Resource Summary

For the

East Souris River Watershed

December, 2005

Acknowledgements

The state of the watershed report for the East Souris River Integrated Watershed Management Plan was compiled through the co-operation and efforts of various individuals and agencies that provided technical information to complete this document.

The support of staff from the following agencies was essential in preparing the state of the watershed report:

Agriculture and Agri-Food Canada
Ducks Unlimited Canada
Environment Canada
Manitoba Agriculture, Food and Rural Initiatives
Manitoba Conservation
Manitoba Habitat Heritage Corporation
Manitoba Industry, Economic Development and Mines
Manitoba Intergovernmental Affairs and Trade
Manitoba Water Stewardship
Turtle Mountain Conservation District

This document could not have been completed without the funding support from the partner municipalities of the Turtle Mountain Conservation District and Manitoba Water Stewardship. A special thank-you is extended to all individuals and organizations that assisted with the preparation of this report.

TABLE OF CONTENTS

List of Figures

List of Tables

List of Appendices

Introduction

This document is to serve as a resource tool for all participants involved in the East Souris River (ESR) Integrated Watershed Management Plan (IWMP). The compilation of technical information related to resources in the study area should help to inform all people interested in the watershed regarding the resources that exist.

The state of the watershed report may also identify data gaps and areas where a lack of information exists. The state of the watershed report is a tool that can be used to make everyone aware of the status of resources in the watershed.

Study Area

The Souris River watershed is situated astride the Canada-U.S. border (Figure 1) with the headwaters originating in the Yellow Grass Marshes north of Weyburn in southeast Saskatchewan. The river continues through northwest North Dakota and terminates in southwest Manitoba where it enters the Assiniboine River. The Souris River is approximately 720 kilometres long and has a drainage area of approximately 45,500 km^2.

The 2,922 km^2 East Souris River watershed consists of four sub-watersheds that will be targeted in this planning process, namely, Waskada Creek (Provincial sub-watershed #65), Medora Creek (Provincial sub-watershed #66), Chain Lakes (Provincial sub-watershed #67) and Whitewater Lake (portion of Provincial sub-watershed #68).

The Waskada Creek, Medora Creek and Whitewater Lake sub-watersheds originate in the Turtle Mountains, while the headwaters of the Chain Lakes sub-watershed starts in the northern portion of the R.M.'s of Winchester and Brenda. The Waskada Creek, Medora Creek and Chain Lakes sub-watersheds terminate at the Souris River, while the Whitewater Lake sub-watershed drains into Whitewater Lake and would only enter the Souris River if water levels become extremely high in very rare situations.

The drainage areas of the Waskada Creek, Medora Creek, Whitewater Lake and Chain Lakes sub-watersheds are approximately 812 km^2, 481 km^2, 971 km^2 and 658 km^2 respectively which combine for a total area of 2,922 km^2 for the East Souris River IWMP study area. The Turtle Mountain Provincial Park exists in the headwaters of the Whitewater Lake sub-watershed. Cottage developments exist on Lake Metigoshe, Dromore Lake, Lake Hasselfield and Sharpe Lake in the R.M. of Winchester. There are also cottage developments on Lake Max and Bower Lake and provincial campgrounds at Lake Max and Lake Adam within the Turtle Mountain Provincial Park.

The majority of land within the study area is used for a variety of agricultural activities, while also providing recreational and tourism opportunities. The study area is also rich in human history.

The towns of Deloraine, Waskada, Hartney, Goodlands, Medora, Napinka, Lauder, and portions of Souris and Boissevain lie within the study area. Portions or entire areas of the R.M.'s of Arthur, Brenda, Winchester, Morton, Cameron, Glenwood and Sifton also comprise the study area.

