectable trend downstream implied that TN loading declined in the upper portions of the creek, but remained constant in downstream reaches.

Along the Red River, water quality monitoring data from station WQ0142, located downstream of Winnipeg, near Selkirk, along with flow data from hydrometric station 05OJ010, showed that from 1978 to 1999 time period, flow adjusted TN median concentrations increased dramatically over the 22-year period, by almost 60%, and TP median concentrations were also found to increase by almost 30%. It should also be noted that water quality monitoring data from stations upstream, in the Upper Red River Watershed study area, found increases in TN and TP concentrations, although less drastic. At the station near the US border crossing TP was found to increase by 23%, and just upstream of Winnipeg TN was found to increase by 29%, with no significant increases in TP. Comparison of these trends suggests that as the river passed through the Winnipeg region the concentration of nutrients increased. The increases seen in this watershed are likely due to a combination of contributions. Nutrient contributions from significant tributaries such as the La Salle, Assiniboine and Seine Rivers, which occur downstream of the south Winnipeg water quality station, are likely large donors. Other contributions would include the numerous creeks and drainage ditches present in this watershed and inputs from runoff and treated effluent discharges from Winnipeg and surrounding municipalities.

The majority of land in the Lower Red River Watershed study area is used agriculturally, and there is the potential for nutrient loading into the river system from agricultural operations. Cooks Creek sub-watershed contains mostly forest at the creek's headwaters near Richer, however intense cultivation and production occurs in the rest of the area. Major point sources of nutrient loading include effluent discharges from the City of Winnipeg. As well, smaller communities in the watershed area discharge secondary effluent into the river or one of its tributaries. It should also be noted that during periods of high water, flow from the upper reaches of Cooks Creek are diverted westward to the Red River Floodway, eventually emptying into the Red River at Lockport, rather than Selkirk.

Bourne et al. (2002) studied the rates of accrual of TN and TP on the Red River between reaches, and found the mean rates of accrual were usually higher between St. Norbert and Selkirk, as opposed to between Emerson and St. Norbert. It should be noted that in some years this trend was reversed. This trend reinforces the fact that nutrient loads from the City of Winnipeg and contributions from tributaries such as the

Seine and Assiniboine Rivers, are increasing the nutrient concentrations along the downstream portions of the Red River.

A study by Bourne et al. (2002), looking at TN and TP loading into Manitoba streams, summarized loading into the Red River watershed as a whole. Nutrient loads from within-stream processes were distinguished from watershed processes load. Within-stream processes included direct effluent discharge, release from stream bed and bank sediments, and infiltration of groundwater. For the purpose of their report, only direct effluent discharge was considered for the within-stream processes. Watershed processes loads are less direct and include the transport of nutrients from land to water from sources such as animal manure and inorganic fertilizer, and depend on soil type, vegetation present, and land-use practices. Analysis determined that within-stream processes contributed 4,176 tonnes/year of TN, and 470 t/y of TP. The study indicates watershed processes load were harder to quantify, and were found to range from 1,582 and 14,628 t/y for TN and 538 and 2,127 t/y for TP. This is a mean of 7,229 and 1,209 for TN and TP, respectively, and based on these means, suggests that watershed processes contribute to a substantial amount more nutrient loading.

Bourne et al. (2002) also looked directly at TN and TP contributions to the Red River from major tributaries, upstream of this watershed. They found nutrient loads from tributary rivers such as LaSalle, Assiniboine, Roseau, Rat and Pembina accounted for a range of 0.3% to 12% of the TN and TP loads into the Red River in 2001. The Assiniboine River was consistently found to be the largest single contributor of TN and TP loads into the river between the years of 1994 and 2001. The Red River itself was found to be the single largest contributor of TN and TP to Lake Winnipeg, over the 1994 to 2001 period. Nutrient loading and concentrations have been studied in further detail for many of these rivers and associated watersheds, where results have been described in other watershed reports. These reports show a variety of results, including increases, decreases and potential concerns regarding nutrient loading and concentrations, and should be consulted if further information is desired.

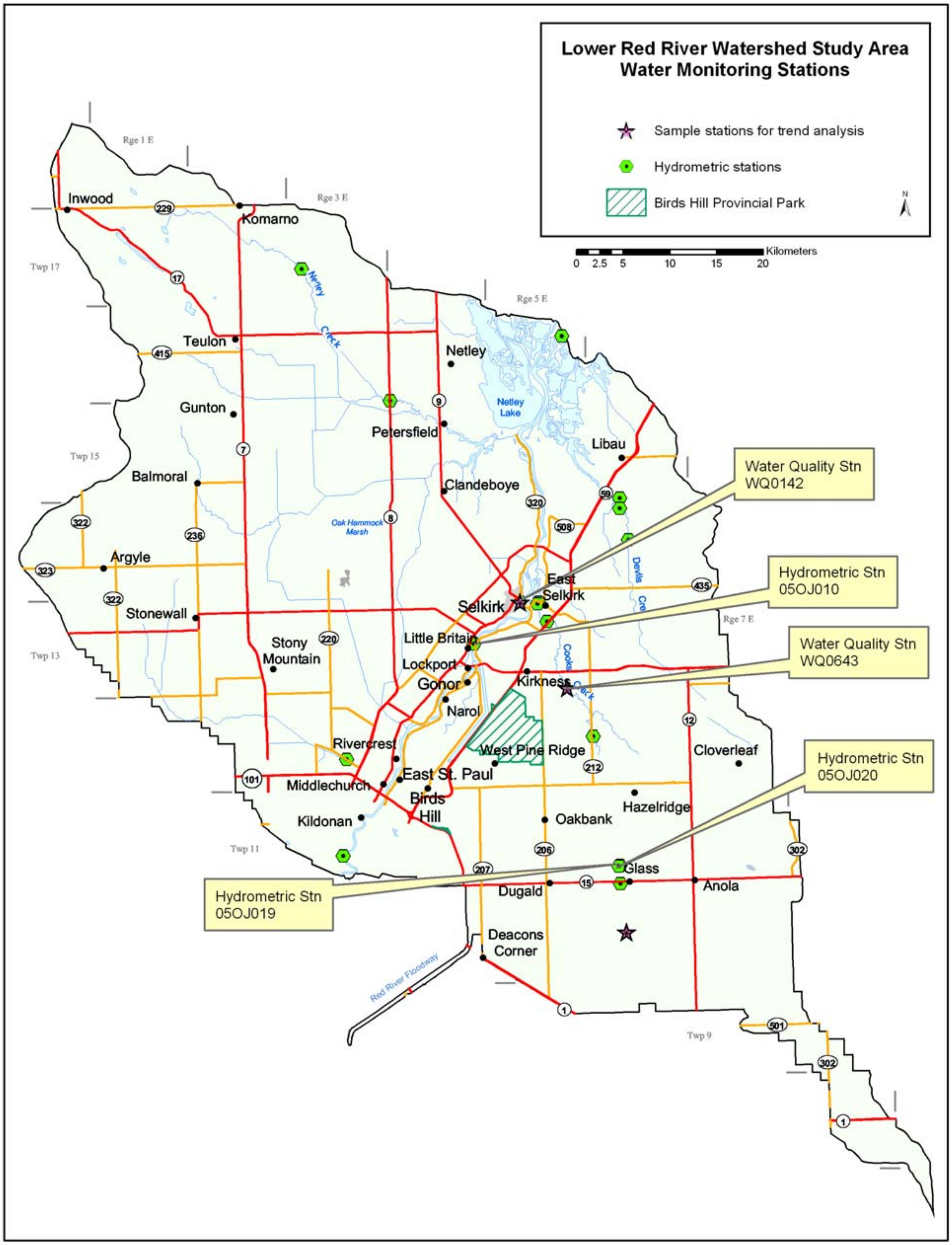

Figure 5.0 Hydrometric gauging and water quality sampling stations in the Lower Red River Watershed

Land Cover

The land cover classification of the watershed has been interpreted from LANDSAT satellite imagery (which has a 30 metre resolution), using computerized classification techniques. Individual spectral signatures were classified and grouped into the seven land cover classes: annual crop land, forage, grassland, trees, wetlands, water, urban and transportation (refer to Appendix A for land cover class descriptions). Figure 6.0 provides a general representation of the 2000 land cover within the watershed (note that the southwestern part of the watershed was analyzed using imagery taken September 3, 2001, the northern section with imagery taken on August 2, 2001, and the central/ southeastern sections with imagery taken on September 28, 2001).

Land use in the watershed is primarily agriculture. Based on 2001 land cover data, approximately 45% (187,480 ha) of the land within this watershed area was classified as annual crop land, most of which is located central portion of the watershed (refer to Table 3.0, Figure 6.0). Grasslands and trees also cover a large amount of land in this watershed and are found in the south-eastern and north-western tips, as well as in Birds Hill Provincial Park. Grassland is also found along the banks of the Red River. Urban and transportation land uses (i.e. infrastructure for urban, transport and recreation) cover almost 7% of the land in this watershed, and are mostly found in the Winnipeg and Selkirk areas, as well as areas between the two urban centres along the Red River.

Land cover information is also available from 1994 satellite imagery taken October 26, 1994 for the northern and south-western part of the watershed and with imagery taken on September 17, 1994 for the central/south-eastern sections) (refer to Figure 7.0). Comparison between the two datasets can result in the emergence of general trends in land cover of the seven-year period, though this will be a rough estimate due to factors such as time/season of satellite image capture, climatic variability and classification requirements.

Over the seven-year period, there was a substantial change in forage cover with a 51% increase in land converted to forages (refer to Table 3.0). Annual crop land had decreased by about 12%, likely converted to forages. Grasslands and trees had both increased over the period, by 18% and 10%, respectively. Wetlands also decreased by roughly 16%, possibly drained or converted for other land uses. Wetland classifications showed slight increases despite the fact that records from Environment Canada indicate that total precipitation in 2001 at Winnipeg was less than 1994 by approximately 138 mm. Wetland and open water classifications may be slightly over estimated due to the fact that the 1994 image classification concentrated specifically on annual cropland to aid in delivery of the Western Grains Transportation Payment Program. Greater attention was paid to all classification categories on the 2001 image classification.

Due to the small size, and tightly integrated nature of wetlands with other land cover categories such as grasslands and shrubs, they can be very difficult to quantify using course resolution imagery. A Prairie Habitat Joint Venture Habitat Monitoring Program coordinated by the Canadian Wildlife Service provides a detailed evaluation of wetland habitat trends in targeted areas of the prairies. Preliminary analysis indicated that in the targeted areas in Manitoba, there has been a net change of -3.0% in wetland areas from 1985 to circa 2000.

Table 3.0 Land cover (2001) and general trend over a seven-year period (1994 – 2001) in the Lower Red River Watershed study area

Class	Area[1] (ha)	Percent of Study Area	Change in Area (ha)	Percent Change Since 1994[2]
Annual Crop Land	187,480	44.7	-26,497	-12.4
Trees	62,826	15.0	5,696	10.0
Water	13,810	3.3	945	7.4
Grassland	96,191	22.9	14,960	18.4
Wetlands	14,497	3.5	-2,744[3]	-15.9[3]
Forages	17,675	4.2	5,943	50.7
Urban/Transportation	27,063	6.5	1,706	6.7
Total	419,542	100	--	--

1. Area totals are approximate due to the nature of the image analysis procedure
2. Negative changes indicate area has decreased since 1994, positive indicates an increase.
3. Due to seasonal changes in wetland size, date of imagery will affect change calculations