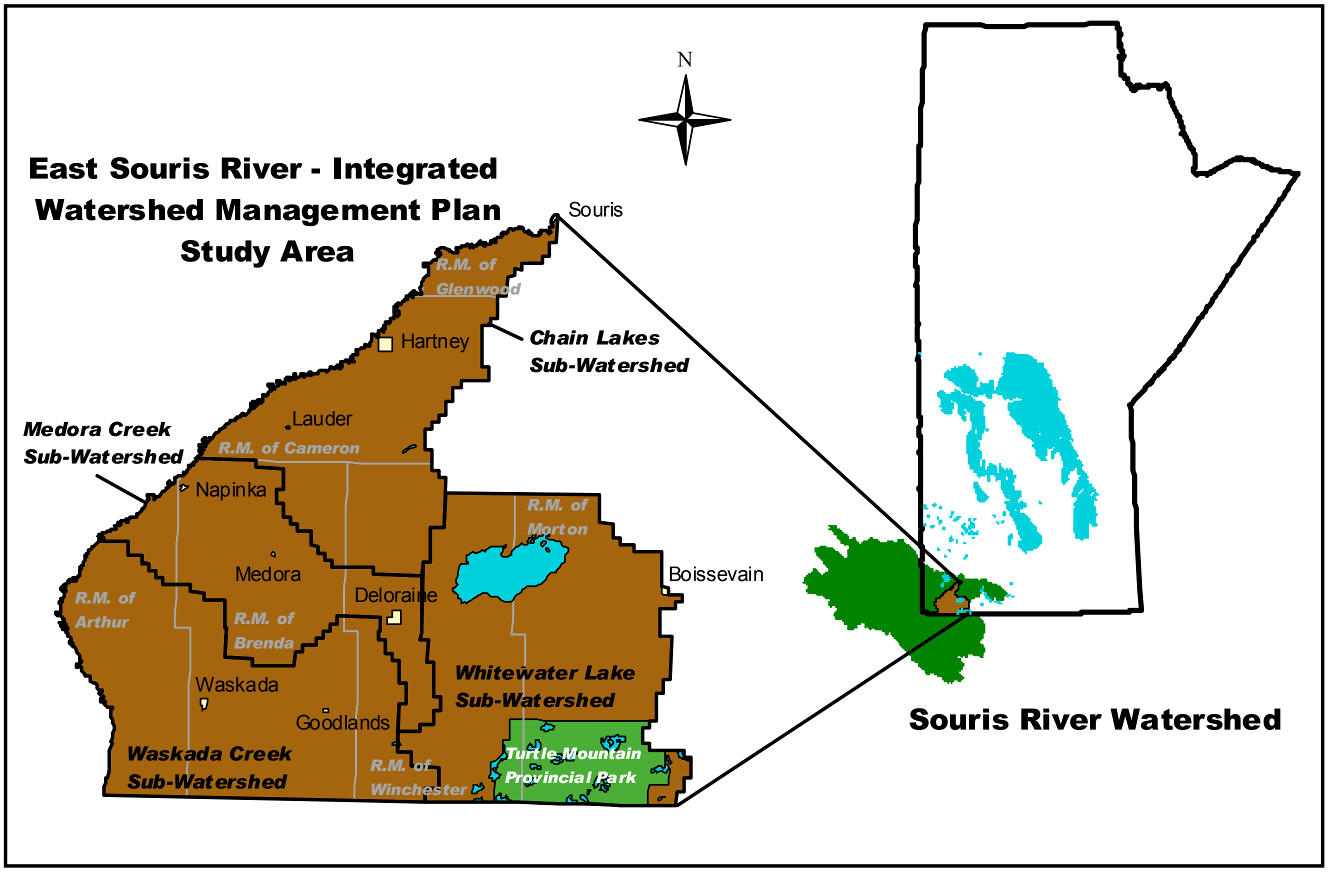

Figure 1. Souris River watershed and location of East Souris River IWMP study area in relation to the Province of Manitoba.

Human History and Population

Early History

Twenty to thirty thousand years ago the basic modern geography of the Turtle Mountain area was being shaped by the last Ice Age. Ten to twelve thousand years ago the ice sheet was melting and breaking up. In melting and in re-flooding of the landscape, the glacial meltwater largely shaped the watershed and drainage patterns which characterize the East Souris River IWMP study area.