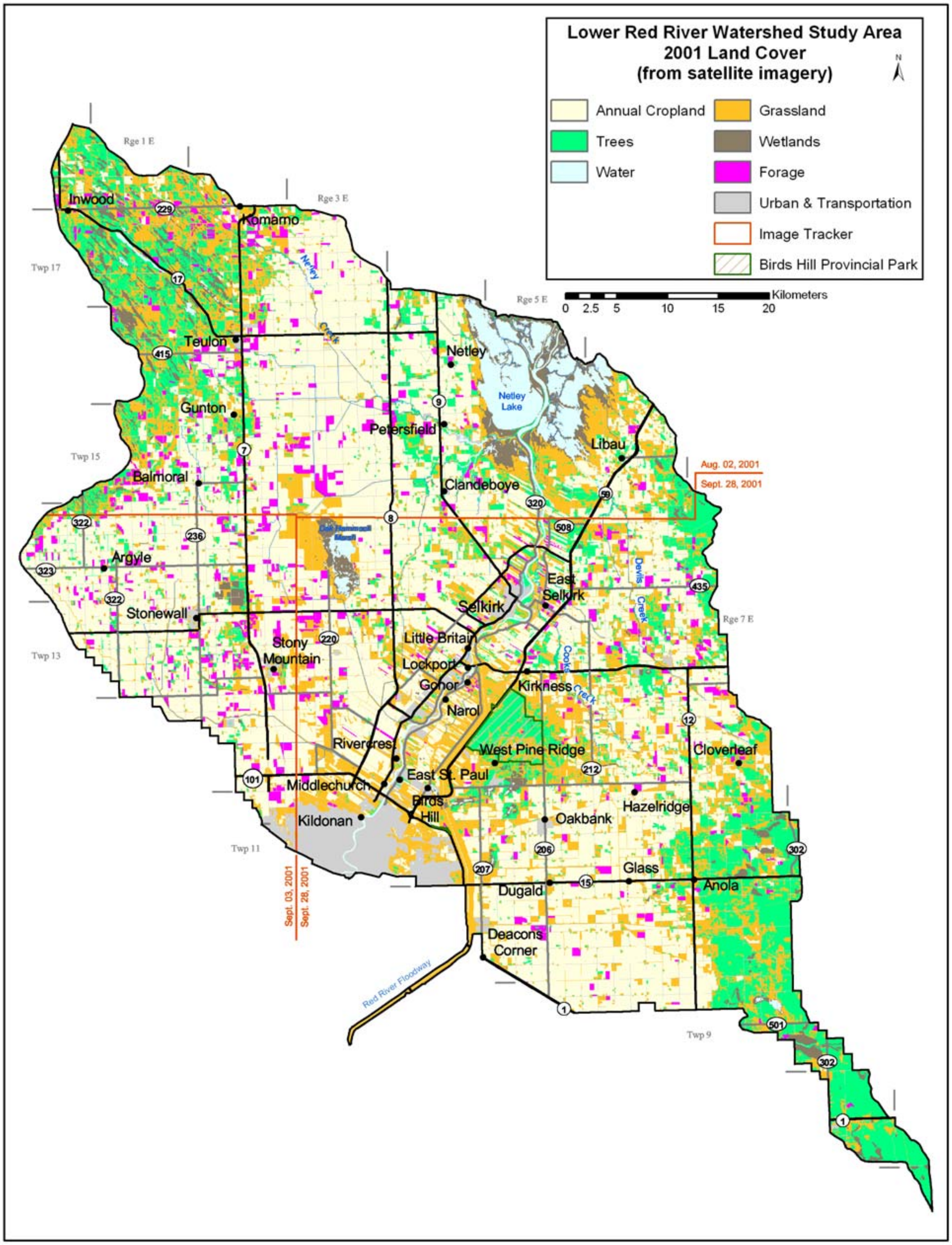

Figure 6.0 2001 Land cover in the Lower Red River Watershed study area

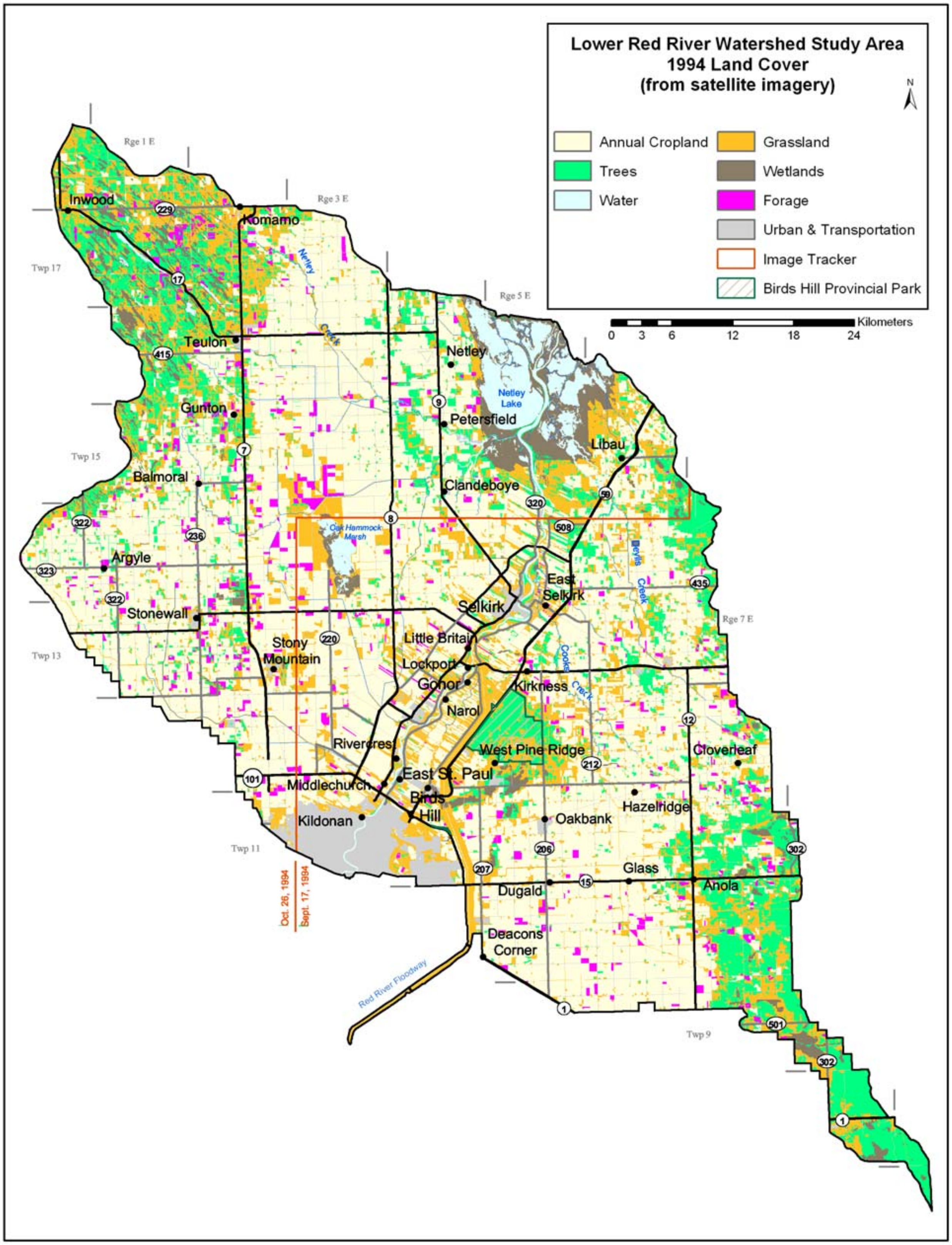

Figure 7.0 1994 Land cover in the Lower Red River Watershed study area

Soil Resources

Soils data is a critical component of land-use planning. Soil characteristics can be used to determine agricultural capability and to predict risks of erosion, leaching, and run-off. This type of information is important for determining suitable land uses, identifying sensitive areas, and targeting land-use improvement efforts. In terms of riparian health, analysis of soil characteristics can help to identify soils at high risk for erosion and run-off that could contribute to riparian degradation.

Soils data is available for all areas within the watershed. The soils data used in this report was mapped at a detailed scale of 1:20,000 for the RMs of Rockwood and Brokenhead, and the Winnipeg region. The remaining area was surveyed at a reconnaissance scale of 1:126,720. Soil information provided in this report is based on the characteristics of the dominant soil series within the soils polygon. A more detailed and complete description of the type, distribution and textural variability of soils in the watershed can be found in the published soil surveys for the area.

This watershed is divided into two regions, the central region surrounding the Red River, and the northwestern portion past Teulon and southeastern portion past Anola. These regions tend to have distinct soils characteristics and land covers. The majority of soils in this watershed was deposited during the time of glacial Lake Agassiz, and is derived from lacustrine deposits underlain by loam stony glacial till. Glacial till deposition is also present in the northwest and southeastern corners of the watershed, with some fluvial-lacustrine areas scattered in amongst it. The Birds Hill area has a different deposition than its lacustrine surroundings, and contains glacial till and glaciofluvial deposition. Waterworked, extremely calcareous, stony, loam till and gravelly sand outwash are common in areas of the watershed, especially the Birds Hill region.

The predominant soils within the watershed are part of the Chernozemic and Gleysolic Orders. Black Chernozems occur throughout the watershed on imperfectly drained soils, while Humic Gleysols occur in poorly-drained areas, sometimes occurring with peaty layers. Black Chernozems are a fertile soil, characteristic of tall grasslands. Weakly developed Brunisols and Grey Luvisols, as well as Dark Grey Chernozems occur in the eastern, northern and north-western parts of the watershed. There are also areas of Organic soils found in the watershed, in the east, south-east, and around the Netley and Oak Hammock Marsh regions. Dark Grey Chernozems characterize a grassland/forest transition zone, whereas Brunisols and Luvisols are typically forest soils. Regosols are found in some places along the Red River and are generally considered to be underdeveloped.

Soil Surface Texture

Soil surface texture strongly influences the soil's ability to retain moisture, its general level of fertility, and the ease or difficulty of cultivation. For example, water moves easily through coarse-textured (sandy) soils, so little moisture is retained and these soils dry out more quickly than fine-textured (clayey) soils. Sandy soils are often characterized by a loose or single-grained structure which is very susceptible to wind erosion. On the other hand, clay soils have a high proportion of very small pore spaces which hold moisture tightly. Clay soils are usually fertile because they are able to retain plant nutrients better than sandy soils. However, they transmit water very slowly and are therefore susceptible to excess moisture conditions.

The predominant soil surface texture within the watershed is clay, which covers much of central watershed (49%) (refer to Table 4.0, Figure 8.0). Fine loams cover 29% of the study area and predominate in the west and southeast corners of the study area. Sands cover the majority of the Birds Hill region, and occur in pockets in the west and southeast portions, covering 6% of the watershed area. There are also some organic textures present in areas throughout the study area.

Table 4.0 Soil surface texture in the Lower Red River Watershed study area[1]

Class	Area (ha)	Percent of Study Area
Clayey	206,228	49.2
Fine Loamy	121,670	29.0
Coarse Loamy	23,479	5.6
Sand	27,043	6.4
Coarse Sand	53	0.01
Organic	26,819	6.4
Rock	2.7	0
Water	11,031	2.6
Unclassified	3,209	0.8
Total	419,534	100

1. Soil surface texture is based on the dominant soils series for each soil polygon

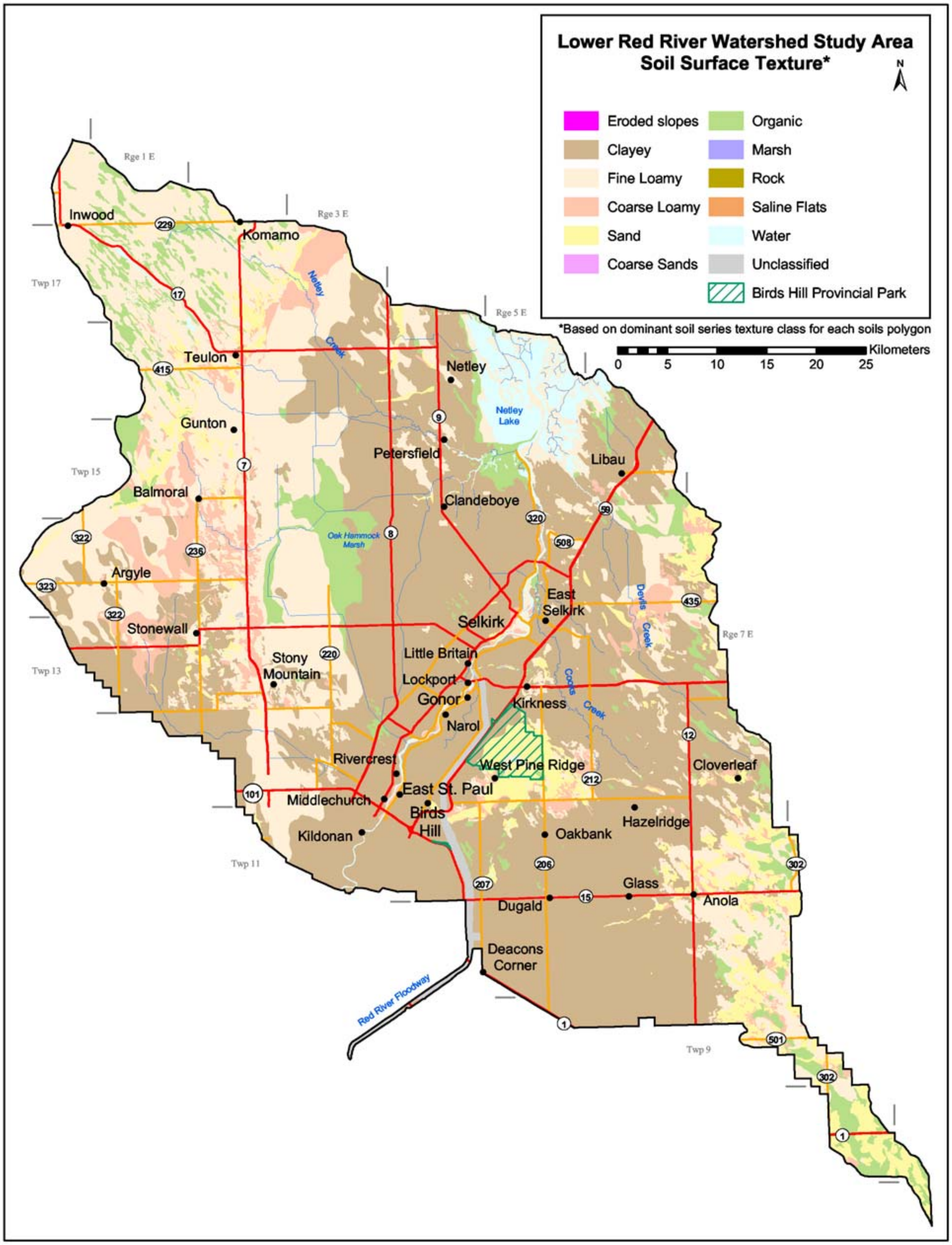

Figure 8.0 Soil surface texture in the Lower Red River Watershed study area

Soil Drainage
Soil drainage is described on the basis of actual moisture content in excess of field capacity and the length of the saturation period within the plant root zone. Excessive water content in the soil limits the free movement of oxygen and decreases the efficiency of nutrient uptake. Delays in spring tillage and planting are more frequent in depressional or imperfectly- to poorly-drained areas of a field. Surface drainage improvements and tile drainage are management practices that can be used to manage excess moisture conditions in soils. Agriculture and Agri-Food Canada's Land Resource Unit has divided soil drainage into five classes:

1) *Very Poor* - Water is removed from the soil so slowly that the water table remains at or on the soil surface for the greater part of the time the soil is not frozen. Excess water is present in the soil throughout most of the year.

2) *Poor* - Water is removed so slowly in relation to supply that the soil remains wet for a large part of the time the soil is not frozen. Excess water is available within the soil for a large part of the time.

3) *Imperfect* - Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Excess water moves slowly down the profile if precipitation is the major source.

4) *Well* - Water is removed from the soil readily but not rapidly. Excess water flows downward readily into underlying materials or laterally as subsurface flow.

5) *Rapid* - Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep slopes during heavy rainfall.

Drainage classification is based on the dominant soil series within each individual soil polygon.

According to the drainage classes defined above, almost 50% (203,955 ha) of the soils within this watershed area are considered imperfectly drained (refer to Table 5.0, Figure 9.0). Scattered areas of poor but improved drainage occur between Teulon and Anola. Improved drainage indicates areas where networks of surface drains enhance the surface runoff and reduce the duration of surface ponding, which is especially important for agricultural land. Areas of rapid and well-drained soils are present in the study area, covering 14% of the watershed area, including the Birds Hill area and some stretches along the Red River.

Table 5.0 Soil drainage classes for the Lower Red River Watershed study area[1]

Class	Area (ha)	Percent of Study Area
Rapid	5,937	1.4
Well	50,558	12.1
Imperfect	203,955	48.6
Poor	14,984	3.6
Very Poor	22,621	5.4
Poor (Improved)	102,293	24.4
Rock	2.7	0
Water	11,031	2.6
Marsh	4,944	1.2
Unclassified	3,209	0.8
Total	419,538	100

1. Area has been assigned to the dominant drainage class for each soil polygon

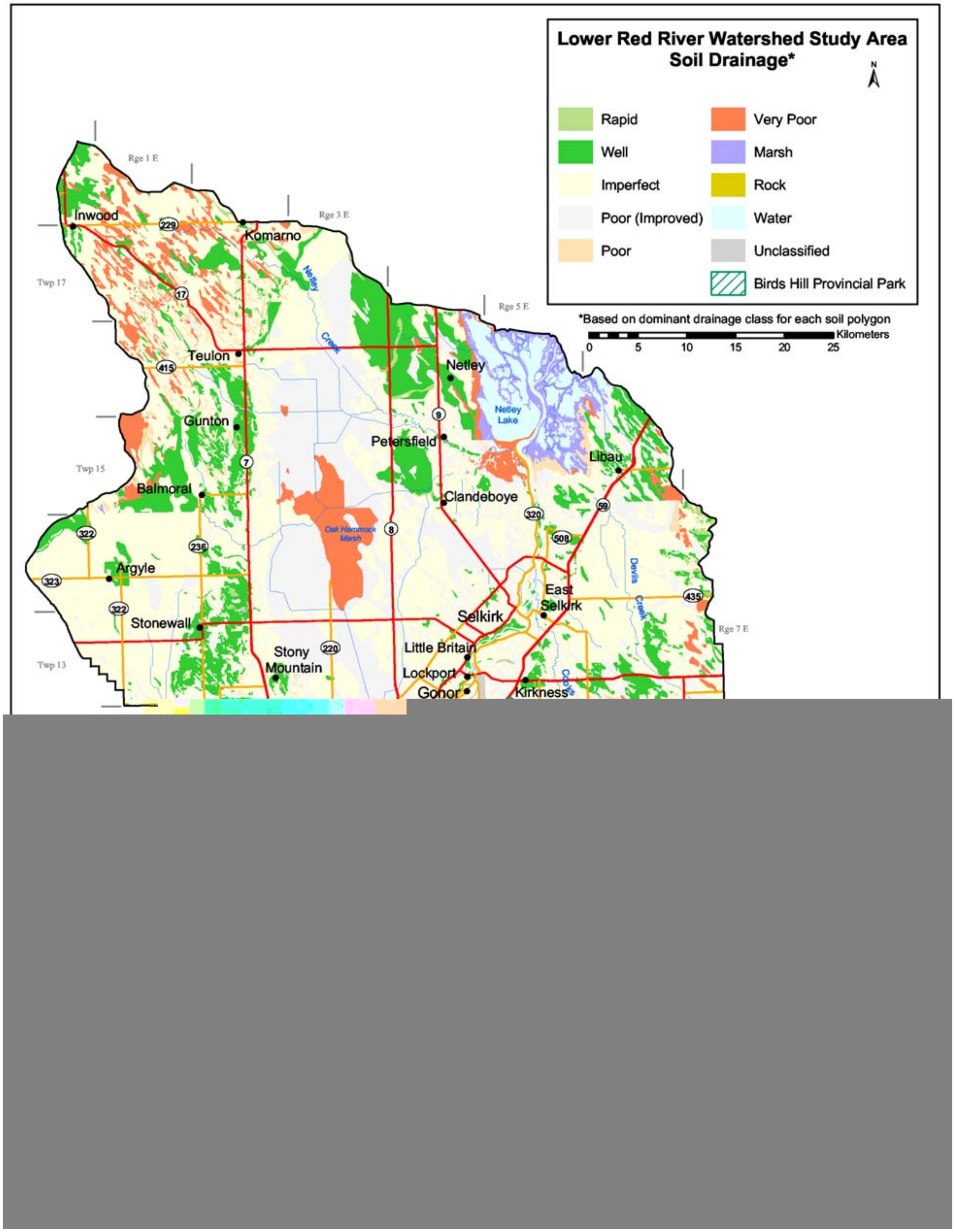

Figure 9.0 Soil drainage classes for the Lower Red River Watershed study area

Agricultural Capability

The Canada Land Inventory System (CLI) was used to classify land based on agricultural capability. The CLI is a comprehensive survey of land capability and use designed to provide a basis for making rational land-use planning decisions. Under the CLI, lands are classified according to physical capability for agricultural use. The system uses seven classes to rate agricultural capability, with Class 1 lands having the highest capability to support agriculture, and Class 7 the lowest. Table 6.0 provides a description of each class. Subclass descriptors are also used to identify specific limiting factors within each class (Table 7.0). The classes indicate the degree of limitation for mechanized agriculture imposed by the soil. The subclasses indicate the type of limitations that individually, or in combination with others, affect agricultural land use. The CLI classification assumes good land management and is independent of location, accessibility, ownership, distance from cities or roads, and the present use of the land (Natural Resources Canada 2000).

Table 6.0 Canada Land Inventory (CLI) class descriptions

Class #	Description
1	Soils in this class have no significant limitations in use for crops.
2	Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices.
3	Soils in this class have moderate limitations that restrict the range of crops or require special conservation practices.
4	Soils in this class have severe limitations that restrict the range of crops or require special conservation practices or both.
5	Soils in this class have very severe limitations that restrict their capability to produce perennial forage crops, and improvement practices are feasible.
6	Soils in this class are capable only of producing perennial forage crops, and improvement practices are not feasible.
7	Soils in this class have no capability for arable culture or permanent pasture
O	Organic soils

Source: Natural Resources Canada 2000.

Table 7.0 Canada Land Inventory (CLI) subclass descriptions

Subclass	Description
C	Adverse climate
D	Undesirable soil structure and/or low permeability
E	Erosion
F	Low fertility
I	Inundation by streams or lakes
M	Moisture limitations
N	Salinity
P	Stoniness
R	Consolidated bedrock
T	Topography
W	Excess water
X	This subclass is comprised of soils having a limitation resulting from the cumulative effect of two or more adverse characteristics

Source: Natural Resources Canada 2000

Figure 10.0 illustrates the classes of agricultural land found within the watershed. At this generalized map scale, subclass limitations could not be displayed. As Table 8.0 indicates, the majority of the land within the watershed is prime agricultural land (Classes 1, 2 to 3), making up over 70% of the area. Most of the more marginal land is found in the north-west and southeast portions of the watershed, along with the Birds Hill Park and Oak Hammock Marsh areas (refer to Figure 10.0). Organic soils occur in depressional areas in amongst the less productive agricultural crop land, as well as near the northern lakes. As indicated in Table 8.0, excess water is the main limitation in agricultural capability in the Class 2 and 3 land, with some potential for salinity in Class 3 land. The main limitations for Class 4 land is undesirable soil structure and stoniness, as well as moisture limitations, which also arise in Class 5 soils.

Table 8.0 Agricultural capability in the Lower Red River Watershed study area and the major type of limitations within each class[1].

Class	Subclass	Area (ha)	Percent of Study Area
Class 1		**1,708**	**0.4**
Class 2		**157,590**	**37.6**
	2D	*15,158*	*3.6*
	2M	*14,179*	*3.4*
	2W	*122,013*	*29.1*
Class 3		**143,604**	**34.2**
	3D	*24,281*	*5.8*
	3N	*12,268*	*2.9*
	3NW	*14,978*	*3.6*
	3W	*88,318*	*21.1*
Class 4		**46,240**	**11.0**
	4DP	*34,528*	*8.2*
	4M	*7,981*	*1.9*
Class 5		**27,392**	**6.5**
	5M	*13,413*	*3.2*
	5W	*13,197*	*3.1*
Class 6		**15,607**	**3.7**
	6W	*14,524*	*3.5*
Class 7		**5,000**	**1.2**
	7W	*4,944*	*1.2*
Organic		**8,154**	**1.9**
Water		**11,031**	**2.6**
Unclassified		**3,209**	**0.8**
Total		**419,538**	**100**

1. Agricultural capability is based on the dominant soil series and slope gradient within each soil polygon

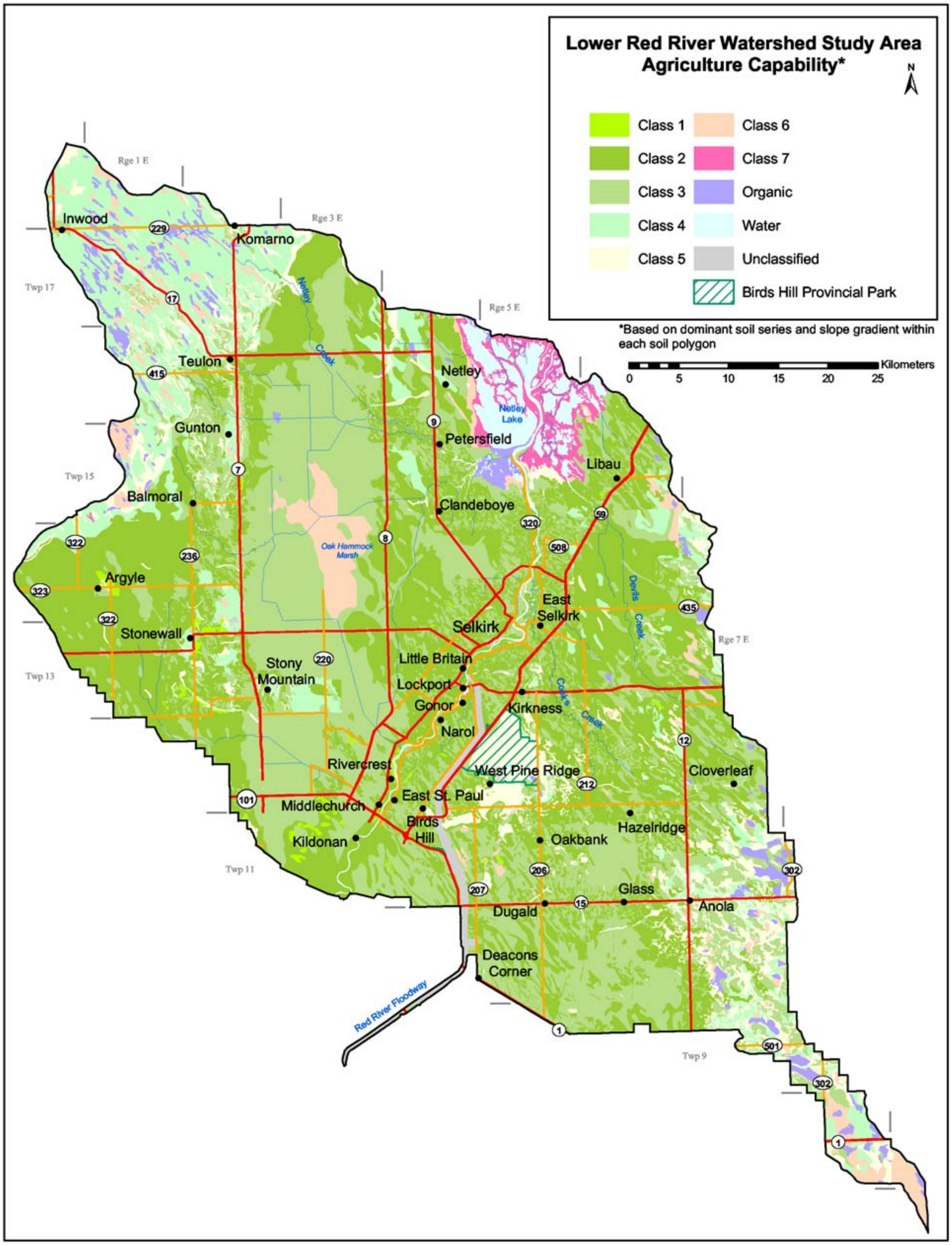

Figure 10.0 Agricultural capability class in the Lower Red River Watershed study area

Water Erosion Risk

The risk of water erosion was estimated using the Universal Soil Loss Equation (USLE) developed by Wischmeier and Smith (1965). The USLE predicted soil loss (tonnes/hectare/year) was calculated for each soil component in each soil map polygon. Water erosion risk factors used in the calculation include mean annual rainfall, slope length, slope gradient, vegetation cover, management practices, and soil erodibility (Eilers et al. 2002). Erosion risk classes were assigned based on the weighted average soil loss for each map polygon. The five classes of soil erosion risk (ranging from negligible to severe) are based on a bare, unprotected soil condition. However cropping and residue management practices can significantly reduce this risk depending on crop rotation, soil type, and landscape features. Basing the soil erosion risk on the bare soil case helps to identify areas dominated by sensitive, erosive soils which may otherwise be masked if a land use or surface vegetation cover factor was considered (Eilers et al. 2002).

According to the interpreted water erosion risk classification for soils, water erosion is of little concern within this study area, with 85% falling under the negligible to low risk category (refer to Table 9.0, Figure 11.0). About 11% of the watershed falls into the moderate category, which is found throughout the watershed but more predominantly in the western part of the study area.

Table 9.0 Water erosion risk classes in the Lower Red River Watershed study area [1]

Risk (tonnes/ha/yr)	Area (ha)	Percent of Study Area
Negligible (<6)	215,531	51.4
Low (6-11)	141,925	33.8
Moderate (11-22)	47,326	11.3
High (22-33)	487	0.1
Severe (>33)	24	0
Water	11,031	2.6
Unclassified	3,209	0.8
Total	419,534	100

1. Water erosion risk is based on the weighted average USLE predicted soil loss within each soil polygon, assuming a bare unprotected soil

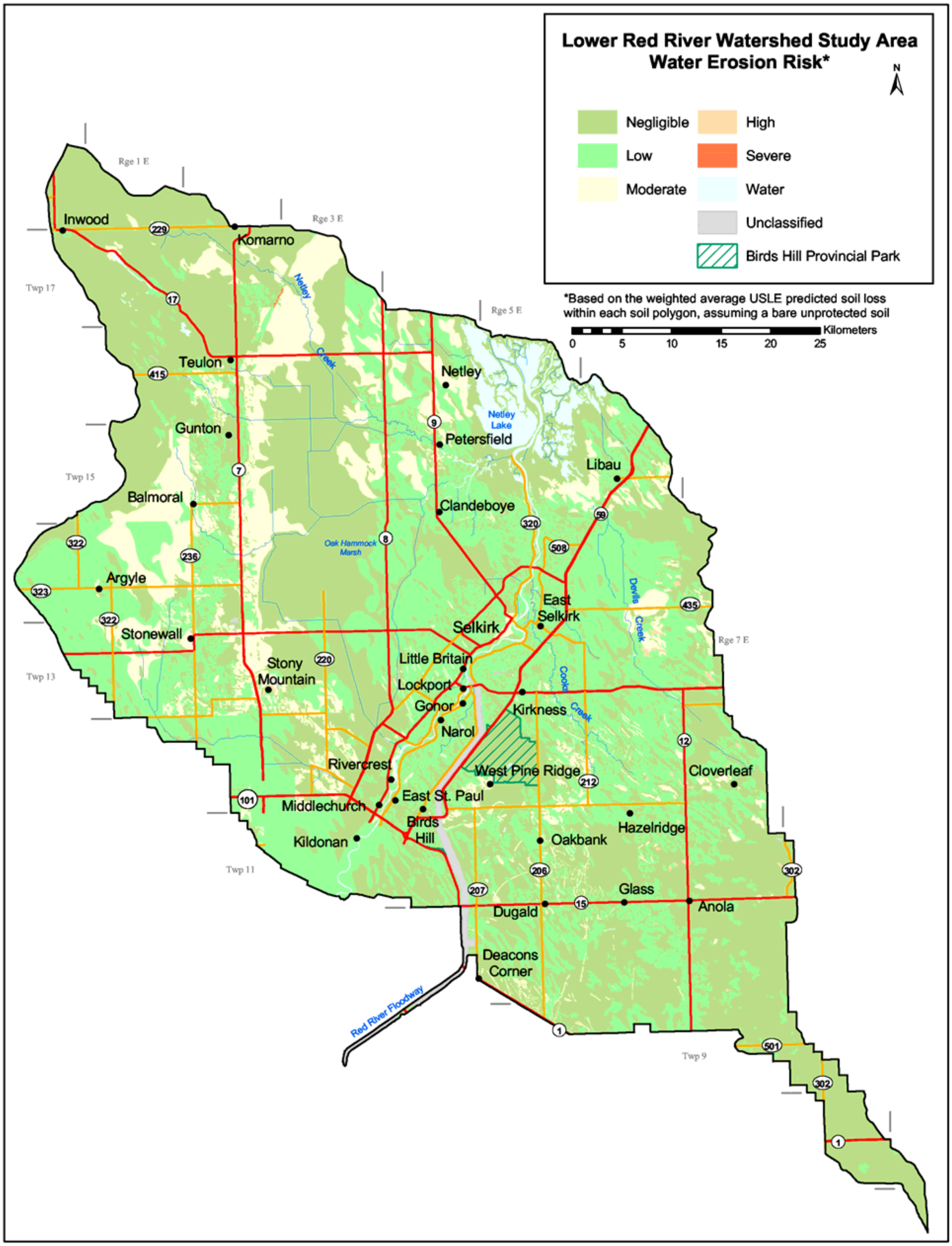

Figure 11.0 Water erosion risk in the Lower Red River Watershed study area

Agricultural Activities

Riparian areas can be impacted by anthropogenic activities occurring within a watershed. Land use and management practices within riparian zones and on upland areas affect the health of riparian areas. Although agriculture is only one component, with other human activities such as industry, recreation and residences contributing to degraded riparian areas, this report focuses on the impacts of agriculture. By knowing the extent and type of agricultural activities within the watershed, more effective decision-making and project planning can be put into place.