The plateau of the Turtle Mountain feature is a relic of the Missouri Couteau, cut off by the gigantic glacial rivers that flowed around and passed it. The outlines of the Souris and Pembina Valleys reflect the general flow of these ice rivers. Many creek beds today follow the drainage away from the original high ground and then bend to follow the route of glacial lobes and rivers.

From about 10,000 BC to 6,000 BC most of the East Souris area was under water. Glacial lakes Souris and Whitewater received drainage from the south, as well as meltwater from the north as the glacier retreated. With no where for this water to go, huge lakes re-flooded the landscape only recently freed from the ice. During this period our rich soils were laid down as lake and river bottom silt, which settled when the water could drain gradually.

It is also from this period of glacial melt and flooding that we obtain the first evidence of human occupation. Clovis and Folsom points found in gravel beds throughout the study area suggest a thin but steady re-colonization of the land. Mammoth, mastodon and giant sloth were hunted by determined cooperative groups.

The large game animals become extinct and were replaced by bison and waterfowl as the staple meat sources. Eventually the ice front retreated north of the Interlake region. This allowed Glacial Lake Souris and Whitewater to drain out onto the newly exposed eastern Manitoba plains. Lake Agassiz formed in the east and north of Manitoba by 6,000 BC. The East Souris River study area entered a new phase as it dried out. Whitewater Lake and the Souris River shrunk to nearer their present size.

The large herd animals and flocks of geese continued to follow the erosion pattern of the receding glacial lakes. A former glacial river drain such as the Blind Souris Valley, once dry became an ideal route for migrating buffalo. Whitewater Lake once the northern edge of migratory waterfowl range became a mid-way stopping point as the flyway extended northward.

The explosion of game and land led to an explosion of human population which is reflected in several hundred known archaeological sites scattered throughout the study area. Trails developed which followed the buffalo herds. Communities and industries sprang up at crossroads. When the Homestead Era arrived in the late 1800’s the incoming pioneers followed the same roads and often settled at the same crossroads. A good camping spot such as Sourisford-Coulter Park or Newcomb’s Hollow may have provided periodic shelter for humans for six to ten thousand years.

The establishment of permanent settlements did not occur until the late 1800's after early explorers had traveled the prairies and fur traders established forts along river systems to allow their type of commerce to flourish. It was not until the mid 1880's that settlers were able to rely on established river and overland routes, like the old Mandan Trail and Yellow Quill Trail, to reach areas outside of the new "postage stamp" province (circa 1870). The Boundary Commission Trail (circa 1874) from Fort Dufferin on the Red River west along the boundary with the U.S.A. to the present Saskatchewan border was the route chosen by the early police force sent west to deal with problems with whiskey traders and by many other people wanting to settle in the southwest corner of Manitoba.

Settlement
The first settlers arrived in the Deloraine area in 1879 encouraged by promises of family ownership of inexpensive and easily farmed land. By 1886, a railway had been built and more immigrants to Canada continued to arrive in the Deloraine area from all over Europe. The townsite of Deloraine was moved in the winter of 1886 to be adjacent to the new railway and 1888 saw the first influx of immigrants from Belgium.

Increasing Population
Population continued to grow from immigration and natural increase (i.e. local births) which supported an increase in the range of goods and services made available to farmers and those who served agriculture and other local industries (like the brick factory and coal mine) established in the region.

Information from early national census takings showed that the number of farms in Canada peaked between 1920 and 1940 and has declined from a high of more than 700,000 in 1940 to only 225,000 by 1988. The number of farms in Manitoba declined sharply between 1996 and 2001 according to more recent agricultural census information. The number of farms in Manitoba has decreased by 28.4% since 1981 with 13.6% of the decline occurring over the five year period after 1996.

By 2001, there were 21,071 farms in Manitoba while in 1981 that number stood at 29,442. Manitoba's share of the nation's farms in 2001 remained virtually stable at just under 9%. Since 1981, the average Manitoba farm has increased in size (i.e. the amount of land farmed, herd size, and gross farm receipts) by 39.4%.

There are many reasons for the decline in the number of farms but the major cause is viewed by many researchers as the replacement of labour-intensive farming by capital-intensive farm operations. The continued industrialization of agriculture has stimulated rural emigration as measured by declining population numbers. This phenomenon is now known as "rural depopulation".

Declining Rural Population
While most early settlers began their prairie life on a farm, the restructuring of agriculture has been partially responsible for growth in urban areas. One hundred years ago, 80% of the people on the North American continent were considered rural. A century later, only 20% of people on that same landscape were living in a non-urban setting. The numbers of people in the rural countryside had changed significantly.

This trend is evident in the local population as well. The Rural Development Institute at Brandon University prepared a report in 1991 which analysed the agro-Manitoba population. In that report, the authors concluded that the local population would continue its decline like so many parts of North America.

Rural populations in the countryside have declined steadily for more than 50 years driven in part by the industrialization of agriculture. Throughout Canada, rural population decline is expected to continue as young people leave the remaining farms and rural communities in numbers dictated by modern farm economics as well as work and lifestyle opportunities, both real and perceived, which exist in larger towns and cities. While Manitoba places like Winnipeg and Brandon are expected to gain the most by migration of the young, many youth are choosing to leave the province for other parts of the country or the world.

Depopulation Challenge

The Rural Development Institute has also expressed the view that the long-term depopulation of most areas of rural Manitoba has occurred in response to short-term labour markets. In the process, however, they also see that the essential labour pool needed for long-term development has disappeared which in turn greatly limits any possibility for long-term stability and growth in the rural regions of the province.

Rural communities facing population decline also endure a loss of commercial businesses, reduced public services, increased municipal taxes, plus increased dependence on the provincial government for roads and schools. The loss of people means that there are fewer and fewer taxpayers to share an ever increasing tax bill just to provide the public services available today. In recent times, there have been many calls for financial support from other levels of government to share the costs of providing local services such as municipal sewer, water, and road infrastructure.

While rural depopulation is certainly not a new trend in the nation, the province, or the local community, rural areas (like the watershed under study) are hitting critically low population levels. Dr. Rounds of the Rural Development Institute is on record suggesting that communities of 1000 or more people have a fighting chance at survival in the new rural landscape.

The challenge for rural leaders is not only to recognize the national and provincial trends, but to launch local efforts to change local attitudes about development and hopefully return to the spirit of optimism that the early settlers lived and breathed. While they may not be able to stop young people from leaving their community to try out the bright lights of beckoning cities in this country and the world, they should at least make every effort attempting to attract those folks back to their home community.

Demographics can teach those leaders that a community with decades of declining numbers of people in the 20 to 34 age bracket will have little hope of a prosperous future. Addressing some of the issues leading to the out migration of youth, and making it possible for those less than 34 years old to return to the community, has to be the foremost challenge for many small communities. Given the trends described above, to do nothing is a decision to allow rural depopulation to continue unchecked and for the community to die a predictable death. Having a healthy and sustainable watershed may be one of the attractions for youth to return to the community.

East Souris River Watershed Population

While population statistics are not available on a watershed basis, the following table shows the calculated population in the East Souris River watershed at 4,267 individuals (see Table 1).

By 2001, the six rural municipalities included in the watershed held 43% of the population and the remaining 57% of people lived in the towns and villages. Between 1986 and 2001, the four towns and one village suffered an average population decline of 20% while the surrounding rural municipalities declined by about 15%. The highest rural area decline was 34% in the RM of Arthur while the Village of Waskada endured the highest urban decline of 40%. Average population decline in the towns was about 8%.