Agriculture data for the watershed was obtained from the 2001 Census of Agriculture using the farm headquarters reporting method, which links census data to the land location of the farm headquarters. In the 2001 Census, the farm headquarters was defined as "the operator's residence if he/she lives on land that is part of the agricultural operation; the location of the main building or main gate of the agricultural operation; or if many parcels of land without buildings are in separate locations, the parcel with the largest land area or share of gross agricultural receipts is considered the farm headquarters" (Statistics Canada 2002). It should be noted that in cases where the farm headquarters location is different from that of the actual farmed land or the location of livestock, inaccuracies in data will be introduced. For example, the reported farm headquarters could fall within one watershed, whereas a proportion of the land/livestock associated with that operation could fall within another. Despite the inaccuracies, the Census of Agriculture provides the most comprehensive source of available agricultural data (see Appendix B for more information and definitions).

The *Statistics Act* requires that all census information be kept confidential. As a result, any data that could disclose information concerning a particular agricultural operation or individual is suppressed in the data tables reported by Statistics Canada. For example, if there are only one or two dairy operations within a watershed, the number of farms reporting dairy will be given, however the total number of dairy cows reported within that watershed will be suppressed. In instances where a geographic area has very few agricultural operations, data are not released separately but are merged with data from one or more geographically adjacent areas (Statistics Canada 2002).

According to the 2001 Census, there were a total of 1,450 farms utilizing 69% of the land in the Lower Red River Watershed study area. For the purpose of this report, farmland includes all land that is owned, rented, leased (including government land) or crop-shared by agricultural operations. Of this land, 13,672 ha (5%) is leased government land. Of the farmland, 173,021 ha (60%) were prepared for seeding in the fall of 2000 or spring 2001.

Land use and management practices of upland areas are important considerations in watershed planning. Crop type (permanent vs. annual, high residue vs. low residue), tillage practices, nutrient management, and conservation practices on the upland landscape are all activities that can affect water quality within the watershed.

Table 10.0 summarizes the major crops grown in the watershed, including crops cut for hay, silage, green feed, etc. According to the 2001 Census data, cereals were the most popular field crop, covering 43% of the farmland. Forages and oilseeds were also grown in the study area, making up 15% and 14% of the farmland. A small portion of the farmland was seeded to pulse crops, the majority of which was dry field beans.

Table 10.0 Summary of cultivated crops, including crops cut for hay, silage, green feed, etc, grown in the Lower Red River Watershed study area (2001 Census)

Crop Type	Hectares[1]	Percent of Farm Land[1]	Percent of Study Area[1]
Cereals (wheat, barley, oats, mixed grain[2], corn for grain[3], buckwheat[4], canary seed[3])	122,458	42.6	29.2
Forages (alfalfa, alfalfa mixtures, corn for silage[2], tame hay and other fodder crops, forage for seed)	41,776	14.5	10.0
Oilseeds (canola, soybeans[3], flaxseed, sunflowers[3])	38,671	13.5	9.2
Pulse Crops (dry field peas[2], dry beans[2])	1,369	0.5	0.3

1 - Numbers do not include suppressed data
2 - Data is suppressed for two farm reporting
3 - Data is suppressed for three farms reporting
4 - Data is suppressed for four farms reporting

Tillage practices on upland fields can affect the amount of erosion and run-off occurring. As the amount of tillage on a field increases, the chance of run-off (containing sediment and nutrients) entering waterways also increases. Table 11.0 provides a breakdown of tillage practices within the watershed. According to the 2001 Census of Agriculture, 66% of the land prepared for seeding in 2001 was tilled to incorporate most of the crop residue, whereas 34% of the fields had little or no tillage for seedbed preparation, retaining most of the residue on the surface of the fields.

Table 11.0 Summary of tillage practices in the Lower Red River Watershed study area (2001 Census)

Tillage Practices	Hectares	Percent of Seeded Area	Percent of Study Area
Tillage incorporating most crop residue	114,489	66.2	27.3
Tillage retaining most crop residue on surface	51,981	30.0	12.4
No till or zero till	6,551	3.8	1.6
Total seeding area prepared	173,021	100	41.3

In addition to minimum or no tillage, other conservation practices also reduce water erosion, thereby decreasing the amount of contaminated runoff entering waterways. Other conservation practices reported within the watershed included crop rotation (alternating low residue crops with high residue crops to maintain a good residue cover), permanent grass cover, winter cover crops, contour cultivation, strip cropping, grassed waterways and shelterbelts or windbreaks. Table 12.0 provides a breakdown of the percentage of farms using these conservation practices within the watershed.

Table 12.0 Summary of the conservation practices carried out in the Lower Red River Watershed study area (2001 Census)

Conservation Practices	Percentage of Farms Using Conservation Practice
Crop rotation	56.5
Permanent grass cover	26.7
Winter cover crops	0.9
Contour cultivation	3.1
Strip cropping	0.5
Grassed waterways	3.7
Windbreaks or shelterbelts	14.1

A number of farms within the watershed reported having livestock. As a result, manure production and the utilization of riparian areas by grazing animals are two areas where appropriate management practices should be implemented to reduce nutrient loading into rivers and streams and maintain healthy riparian areas. Table 13.0 provides a breakdown of the livestock distribution within the watershed. Almost 30% of the farms within the watershed have cattle, the majority of which were beef cows. There were also 125 farms reporting hens/chickens and 86 reporting pigs. The number of horses and ponies within the watershed area averaged almost 8 animals per farm and may be an indication of a higher number of small hobby farms.

Total Animal Units (AU) produced in the watershed (based on annual nitrogen production) has been calculated using Manitoba's Animal Unit coefficients and by making several assumptions (refer to Appendix C). As representing in Table 13.0, beef cattle made the largest contribution to the total AU produced in the study area. Pigs contributed 27% to the total AU while dairy contributed to 13%.

Table 13.0 Livestock distribution in the Lower Red River Watershed study area (2001 Census)

Livestock	Total Number of Ffarms[1]	Number of Animals[2]	AU Coefficient[3]	Total AU[2]
Total cattle and calves	564	47,232	--	
Total dairy cows	59	3,230	2	6,460
Total beef cows	461	16,330	1.25	20,413
Total heifers & steers for slaughter and feeding (1 yr and older)	--	6,711	0.631	4,235
Total pigs	86	117,827	--	
Total sows	50(2)	11,731	0.313	3,672
Total nursing and weaner pigs	42(2)	33,848	--	
Total grower and finisher pigs	73	68,259	0.143	9,761
Boars	45(1)	448	0.2	90
Total hens and chickens	125	188,037	--	
Broilers and Roasters	61(8)	104,866	0.005	524
Layers (19 weeks and older)	100(4)	75,019	0.0083	623
Pullets (under 19 weeks)	23(3)	6,508	0.0033	21
Turkeys	25(4)	113,859	0.014	1,874
Total sheep and lambs	51	3,963	--	
Ewes	50(3)	1,545	0.2	309
Lambs	43(2)	1,954	--	
Total horses and ponies	223	1,763	1	1,763
Bison	7(4)	351	0.8875	312
Elk	1(1)	0	0.52	0
Goats	53	875	0.143	125
				50,181

1 - Numbers in parentheses indicate the number of farms for which data is suppressed for that livestock category
2 - Numbers do not include suppressed data
3 - Refer to Appendix C for the definition of Animal Unit and assumptions used to derive Animal Unit coefficients

Manure is a valuable source of nutrients for crop production. With the prevalence of livestock production in the study area, manure management becomes important. Table 14.0 provides a summary of the method of manure application on the land in the watershed. Although more farms reported spreading solid manure in the study area in 2000, liquid manure was applied to almost the same area. Liquid manure was applied using three different methods in the study area with 44 farms spreading it on the surface, 52 farms injecting it and one farm reported applying it through irrigation. In order to achieve efficient use of the nutrients while ensuring no adverse effects to riparian health and water quality, management practices should include incorporation of manure as soon as possible after field application, determination of application rates based on crop nutrient requirements, and timing of field applications to nutrient utilization by crops.

Table 14.0 Summary of manure application in the Lower Red River Watershed study area in 2000 (from 2001 Census of Agriculture)

Method of Manure Application	Number of Farms Reporting[1]	Area (ha) [2]
Solid Spreader	285	5420
Liquid Spreader (on surface)	44 (2)	1616
Liquid Spreader (injected)	52	3883
Irrigation System	1 (1)	--

1. Numbers in parentheses indicate the number of farms for which data is suppressed in that category
2. Numbers do not include suppressed data

Watershed Considerations

The Red River is an international waterway and one of southern Manitoba's primary waterways. Many other important rivers drain into the Red River Watershed, which means the river is a recipient of water and associated transmissions from much southern Manitoban land. The Lower Red River Watershed study area is itself drained by numerous creeks, drainage ditches and diversions. This large amount of riparian area must be properly managed to protect surface water quality for users both within the watershed and downstream. Land management decisions in upland areas will also influence riparian health.

Manitoba Conservation monitored Total Nitrogen (TN) and Total Phosphorous (TP) levels in the Lower Red River area from 1978 to 1999 and Cooks Creek from 1990 to 1999. Analysis shows a trend of increasing TN and TP concentrations at the Lower Red River site, near Selkirk, over this time period (Jones and Armstrong 2001). At the Cooks Creek site, there was a trend of decreasing TN but no significant trend in TP concentrations. Upstream portions of the Red River, outside of this watershed, found increases in nutrient concentrations as well, however less drastic. Changes in nutrient concentrations can be attributed to land-use practices and seem to accumulate at downstream portions of the river.

Concentration of nutrients on the river are high enough to support algal growth, however the turbidity of the river has prevented much of this activity. As the river approaches and enters Lake Winnipeg and slows down, however, algal growth will occur. The transport of nutrients from land to water, for example, from manure and fertilizer runoff, was found by Bourne et al. (2002) to contribute a considerable amount more to nutrient loading to the Red River, than direct effluent discharge. While direct effluent discharge contributes a substantial amount of loading as well, the input from sizeable tributary rivers upstream also contribute concerning amounts. Enhanced monitoring and treatment from input systems could be beneficial.

Soils and Land Cover
The characteristics of soil and landscape affect land use. The majority of the soils within the study area are rated as Class 1, 2 or 3 (72% of the study area) and are productive agricultural lands, with the main limiting factor to production being excess water. Class 4 to 6 soils found in the northwest and southeastern corners, as well as Birds Hill Provincial Park, are also affected by excess water, as well as lack of moisture stoniness and an undesirable soil structure.

Almost 50% of this watershed has imperfect drainage, while 24% has poor but improved drainage, mainly in the more productive crop land region. To overcome the excess water limitations in some areas of the watershed, a network of drainage systems has been established. These drains are effective at moving water off fields quickly and decreasing the amounts of standing water on fields, allowing for agricultural operations to take place. However, these advantages to agricultural production also cause some concern. The drains move water off fields quicker than normal, loading the river channel to high water levels in response to heavy precipitation events. This could place the river into a flood or near-flood stage, thereby increasing the risk for water erosion. In addition, man-made drains seldom have riparian areas around them, unlike most natural watercourses. With small or non-existent riparian zones, there is increased risk of nutrient and sediment loading into watercourses. Riparian areas and permanent vegetation on adjacent lands are able to trap and store sediment and nutrients found in field runoff, reducing the risk of contamination of surface water.

Land cover provides a glimpse into agricultural practices in the watershed. In 2001 the dominant land cover was annual crop land, making up 45% of the watershed. The most notable change in land cover is the increase in forage cover. Although forages made up a small part of the watershed (4%) in 2001, the area had increased 1.5 times since 1994. Forage fields were likely converted from annual crop land, since this category experienced a decrease in area over the seven-year period. The increase in forages reflects the expansion of the livestock industry in Manitoba over the last several years.

Riparian Areas
In order to provide an indication of the amount of riparian areas present in the study area, a shoreline density was calculated using the length of shoreline around watercourses and waterbodies. This shoreline density can provide a glimpse into how much upland is in contact with surface waterbodies and watercourses (riparian areas). A higher shoreline density could mean there is a greater potential for interaction between upland activities and surface water. For this analysis, length of shoreline of both permanent and intermittent waterbodies and watercourses was determined from the 1:50,000 NTS datasheets (note that densities will be underestimated since numerous small wetlands and potholes as well as some small constructed water courses (first, second and third order drains) are not captured by the NTS sheets). Table 15.0 provides a summary of the length and density of shoreline in the study area. In the Lower Red River Watershed study area, Sub-watershed #240 has the highest concentration of riparian areas with 16.3 m of shoreline/ha. Over half of the shoreline in this area borders on waterbodies (refer to Figure12.0). Watercourses (rivers, creeks, streams, etc) make up the majority of shoreline in the remainder of the study area. A

higher shoreline density will indicate a greater concentration of riparian areas. Since riparian areas provide a buffer between upland areas and surface water, management practices (including riparian pasture management, buffer strips, and grassed waterways) become important to maintain this vegetated buffer area surrounding waterbodies and watercourses.

Table 15.0 Summary of shoreline density in the Lower Red River Watershed study area (includes permanent and intermittent streams and waterbodies).