In broad general terms, the watershed population has declined by about 14% over the past 15 years with the urban area population declining at a slower rate than in the surrounding farming areas. It would be fair to suggest that having some farmers choosing to move to the nearby town at retirement were responsible for the different rate of decline in those populations.

Table 1. Population data for municipalities and towns within the East Souris River IWMP study area from 1986-2001.

Municipality	**1986**	**1991**	**1996**	**2001**	**Illustrated Trends from 1986 and 2001**		**% of Municipality within ESR study area**	**Estimated Population within ESR study area in 2001**
	#	**#**	**#**	**#**	**#**	**%**		
Arthur	731	581	528	480	(251)	34.3	49.8	227
Brenda	906	801	726	616	(290)	32.0	nearly 100	616
Cameron	613	538	537	496	(117)	19.1	49.7	247
Glenwood	708	722	710	697	(11)	1.6	14.0	98
Morton	885	848	832	760	(125)	14.1	53.4	406
Winchester	718	661	625	573	(145)	20.2	100.0	573
Totals	**4561**	**4151**	**3958**	**3622**	**(939)**	**20.3**		**2167**
Town								
Waskada	349	289	288	208	(141)	40.4	100.0	208
Boissevain	1572	1484	1544	1495	(77)	4.9	14.1	210
Deloraine	1134	1045	1041	1026	(108)	9.5	100.0	1026
Hartney	523	477	462	446	(77)	14.7	100.0	446
Souris	1751	1662	1613	1683	(68)	3.9	12.5	210
Totals	**5329**	**4957**	**4948**	**4858**	**(471)**	**14.7**		**2100**
Watershed Totals	**9890**	**9108**	**8906**	**8480**	**(1410)**	**14.3**		**4267**

Socioeconomic Profile

Statistical information on individual earnings for people living within the watershed suggests that the urban areas have witnessed earning growth around 12 % in the five year period ending in 2001. During that same time frame, the rural areas have shown a similar decline in individual earnings.

Based on Statistic Canada 1996 and 2001 Census for the average individual earnings, based on all persons with earnings, for the towns in the East Souris River study area are as follows;

	1996	**2001**
Boissevain	$20,093	$24,661
Deloraine	$23,326	$22,503
Hartney	$16,534	$19,793
Souris	$21,641	$24,012
Waskada	$20,184	unavailable
Average	**$20,356**	**$22,742**

Based on Statistic Canada 1996 and 2001 Census for the average individual earnings, based on all persons with earnings, for the rural municipalities in the East Souris River study area are as follows;

	1996	**2001**
RM of Arthur	$17,056	$20,925
RM of Brenda	$23,817	$13,682
RM of Cameron	$20,739	$20,649
RM of Glenwood	$23,158	$17,821
RM of Morton	$22,017	$16,757
RM of Winchester	$18,233	$18,830
Average	**$20,837**	**$18,111**

Figures 2 and 3 demonstrate that the senior portion of the urban population has declined by about 2 % between 1991 and 2001 while the urban youth portion remained fairly steady over that decade. The younger portion of the work force ages 20 – 44 years grew by 2 % in the towns and villages while school aged children 0 – 19 years increased by 4 %.

Figures 4 and 5 show that the youth and senior portions of the rural population have declined in numbers over that same decade. As a percentage of the rural population, however those two groups have remained steady at about 10 %. Like the urban areas of the watershed, the younger part of the workforce decreased while the 45 – 64 years age group increased as a percentage of the rural population.

Conclusions:
This bit of information on the socio-economic profile of the people living in the watershed clearly indicate that like many parts of North America the non-urban parts of the country and province are suffering from population decline. While all areas of the watershed under study reveal a decrease in population, the towns and villages are experiencing a slower rate of decline than the rural municipalities (Table 2). In addition, there is evidence of a declining and aging workforce as well as declining incomes in the rural areas of the watershed.