Sub-watershed ID	Length of Shoreline[1] (m)	Percent Watercourse Shoreline	Percent Waterbody Shoreline	Shoreline Density[2] (m/ha)
235	397,528	88.4	11.6	11.0
237	295,693	81.7	18.3	6.3
238	524,110	78.8	21.2	11.3
239	550,150	85.7	14.3	7.4
240	1,111,796	48.5	51.5	16.3
241	903,596	81.0	19.0	6.9

1. Length of shoreline is determined from the 1:50,000 NTS data sheets and will be underestimated due the fact that many small wetlands and potholes as well as some small constructed water courses (first, second and third order drains) are not captured in the data sheets
2. Area is calculated as the entire area of the sub-watershed (minus area of waterbodies from the 1:50,000 NTS data sheets)

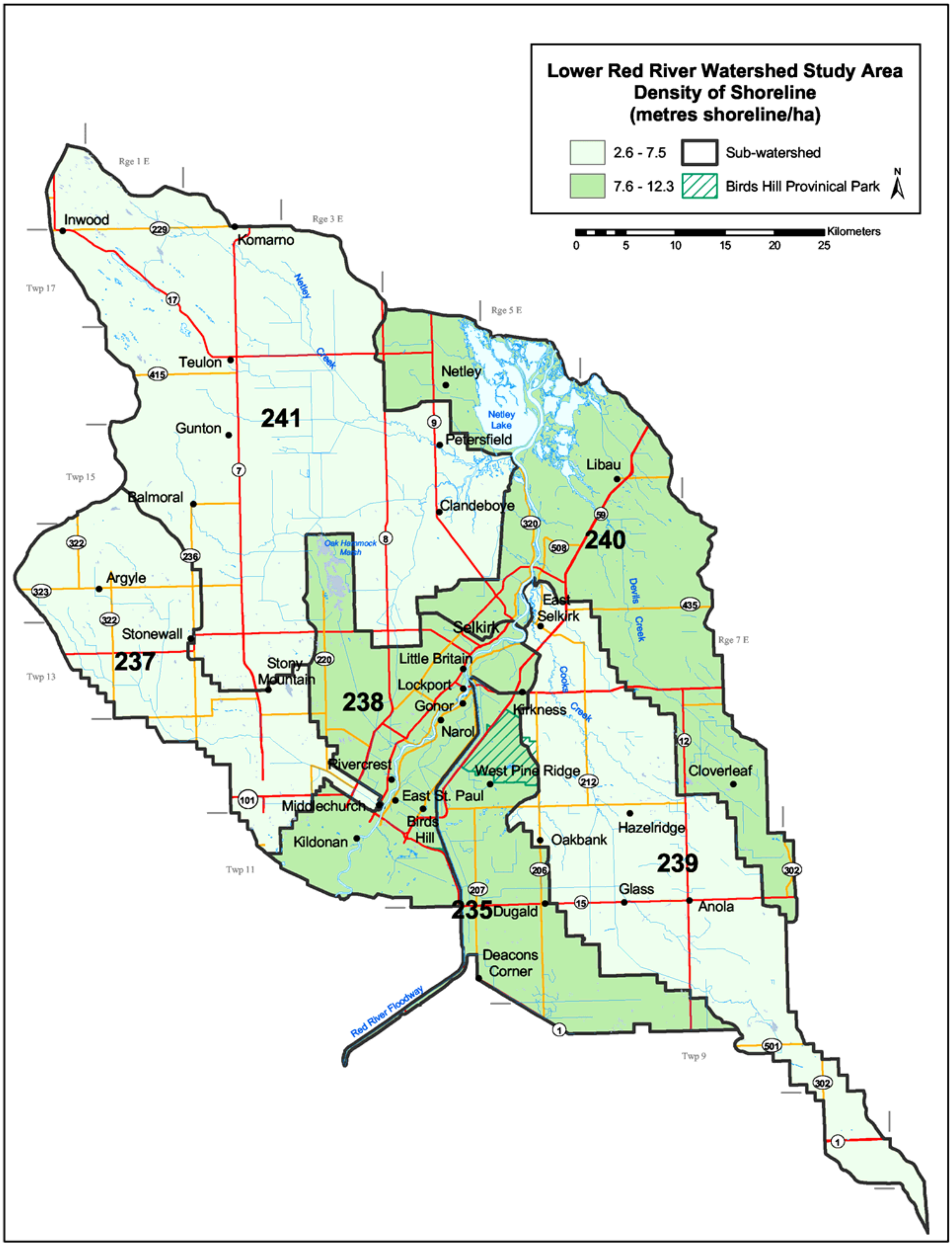

Figure 12.0 Density of shoreline in the Lower Red River Watershed study area, as determined by the 1:50,000 NTS data sheets

Riparian areas play a very important role in reducing the impact of agriculture on surface water quality. Riparian areas reduce the amount of contaminants, nutrients, and pathogens reaching surface waters by trapping and filtering sediments and by absorbing excess nutrients. The health of a riparian area determines the extent to which the riparian area can perform its functions. Riparian health is generally determined by on-site assessment and evaluation, however this was not feasible for this project. Instead, land cover in a 50 m buffer around waterbodies and water courses (both permanent and intermittent) within the study area was analyzed, since these areas will have a greater likelihood of influencing water quality. Although this method cannot determine management practices occurring in the riparian areas (ie. livestock use of riparian areas, nutrient and pesticide management practices, etc), percentage of trees and annual crops within the buffered area could give an indication of possible health of riparian areas as well as potential agricultural impacts to water quality. Trees are an important part of the riparian area. Tree roots help to stabilize banks and hold the soil in place while canopy cover provides protection from rain drops. Their sparse presence could be an indication of declining riparian health. Another indicator of potential decline in riparian health is the presence of annual crop land in the buffer area. Annual crop land can potentially impact water quality by allowing contaminated run-off to enter surface water.

Table 16.0 provides a summary of the 2001 land cover in a 50 m buffer area around all water courses and waterbodies in the Lower Red River Watershed study area (from the 1:50,000 NTS data sheets). Approximately 4% of the study area is located within 50 m of a watercourse or waterbody (including intermittent streams and wetlands). In this buffered area, about 28% was in annual crops while almost 9% was treed.

Potential impacts of crop production to riparian areas may be greater in areas where annual crop land is predominant within a 50 m area from a watercourse or waterbody. In the Lower Red River Watershed study area, areas which have a higher occurrence of annual crop land in this buffered areas are in sub-watersheds which contain a network of man-made drains (refer to Table 16.0 and Figure 12.0). Cultivation adjacent to man-made drains usually leaves little or no riparian area on the drain. Impacts will be reduced due to the fact that 34% of the crop land was prepared using minimum or zero tillage.

The presence of trees within the 50 m buffer may give an indication of the potential for a riparian area to be healthy. Overall, trees are not common in the buffered areas the study area though in some areas they are found in higher proportions (northwest and southeast corners – refer to Figure 6.0). Absence of trees can be a result of several factors; trees have been removed due to overgrazing, cultivation, straightening of creeks, or hydrological conditions have changed.

Table 16.0 Summary of land cover in a 50 m buffer around all waterbodies and on either side of watercourses in the Lower Red River Watershed study area (using 2001 satellite imagery and 1:50,000 NTS water layers)[1].

Sub-watershed ID	Buffered area (percent of sub-watershed)	Percent of Buffered Area						
		annual crop land	trees	water	grassland	wetland	forages	roads, urban
235	5.6	30.8	2.6	6.1	49.9	2.7	0.5	7.4
237	3.3	46.1	0.7	0.2	38.8	1.3	4.2	8.7
238	5.5	17.5	4.8	8.7	44.8	5.6	1.0	17.4
239	3.7	27.5	14.0	4.5	43.9	2.5	1.7	5.9
240	4.4	24.4	10.6	15.9	29.9	12.6	2.6	4.1
241	3.5	34.0	11.6	4.5	25.1	10.4	5.7	8.6
Total	4.1	29.1	8.7	7.3	36.3	7.1	3.0	8.4

1. Due to the nature of clipping raster data (land cover layer) with vector data (1:50,000 NTS water layer) and the various scales of the data, areas are estimate.

Farm Management Practices

The 2001 Census of Agriculture had 1,450 farm headquarters reporting within the study area (note that census data is attached to farm headquarter and reports on activities on farmland associated with that farm headquarter, therefore whether or not the farmland is located within the watershed cannot be differentiated). In 2001, agriculture in the watershed consisted mainly of livestock and grain production with about 69% of the land utilized by farmers. This includes land that is owned, rented, leased (including government land) or crop shared. Land management practices will have an effect on the health of the riparian areas. Upland management practices such as crop selection and rotation, tillage practices, nutrient management and grassed waterways can have impacts on riparian areas. According to the census data, 60% of the farmland was prepared for the 2001 growing season, of which 34% was prepared using minimum or zero tillage, resulting in a reduction to the risk of soil erosion. In addition, the majority of the farmers practice crop rotation which, along with minimum and zero tillage, will assist in providing extra soil protection by carrying residues over from one year to the next. In 2001, three times as much land was sown to cereals as compared to oilseed and pulse crops. Grassed waterways are another effective practice and, when located along natural drainage paths in fields, can help to reduce water erosion and filter out sediments from runoff before it enters the watercourse or waterbody. In the Lower Red River Watershed study area, 4% of the farms reported using grassed waterways. Efforts should continue to promote reduced tillage, crop rotation, grassed waterways and other practices which will help reduce soil erosion.

Livestock grazing management is important to the health of riparian areas. Although grazing livestock in the watershed include cattle, sheep and horses, beef production is predominant with approximately 32% of the farms having cow/calf operations. Pastures and forages are necessary for summer grazing and winter feed, and land cover trends show an increase in area dedicated to forages to meet the demand for feed. In order to maximize forage productivity and promote healthy riparian vegetation, ranchers must ensure that they avoid grazing riparian areas during vulnerable times, such as when streambanks and shorelines are saturated and are more vulnerable to trampling. Ranchers should also ensure that they allow the vegetation a proper rest period after grazing during the growing season. Vegetation requires adequate rest in order to rebuild roots (energy supply), and restore vigour. During grazing periods, ranchers should utilize management tools to distribute livestock evenly over the grazing area. This not only reduces streambank damage due to trampling and overuse, but it also helps to distribute manure evenly across the grazing area. Manure is a valuable source of nutrients for plants, and when evenly distributed can be fully utilized with minimal risk of contamination to nearby waterbodies.

In contrast to grazing systems, confined livestock operations often result in an accumulation of manure that will require mechanical removal and subsequent land application. In the Lower Red River Watershed study area, there were 59 dairy operations, 86 hog operations and 125 poultry operations in 2001. The majority of these will have confined livestock facilities with associated manure storage facilities. Accumulated manure is a valuable source of plant nutrients and organic matter, which can be used to improve soil quality and crop production. Although riparian areas can trap nutrients found in runoff from fields and reduce the risk of contamination of water sources, manure management practices should include incorporation as soon as possible after application to the field and maintenance of buffer zones around riparian areas to minimize the risk of contaminated runoff entering water sources. Other manure management practices include soil and manure testing to assist in applying nutrients to crop requirements.

Agriculture Production Intensity

Riparian areas can be affected by all aspects of activities within a watershed, including agriculture, urban areas, recreation activities, etc. For this report, an attempt was made to determine the level of agriculture production intensity within each sub-watershed to determine which areas of the watershed may have a greater potential to impact riparian health. The level of livestock and crop production was determined on a per hectare basis. Because information is not available to indicate at what point the livestock density or crop production intensity becomes critical with respect to potential impacts on riparian health, the values calculated were compared to the highest value calculated in a sub-watershed in all of Manitoba.

Livestock density was calculated for each sub-watershed. Densities of different types of livestock were standardized by calculating Animal Units per hectare (AU/ha). In Manitoba, an Animal Unit (AU) is defined as the number of livestock required to excrete 73 kg (160 lbs) of nitrogen in a 12-month period. Refer to Appendix C for assumptions used to derive AU coefficients. Suppression of livestock numbers in the census data will affect total AU to varying degrees, depending on the amount of suppression (refer to Table 13.0). Area used in the calculation consisted of hay and crop land, summerfallow, tame pasture and native land used for pasture (as reported in the 2001 Census of Agriculture). In Manitoba, the sub-watershed in which the City of Steinbach is located (in the Seine River Watershed Study Area, refer to Appendix D), had the highest livestock density (0.98 AU/ha). All other livestock densities were compared to this one.

Table 17.0 and Figure 13.0 illustrate the different livestock densities within the sub-watersheds of the Lower Red River Watershed study area. Overall, beef cattle produced the majority of AU in the study area. Sub-watershed #241 had the greatest livestock density of 0.22 AU/ha. This is still only 23% of the province's highest value. Sub-watershed #235 had the lowest livestock production density in the study area but also had very high fertilizer and pesticide crop inputs (refer to Table 18.0). Livestock production at any density requires attention to manure management, nutrient management and riparian pasture management. Any area with a higher livestock density may have a greater potential to impact riparian areas.

Table 17.0 Comparison of livestock density in the Lower Red River Watershed study area using 2001 Census livestock numbers converted to Animal Units[1]

Sub-watershed ID	Area[2] (ha)	Livestock Density	
		AU/ha[1]	As a percentage of 0.981 AU/ha[3]
235	23,961	0.11	10.9
237	45,869	0.21	21.3
238	21,753	0.14	14.1
239	40,070	0.18	17.9
240	39,098	0.11	11.0
241	97,638	0.22	22.9

1. Refer to Appendix C for the assumptions used in calculating Animal Units. Some suppression of data occurs (see Table 13.0)
2. Area is calculated as the amount of land planted to annual and hay crops, summerfallow, tame pasture and native land used for pasture, as reported in the 2001 Census of Agriculture
3. Value is calculated as a percentage of the highest AU/ha value determined in Manitoba (using 2001 Census of Agriculture data)

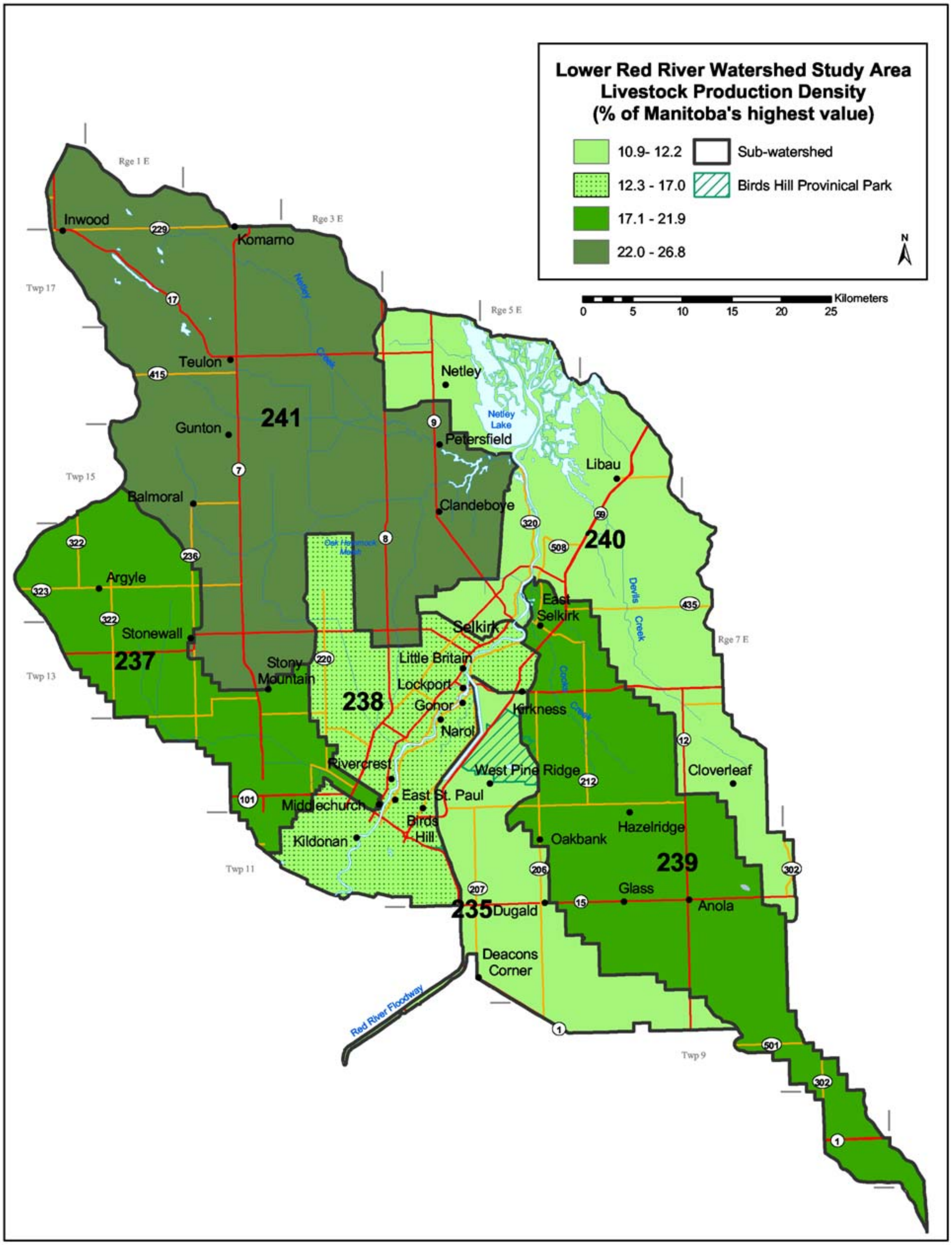

Figure 13.0 Livestock density in the Lower Red River Watershed study area, as a percentage of the highest value in Manitoba of 0.98 AU/ha (as reported in the 2001 Census of Agriculture)

The potential for crop production to impact riparian health and is present in all the sub-watersheds but may be greater in those with higher fertilizer and pesticide crop inputs. Runoff containing nutrients from manure and commercial fertilizers, pesticides, and pathogens can affect riparian vegetation and biodiversity. The value of commercial crop inputs can be used as an indication of crop production intensity. Crop production intensity within a watershed was determined as dollars spent on fertilizers and pesticides (herbicides, insecticides and fungicides) per hectare in the year 2000, as reported by farms in the 2001 Census. Land area was calculated as the number of hectares used for crop and hay production and summerfallow (as reported by farms within the study area). These numbers ($ fertilizer/ha, $ pesticides/ha) were then compared to the highest respective value calculated in all the sub-watersheds with census data in Manitoba. Fertilizer dollars spent per hectare were compared with the highest value of $101.23/ha, found in the sub-watershed containing the community of Bagot (in the Whitemud River Watershed Study Area). Pesticide dollars were compared with the highest value of $81.65/ha, found in the sub-watershed containing the communities of Poplar Point and High Bluff, north of the Assiniboine River (in the Lower Assiniboine River Watershed Area, refer to Appendix D).