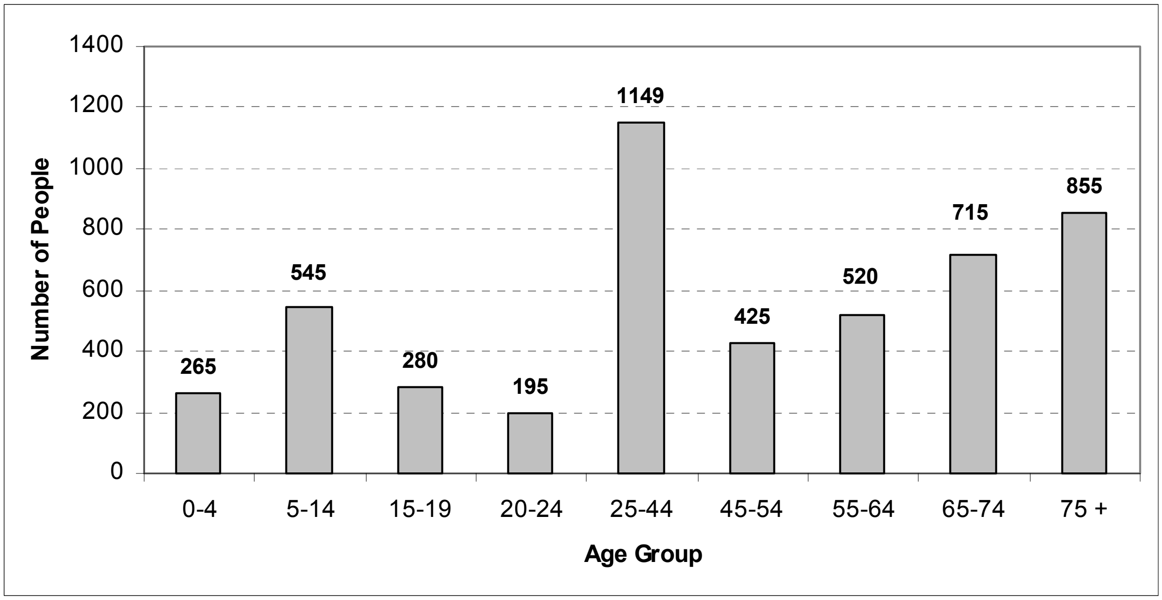

Figure 2. Total population by age group for Boissevain, Deloraine, Hartney, Souris and Waskada for 1991 (Source Statistics Canada).