Table 18.0 and Figures 14.0 and 15.0 illustrate the different levels of fertilizer and pesticide use in 2000 within the sub-watersheds of the Lower Red River Watershed study area. Fertilizer and pesticide inputs were highest in Sub-watershed #235, where fertilizer inputs averaged almost 84% of the provinces highest input. The sub-watershed of Devil's Creek/Netley Lake had the lowest fertilizer and pesticide inputs in the watershed. Though areas with higher crop production intensities may have a greater potential to impact riparian areas and water quality, best management practices with regards to pesticide and fertilizer use are important in all areas.

Table 18.0 Comparison of crop production intensity the Lower Red River Watershed study area (using dollars spent on pesticides and fertilizers in 2000, as reported in the 2001 Census of Agriculture)

Sub-watershed ID	Area[1] (ha)	Fertilizer[2] (as a percentage of $101.23/ha)	Pesticides[2] (as a percentage of $81.65/ha)
235	22,224	83.7	63.2
237	38,875	59.7	59.0
238	20,341	64.1	50.2
239	34,883	70.7	51.2
240	33,620	51.1	42.0
241	70,775	65.9	50.2

1. Area is calculated as the land planted to annual and hay crops, and summerfallow, as reported in the 2001 Census of Agriculture
2. Value is calculated as a percentage of the highest fertilizer (or pesticide) dollars/ha value determined in Manitoba (using 2001 Census of Agriculture data)

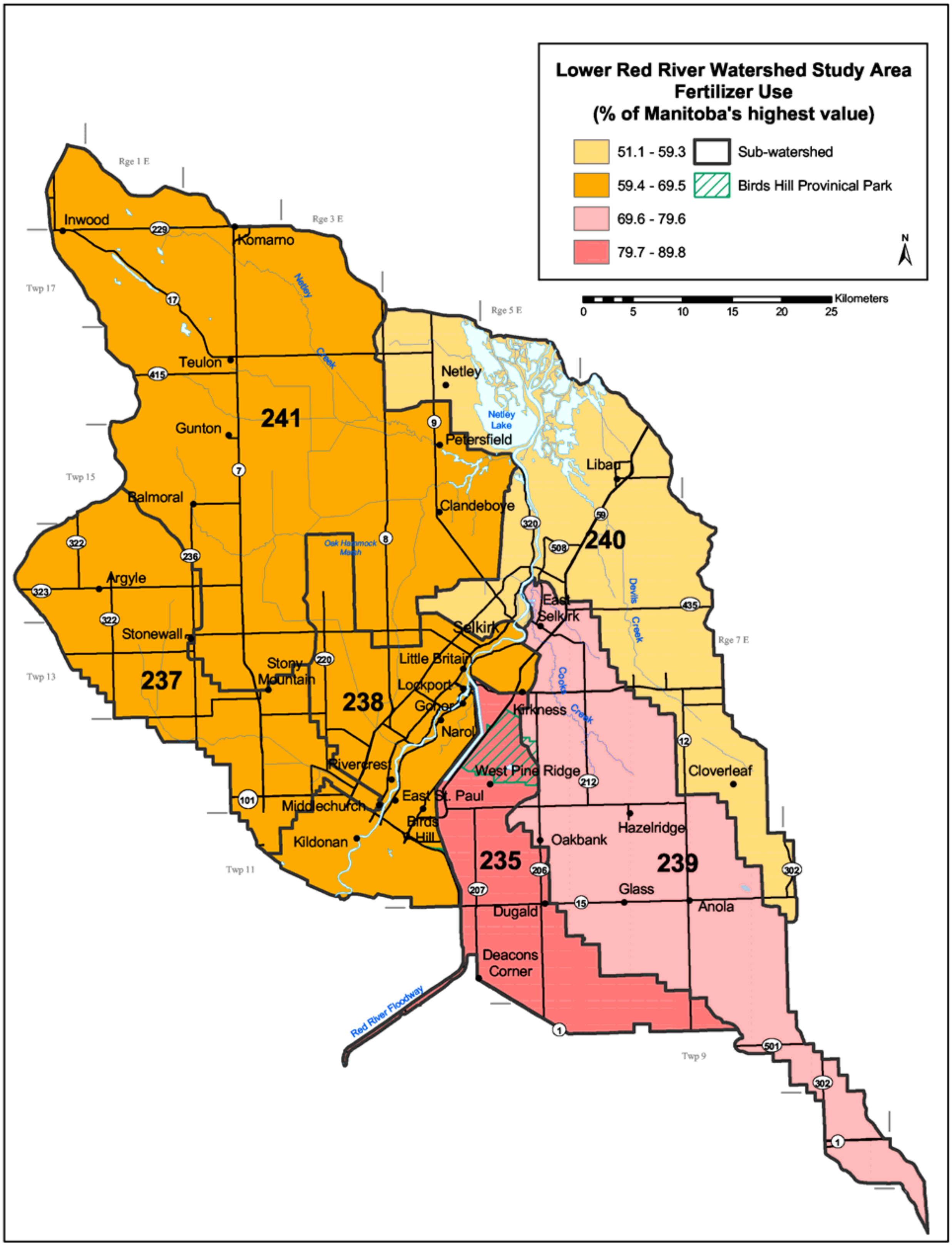

Figure 14.0 Level of fertilizer use in the Lower Red River Watershed study area in 2000, as a percentage of the highest value in Manitoba of $101.23/ha (as reported in the 2001 Census of Agriculture)

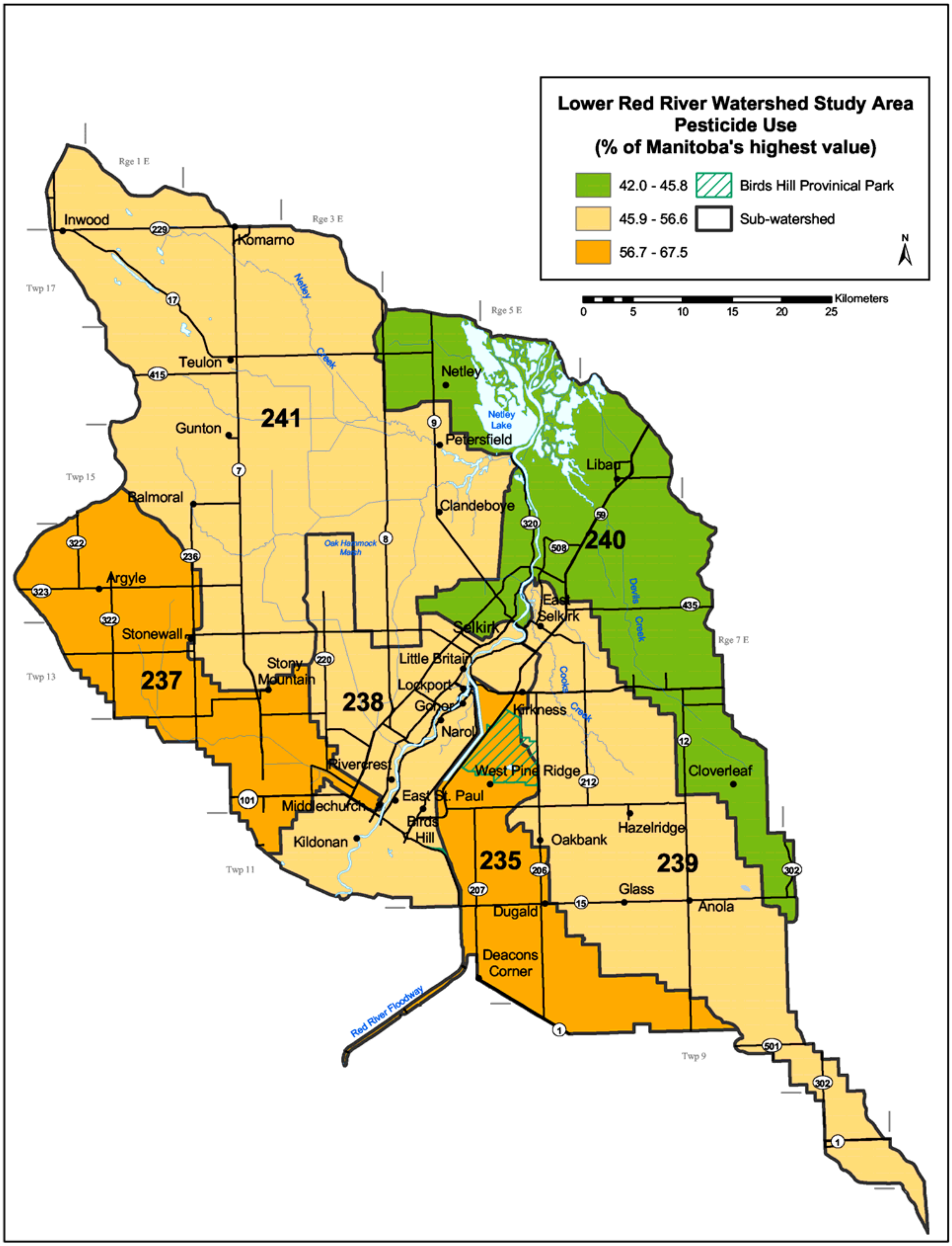

Figure 15.0 Level of pesticide use in the Lower Red River Watershed study area in 2000, as a percentage of the highest value in Manitoba of $81.65/ha (as reported in the 2001 Census of Agriculture)

Summary

Although riparian areas are affected by all activities in a watershed, this report concentrates on the potential impact from agricultural activities. The Lower Red River Watershed study area contains a variety of soils and landscapes and, as a result, supports a diverse agricultural landscape. Appropriate management of agricultural activities is very important to protect riparian areas in the watershed.

Almost three quarters of the Lower Red River Watershed study area is productive agricultural land. Annual crop land is the prevalent land cover and the risk of erosion is reduced somewhat due to the fact that 34% of cropped fields had zero or minimum tillage. Although the majority of the land was in annual crop land in 2001, forage hectares have increased 1.5 times since 1994, reflecting the expansion of the livestock industry. Beef cattle made up the majority of the livestock, representing 51% of the Animal Units produced in the study area. Hogs are also present, though to a much smaller extent. Efforts should continue on education and awareness of the importance of nutrient management, manure management, residue management and crop rotation.

By looking at land cover in an area within a 50 metre distance from all waterbodies and watercourses, an attempt was made to determine areas which might have the potential for healthier riparian areas and areas which may be impacted by agricultural activities. Overall, approximately 29% of the buffered area was annually cropped while a much smaller percentage was under trees. Man-made drains, which facilitate the removal of excess surface water off fields in areas of crop production in the study area, tend to have little or no riparian zones, resulting in a higher presence of annual crop lands and little or no trees in the 50 m buffer area around waterbodies and water courses. With annual crop land in close proximity to surface water, there may be a greater risk for contaminated runoff to enter surface water. Trees are an important part of the riparian area and their presence or absence can indicate a certain level of riparian health. More detailed on-site analysis will be required to determine actual riparian health.

Calculation of shoreline densities provides information on areas where riparian areas are more concentrated. In the Lower Red River Watershed study area, the sub-watershed of Devil's Creek/Netley Lake has the highest shoreline density. Throughout the study area, rivers and creeks, including intermittent streams make up the majority of shoreline, with the exception of the Devil's Creek/Netley Lake sub-watershed where the length of shoreline from waterbodies and from watercourses is almost equal. A higher shoreline density will indicate a greater concentration of riparian areas. Since riparian areas provide a buffer between upland areas and surface water, efforts should continue to promote management practices which maintain or improve riparian health.

An attempt was made to determine an overall level of agricultural intensity with respect to livestock production and crop production. Because thresholds are not known, determinations of high, medium and low were not made. Instead, values were compared to the highest value calculated in Manitoba. In the Lower Red River Watershed study area, livestock densities tend to be higher in the western portion of the study area, with the highest value found in the Netley Creek sub-watershed. This is still

only 23% of the highest livestock density in Manitoba. Crop production intensity was generally found to be highest in the central (west of Winnipeg) and soutwest parts of the watershed. Areas with higher levels of livestock density or crop production intensity, or both, should be targeted for programs which promote the use of management practices that improve riparian health and reduce impacts to water quality.

This report has been presented to provide a central source of riparian-related information to assist in strategic planning for riparian areas in Manitoba. Riparian areas play an important role in surface water quality and their ability to carry out this function can be affected by anthropogenic activities on the landscape. Agriculture is only one component, with other human activities such as industry, recreation and residences contributing to degraded riparian areas. The intent of this report is to be a first step towards addressing the issue of riparian health, with respect to agriculture, in the watershed study area. By providing information on the land resources and the agricultural activities in the study area, a better understanding of the issue can be obtained which will assist towards better planning and priority setting by local decision makers, land use planners and policy decision-makers. While this reports studies the agricultural aspect of the watershed study area, in a true watershed study, all factors of activities of all sectors must be considered. Due to scale and accuracy limitations, this report does not replace the need for site specific analysis; rather, it serves as a guide for general planning purposes Lower Red River Watershed study area.

Future Steps

Agriculture is a significant land use found within many watersheds across the southern portions of Manitoba. The way in which individual producers manage their land can have positive and negative impacts on the environment. The understanding of the relationship between management choices available to agricultural producers in Manitoba and the type and extent of their impact on riparian and water quality issues is not well understood. It is crucial that a better understanding of these relationships be developed. This, in combination with more information about the agricultural activities within a watershed, will provide a solid foundation of science and information upon which programs, policies and beneficial management practices can be developed and evaluated.

However, agriculture is only one component of the anthropogenic activities that occur within any given watershed. Other human activities, such as industry, residences and recreation can also significantly contribute to degraded riparian areas and reduced water quality within a watershed. As with agriculture, the relationship between these activities and the type and extent of their impact is typically not well known. If issues related to riparian areas and water quality within watersheds are to be understood there needs to be significant work done to collect information on these other activities and relate them to watershed issues. This will require all sectors, public and private, to jointly focus on these issues and work together to reaching their resolution.

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Glossary

Alluvial – An accumulation of alluvium (sediment), consisting of gravel or clay, in the bed of a former river. Glaciers may also deposit alluvium known as till.

Animal Unit - the number of livestock required to excrete 73 kg (160 lbs) of nitrogen in a 12-month period in Manitoba

Erosion – The wearing away of the land surface by detachment and transportation of soil and rock material through the action of moving water, wind or other geological processes.

Field Capacity – The amount of water remaining in a soil after free water has been allowed to drain away after the root zone had been previously saturated

Fluvial – All sediments past and present, deposited by flowing water, including glaciofluvial deposits. Sediments generally consist of gravel and sand with a minor fraction of silt and clay. The gravels are typically rounded and contain interstitial sand. Fluvial sediments are commonly moderately to well-sorted and display stratification, but massive, nonsorted fluvial gravels do occur. Finer textured fluvial deposits of modern rivers are termed Alluvium.

Glacial till – Unstratified glacial deposits consisting of clay, sand, gravel and boulders intermingled in any proportion.

Lacustrine – Mineral deposits that either have settled from suspension in bodies of standing fresh water or have accumulated at their margins through wave action. The sediments generally consist of either stratified are varved (layered annual deposits) fine sand, silt and clay deposited on the lake bed; or moderately well sorted and stratified sand and coarser materials that are beach and other near-shore sediments transported and deposited by wave action.

Mean Annual Growing Degree Days - accumulation of days that the daily average temperature [average of maximum and minimum temperature] is greater than 5 C multiplied by the number of 5 C the daily average exceeds 5 C for each day).

Moisture Deficit – Precipitation [P] – Potential Evapotranspiration [PE] = Moisture Deficit accumulated over the growing season by August 13 or September 30.

Permeability – The ease with which water and air pass through the soil to all parts of the profile.

Appendix A

Classification Scheme: Land Cover Mapping of Manitoba	
1. Annual crop land:	Land that is normally cultivated on an annual basis.
2. Forage:	Perennial forages, generally alfalfa or clover with blends of tame grasses.
3. Grassland:	Areas of native or tame grasses, may contain scattered stands of trees
4. Trees:	Lands that are primarily in tree cover
5. Wetlands:	Areas that are wet, often with sedges, cattails, and rushes
6. Water	Open water – lakes, rivers, streams, ponds, and lagoons
7. Urban and Transportation:	Towns, roads, railways, quarries

Appendix B

The Census of Agriculture is conducted concurrently with the Census of Population by Statistics Canada, every five years. The 2001 Census of Agriculture is the most recent Census to date. The Census of Agriculture collects information from operations that meet the definition of a census farm.

In 1996 and 2001, a census farm was defined as "an agricultural operation that produces at least one of the following products intended for sale: crops (hay, field crops, tree fruits or nuts, berries or grapes, vegetables, seed); livestock (cattle, pigs, sheep, horses, game animals, other livestock); poultry (hens, chickens, turkeys, chicks, game birds, other poultry); animal products (milk or cream, eggs, wool, furs, meat); or other agricultural products (Christmas trees, greenhouse or nursery products, mushrooms, sod, honey, maple syrup products)" (Statistics Canada 2002).

The *Statistics Act* requires that all census information be kept confidential. As a result, any data that could disclose information concerning a particular agricultural operation or individual is suppressed in the data tables reported by Statistics Canada. Suppressed data are, however, included in the aggregate subtotals and totals within each data table. In instances where a geographic area has very few agricultural operations, data are not released separately, but are merged with data from one or more geographically adjacent areas (Statistics Canada 2002).

2001 Census of Agriculture Terms and Definitions (*Source: Statistics Canada 2002)*

Agricultural operation: a farm, ranch or other agricultural operation producing agricultural products for sale. Other agricultural operations include, for example: feedlots, greenhouses, mushroom houses, nurseries, Christmas tree farms, fur farms, hobby farms, game farms, beekeeping, sod, fruit and berry, maple syrup and poultry hatchery operations. Sales in the past 12 months are not necessary but there **must** be the intent of sales.

Summerfallow land: a term used to describe land on which no crop will be grown in order to conserve moisture but which will be sprayed or cultivated for weed control.

Tame or seeded pasture: grazeable land that has been improved from its natural state by seeding, draining, irrigating, fertilizing or weed control.

Natural land for pasture: grazeable land that has not been recently improved.

Tillage: the practice of working the soil for the purpose of bringing about the more favourable conditions for plant growth. Clean-till (conventional tillage) incorporates most of the crop residue into the soil, while minimum-till (conservation tillage) retains most of the crop residue on the surface. No-till includes direct seeding into stubble or sod.

Crop rotation: a practice where crops are alternated each year, or in a multi-year cycle, for soil conservation or disease control purposes.

Permanent grass cover: a practice where a field or land is kept in grass cover indefinitely to keep the soil from being eroded away.

Winter cover crops: crops such as oats or fall rye seeded in the fall to protect the soil from water and wind erosion during the winter and from heavy rains and runoff in the spring.

Green manure crops for plough down: the practice of incorporating young green plants into the soil for fertility purposes. These plants are usually grown with the single purpose of being used as a soil improver. Common examples are buckwheat and red clover.

Contour cultivation: the practice of cultivating the field across the slope to reduce soil erosion from rapid water runoff.

Grassed waterways: either natural or constructed, to control soil erosion. The waterway is permanently grassed and consists of a shallow channel, which is designed to slow down runoff water. The grass stabilizes the soil and prevents it from being washed away. They are usually shaped to allow easy crossings by farm machinery.

Strip-cropping: (or strip farming, field strip-cropping or wind strip-cropping) a method of controlling soil erosion by dividing the farm into narrow fields having different crops, with or without fallow. For example, the narrow fields may be alternately cropped–uncropped (e.g., wheat–fallow–wheat–fallow) or they may be strips of different crops (cereals, corn, soybeans). The widths of the cropped strips are usually multiples of a tillage implement or spray boom, etc.

Windbreaks or shelterbelts: trees, either planted or naturally present. This practice is used more predominantly in western Canada where farmland is more susceptible to wind action and where trapping snow for moisture is important.

Appendix C

Summary of Animal Unit coefficients used in Manitoba as compared to those used for calculations in this report[1]. Assumptions are given in the following Table.

Livestock	Animal Units produced by one animal (MAFRI)	Animal Unit coefficient used in report
Dairy		
Milking Cows (including associated livestock)	2.000	2.000
Beef		
Beef Cows, incl. associated livestock	1.250	1.250
Backgrounder	0.500	\
Summer pasture	0.625	} 0.631
Feedlot	0.769	/
Hogs		
Sows, farrow-to-finish	1.250	--
Sows, farrow-to-weanling	0.313	0.313
Sows, farrow-to-nursery	0.250	--
Weanlings	0.033	--
Grower/finishers	0.143	0.143
Boars (artificial insemination operations)	0.200	0.200
Chickens		
Broilers	0.0050	0.0050
Roasters	0.0100	--
Layers	0.0083	0.0083
Pullets	0.0033	0.0033
Turkeys		
Broilers	0.010	\
Heavy Toms	0.020	} 0.014
Heavy Hens	0.010	/
Horses (PMU)		
Mares, including associated livestock	1.333	1.00
Sheep		
Ewes, including associated livestock	0.200	0.200
Feeder Lambs	0.063	--
Goats	0.143	0.143
Bison		
Cow	1.00	\
Bull	1.00	} 0.8875
Calf	0.25	/
Elk		
Cow	0.53	\
Bull	0.77	} 0.520
Calf	0.05	/

1. An Animal Unit is defined as the number of livestock required to excrete 73 kg (160 lbs) of nitrogen in a 12-month period (as defined in the Farm Practices Guidelines for Poultry Producers in Manitoba)

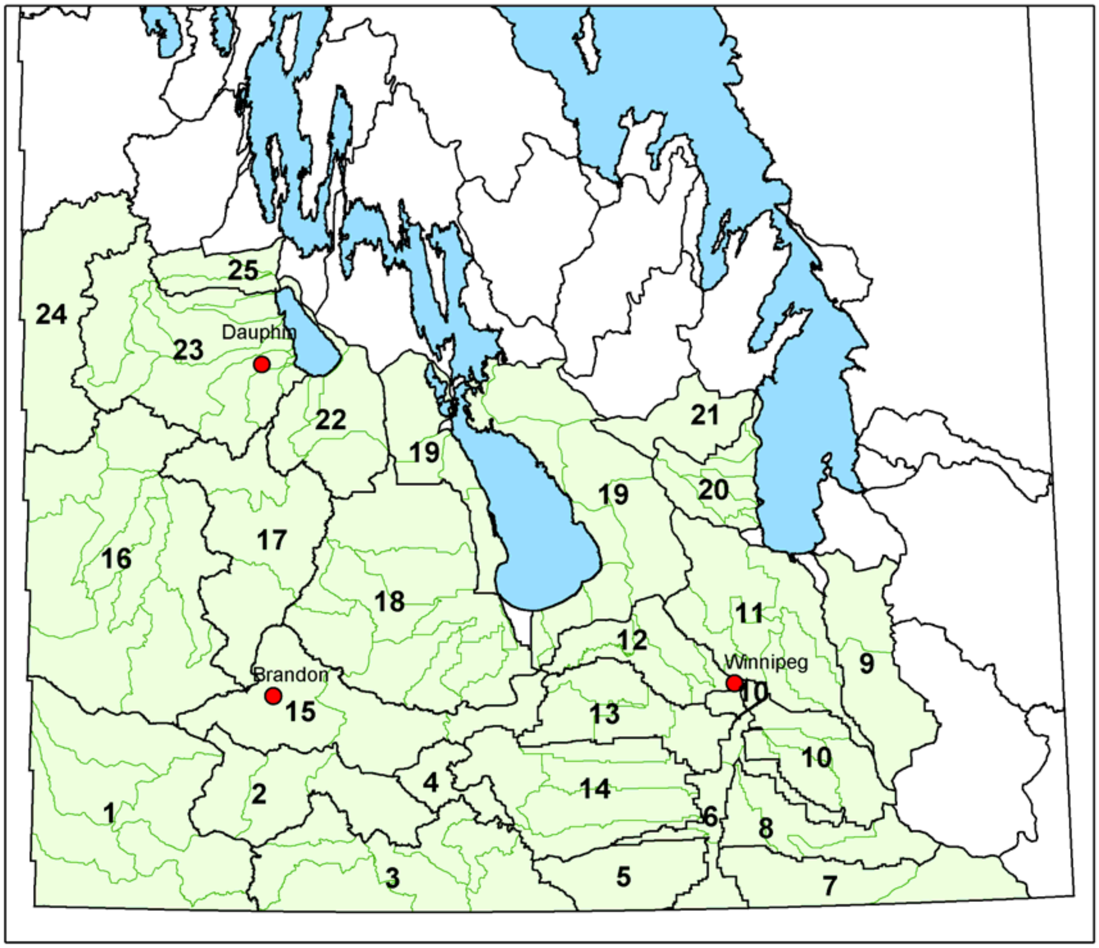
Summary of assumptions made in calculating Animal Units[1] from 2001 Agricultural Census Data.

Livestock	Manitoba Animal Unit Category	Census Category	Assumptions Used for Animal Unit Calculations with census data
Dairy	Milking cows (including associated livestock)	Dairy cows	Assumed categories are equal.
Beef	Beef cows	Beef cows	Assumed number of beef cows reported in 2001 Census equal cow/calf pairs
	Backgrounder Summer pasture Feedlot cattle	Heifers and steers for slaughter or feeding 1 yr and older (combined categories)	Assumed steers and heifers reported in these census categories are split into the three categories (communication with MAFRI). Animal unit coefficient determined using this ratio.
Pigs	Sows, farrow–to-weanling	Sows	Assumed there are no farrow-to-finish operations and no weanling operations in Manitoba – only farrow-to-weanling and grower/finisher operations.
	Grower/finishers	Grower and finisher pigs	
	Boars (artificial insemination operations)	Boars	Assumed all boars reported in the 2001Census are from artificial inseminations.
Chickens	Broilers	Broilers and roasters	Assumed all birds reported in the census category are broilers (communication with MAFRI).
	Layers	Laying hens (19 weeks and older)	Assumed categories are equal.
	Pullets	Pullets (under 19 weeks)	Assumed categories are equal.
	Broiler breeding hens	Laying hens in hatcheries	Assumed all laying hens in hatchery supply flocks reported in Manitoba are broiler breeder hens.
Turkeys	Broiler, Heavy Toms, Heavy Hens	Turkeys	Assumed "turkeys" represents 20% boilers, 40% heavy toms, 40% heavy hens (communication with MAFRI). Animal unit coefficient is determined using this ratio.
Sheep	Ewes, including associated livestock	Ewes	Assumed ewe/lamb pairs (communication with MAFRI).
	Feeder lambs	Lambs	Assumed no feeder lambs in province since numbers are very small and cannot be determined from census data (communication with MAFRI).
Horses	Horses	Total horses and ponies	Assumed each animal produces 1 Animal Unit – PMU farms not identified in Census (communication with MAFRI).

Livestock	Manitoba Animal Unit Category	Census Category	Assumptions Used for Animal Unit Calculations with census data
Bison	Bison	Bison	Assumed adults represent 85% and calves represent 15% of bison population in Manitoba (communication with MAFRI). Animal unit coefficient is determined using this ratio.
Elk	Elk	Elk	Number of calves and sex of animals not identified in Census – assumed 45% cows, 35% bulls and 20% calves (communication with MAFRI). Animal unit coefficient is determined using this ratio.
Goats	Goats	Goats	Number of kids and sex of animals not identified in Census – assumed 7 goats make up one Animal Unit, irregardless of age and sex.