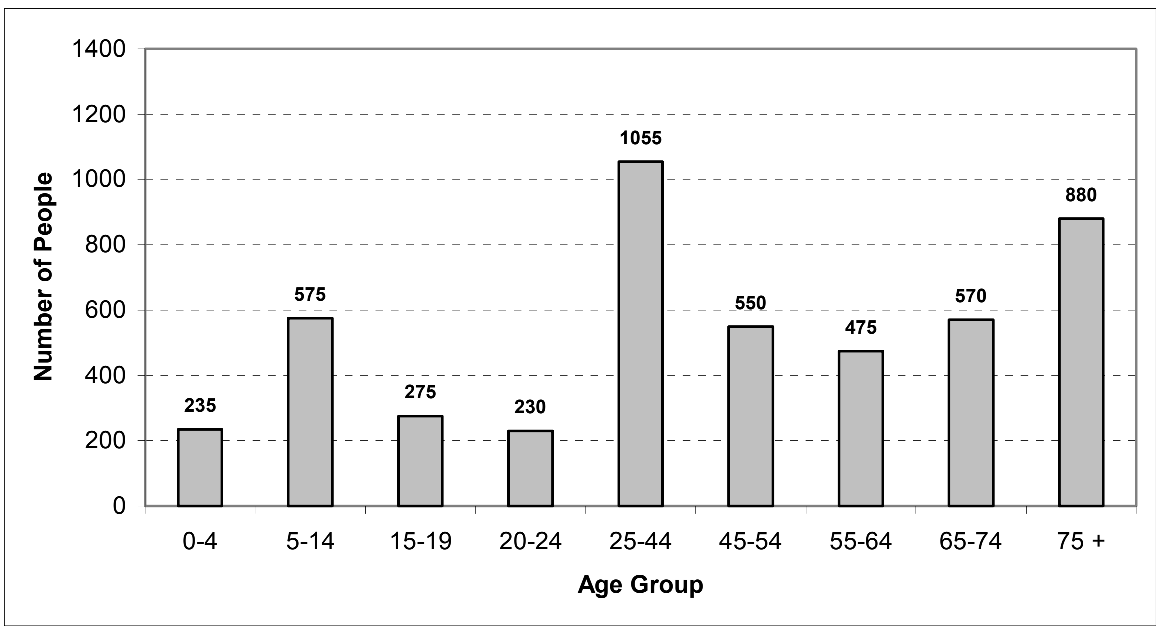

Figure 3. Total population by age group for Boissevain, Deloraine, Hartney, Souris and Waskada for 2001 (Source Statistics Canada).

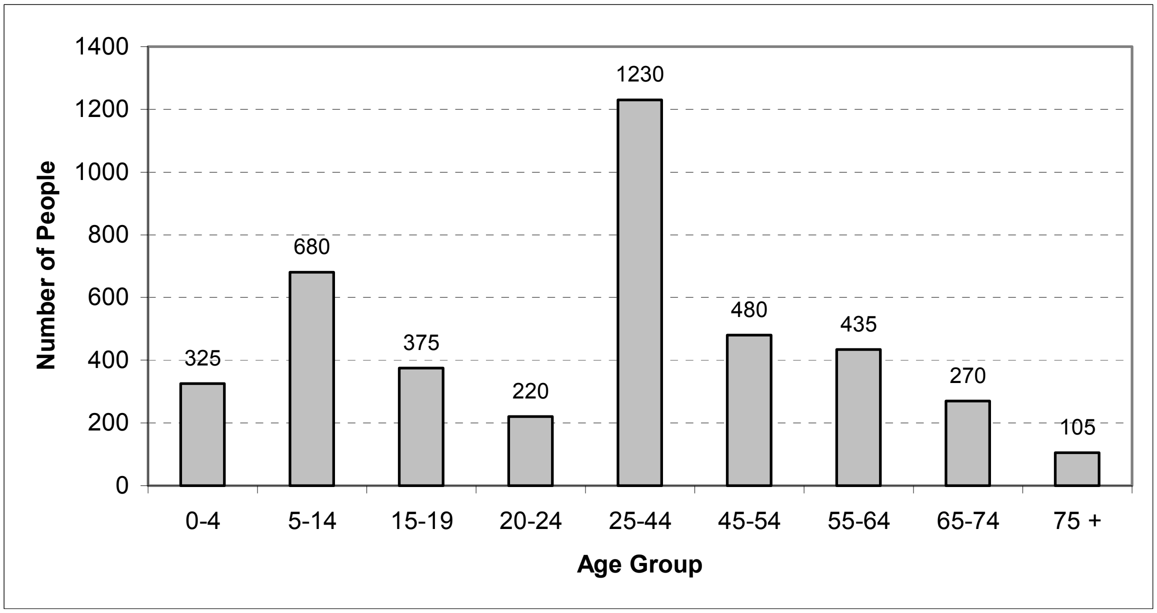

Figure 4. Total population by age group for the Rural Municipalities of Arthur, Brenda, Cameron, Glenwood, Morton and Winchester for 1991 (Source Statistics Canada).