1. One Animal Unit is defined as the number of livestock required to excrete 73 kg (160 lbs) of nitrogen in a 12-month period (as defined in the Farm Practices Guidelines for Poultry Producers in Manitoba)

Appendix D

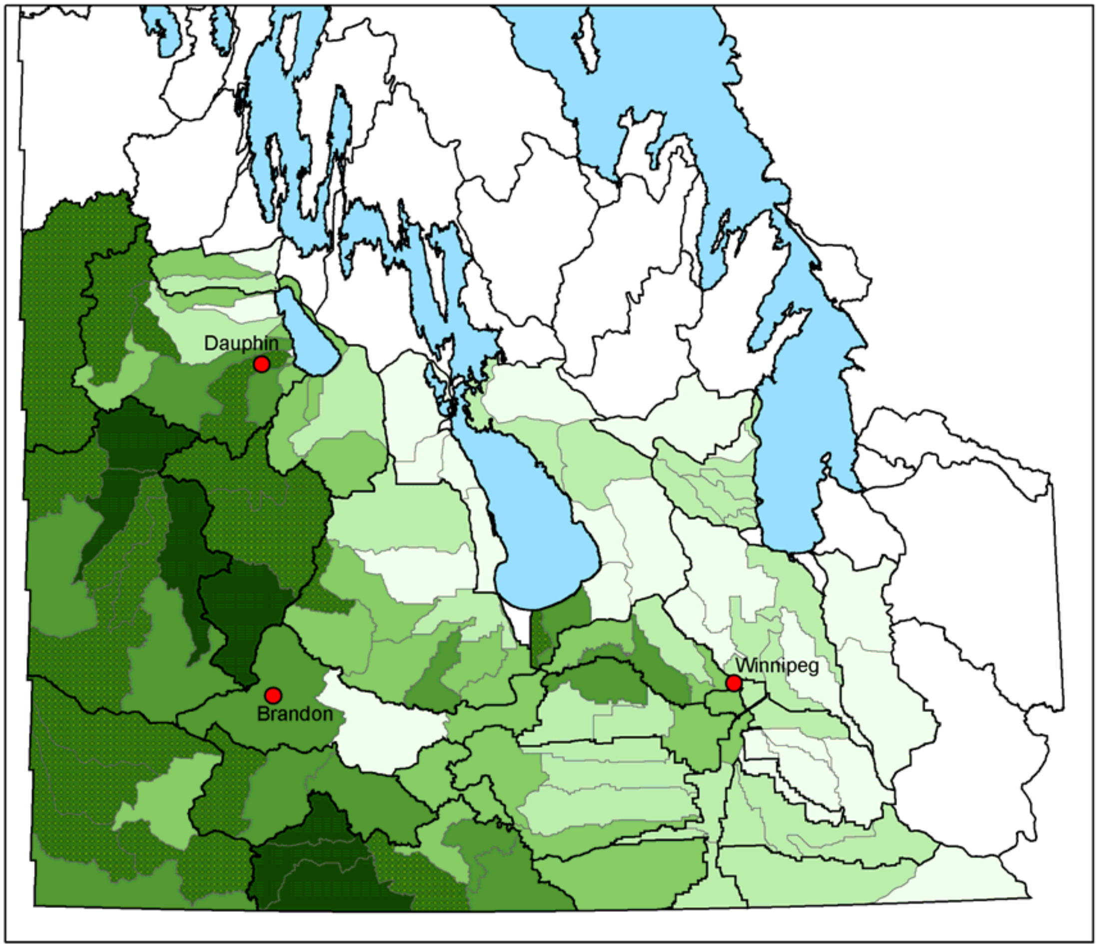


Watershed Study Area Summary Reports in Manitoba (black outline) and the sub-watershed areas (green outlines) used for the custom tabulation of the 2001 Census data.

Watershed Study Areas   Sub-watershed areas

ID	Report	ID	Report
1	Upper Souris River Watershed Study Area	14	Boyne-Morris River Watershed Study Area
2	Lower Souris River Watershed Study Area	15	Middle Assiniboine River Watershed Study Area
3	Pembina River Watershed Study Area	16	Upper Assiniboine River Watershed Study Area
4	Cypress River Watershed Study Area	17	Little Saskatchewan River Watershed Study Area

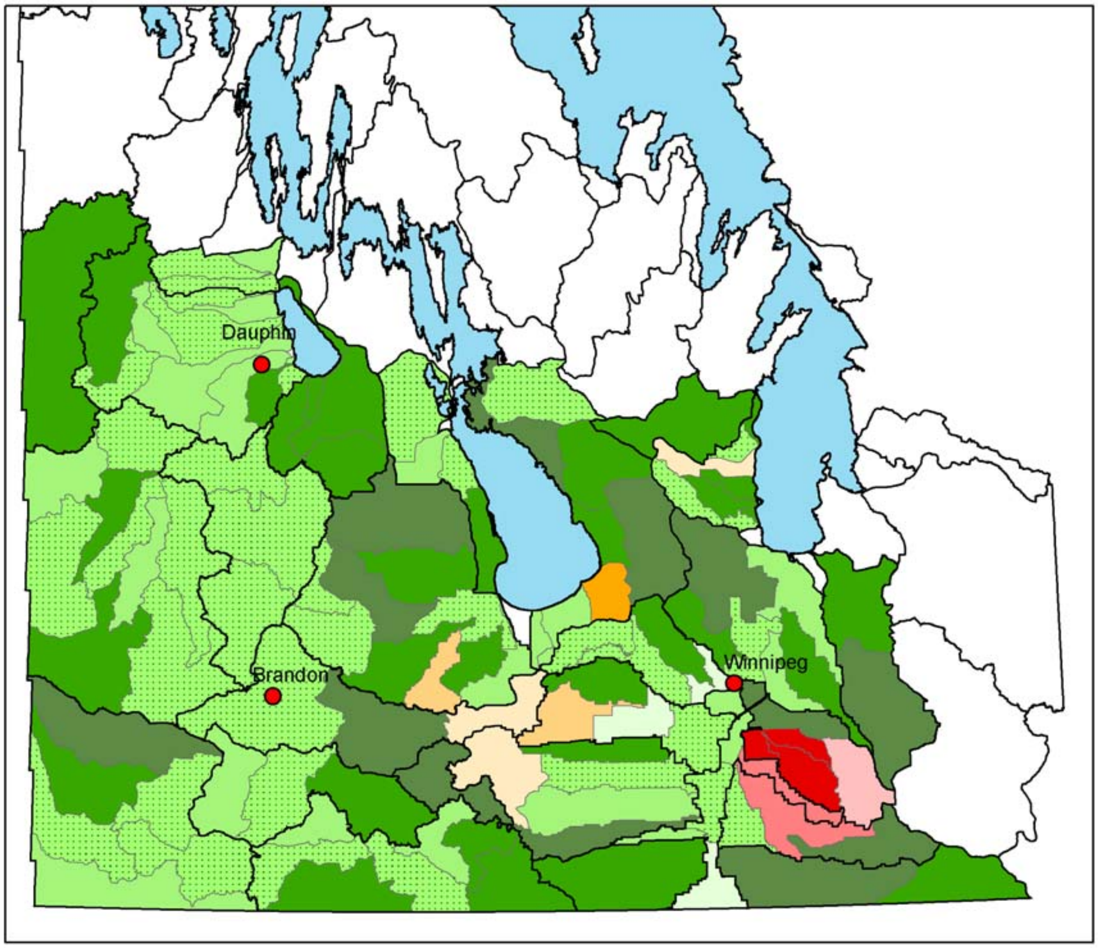
[redacted]



Comparison of Shoreline Densities in Manitoba calculated as metres of shoreline/ha in each sub-watershed*

2.6 - 7.5	17.3 - 22.1
7.6 - 12.3	22.2 - 27.0
12.4 - 17.2	27.1 - 31.8

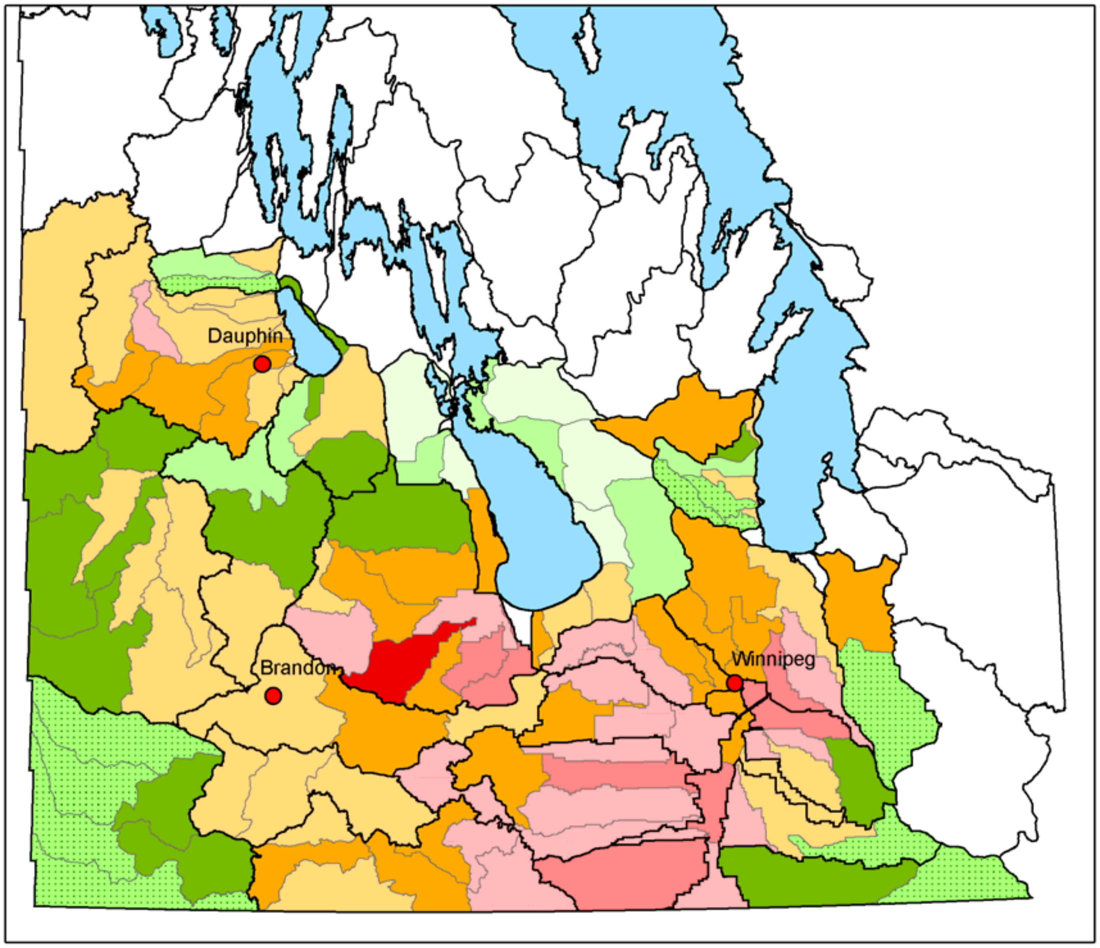
* Length of shoreline of both permanent and intermittent waterbodies and watercourses was determined from the 1:50,000 NTS datasheets (note that densities will be slightly underestimated since numerous small wetlands and potholes as well as some small constructed water courses (first, second and third order drains) are not captured by the NTS sheets).



Comparison of livestock production densities in Manitoba as a percentage of the highest value calculated in a sub-watershed using 2001 Census livestock numbers converted to Animal Units*

- 2.4% - 7.3%
- 7.4% - 12.2%
- 12.3% - 17.0%
- 17.1% - 21.9%
- 22.0% - 26.8%
- 26.9% - 31.7%
- 31.8% - 36.6%
- 41.4% - 46.3%
- 70.7% - 75.6%
- 75.7% - 80.5%
- 95.1% - 100%

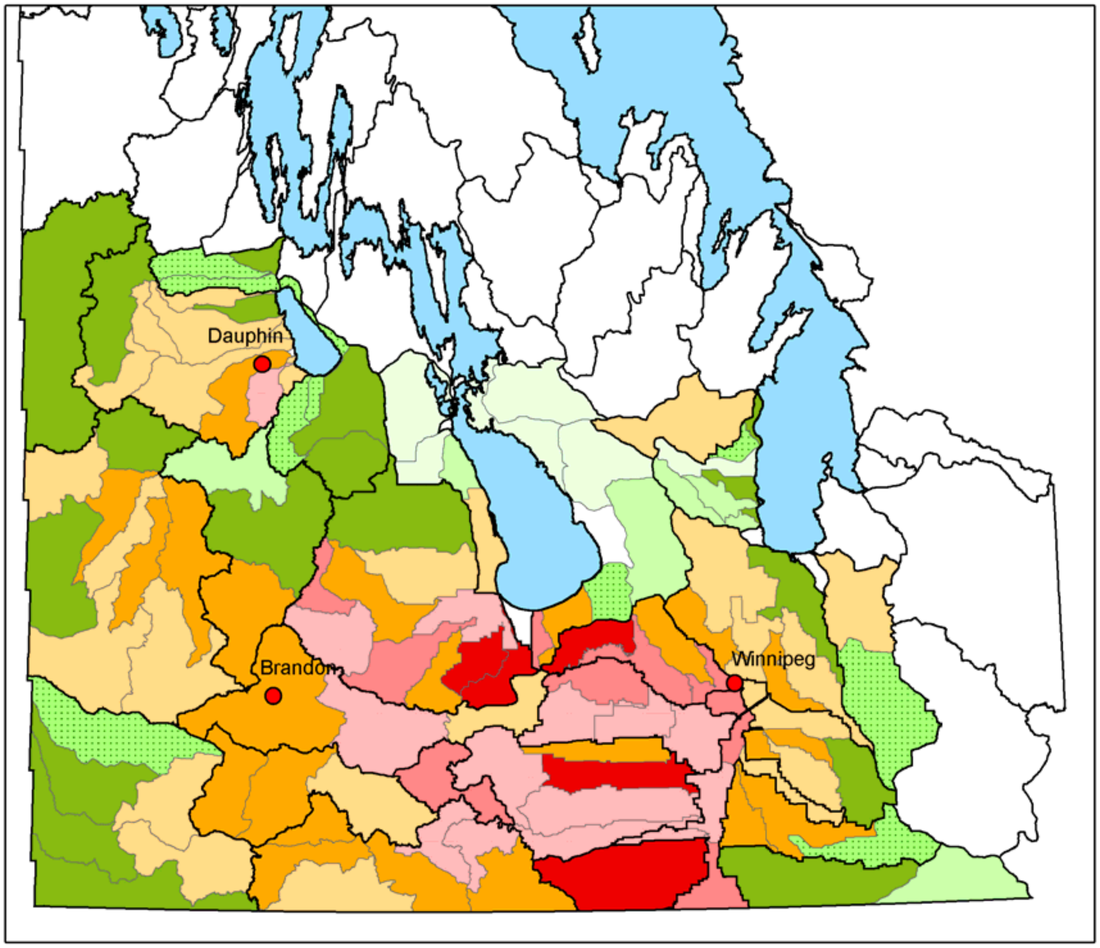
* Densities of different types of livestock were standardized by calculating Animal Units per hectare (AU/ha). In Manitoba, an Animal Unit is defined as the number of livestock required to excrete 73 kg (160 lbs) of nitrogen in a 12-month period (refer to Appendix C for assumptions used to derive AU coeffiecients). Suppression of livestock numbers in the census data will affect total AU to varying degrees, depending on the amount of suppression. Area used in calculation consisted of hay and crop land, summerfallow, tame pasture and native land used for pasture (as reported in the 2001 Census of Agriculture).



Comparison of commercial fertilizer use in sub-watersheds in Manitoba, calculated as a percentage of the highest value in a sub-watershed (as reported in the 2001 Census of Agriculture).*

8.4% - 18.6%	39.0% - 49.1%	69.6% - 79.6%
18.7% - 28.8%	49.2% - 59.3%	79.7% - 89.8%
28.9% - 38.9%	59.4% - 69.5%	89.9% - 100%

* Level of fertilizer use is calculated as dollars spent on fertilizers per hectare in the year 2000, as reported by farms in the 2001 Census of Agriculture. Land area was calculated as the number of hectares used for crop and hay production and summerfallow (as reported by farms for the 2001 Census).



Comparison of pesticide use in sub-watersheds in Manitoba, calculated as a percentage of the highest value in a sub-watershed (as reported in the 2001 Census of Agriculture).*

2.4% - 13.2%	35.0% - 45.8%	67.6% - 78.3%
13.3% - 24.1%	45.9% - 56.6%	78.4% - 89.2%
24.2% - 34.9%	56.7% - 67.5%	89.3% - 100%

* Level of pesticide use (herbicides, insecticides and fungicides) is calculated as dollars spent on fertilizers per hectare in the year 2000, as reported by farms in the 2001 Census of Agriculture. Land area was calculated as the number of hectares used for crop and hay production and summerfallow (as reported by farms for the 2001 Census).