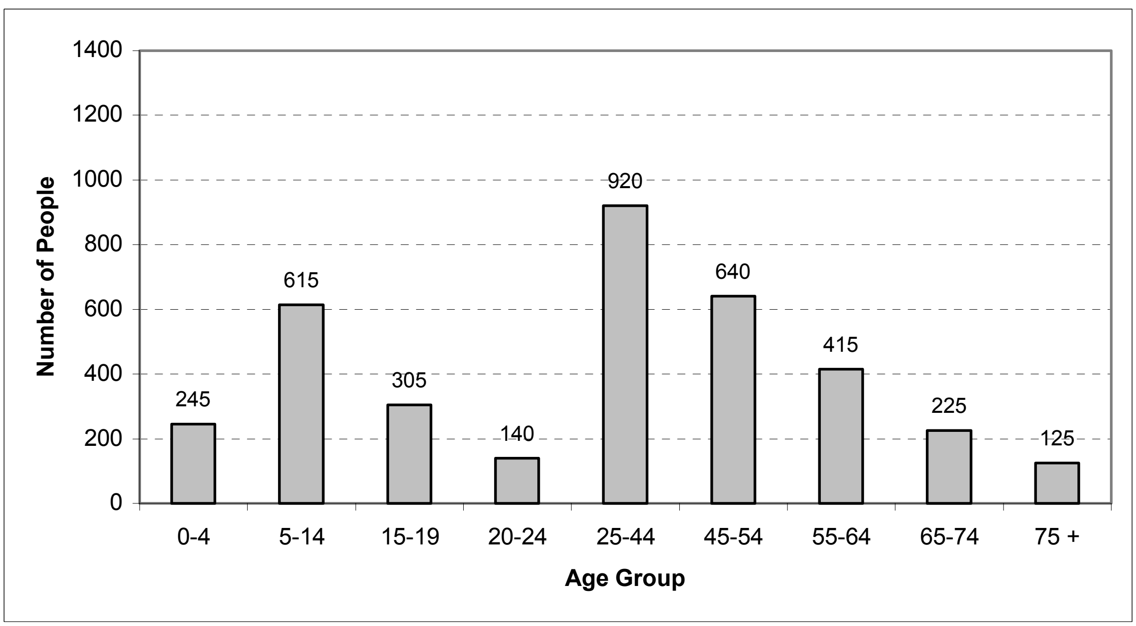

Figure 5. Total population by age group for the Rural Municipalities of Arthur, Brenda, Cameron, Glenwood, Morton and Winchester for 2001 (Source Statistics Canada).

Table 2. Population trend data for municipalities and towns within the East Souris River IWMP study area from 1986-2001.

Rural Municipality	1986	1991	1996	2001	Decrease from 1986 to 2001 Number of People	Decrease from 1986 to 2001 Percentage (%)
Arthur	731	581	528	480	251	34.3
Brenda	906	801	726	616	290	32.0
Cameron	613	538	537	496	117	19.1
Glenwood	708	722	710	697	11	1.6
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Winchester	718	661	625	573	145	20.2
Totals	4561	4151	3958	3622	939	20.6

Town	1986	1991	1996	2001	Decrease from 1986 to 2001 Number of People	Decrease from 1986 to 2001 Percentage (%)
Waskada	349	289	288	208	141	40.4
Boissevain	1572	1484	1544	1495	77	4.9
Deloraine	1134	1045	1041	1026	108	9.5
Hartney	523	477	462	446	77	14.7
Souris	1751	1662	1613	1683	68	3.9
Totals	5329	4957	4948	4858	471	8.8

Climate

The East Souris River (ESR) study area is situated in the Prairie Region of the Canadian Climate Regions. This region has been classified as having a continental semi-humid climate, which essentially means that there are extensive variations in seasonal and annual temperatures and precipitation amounts. There may also be extensive variations with temperatures on a day to day basis as well as between temperatures between the day and night.

For the purpose of this report we will be using climate data accumulated from several different locations at varying points within or on the border of the ESR study area. These locations include Deloraine, International Peace Gardens and Souris.

Weather data from Deloraine indicates that the mean annual temperature is 3.3 ^{0}C with a mean daily maximum temperature of 9.3 ^{0}C and a mean daily minimum temperature of -2.7 ^{0}C (Appendix 1). The annual amount of precipitation averages 478.1 mm with rainfall accumulation accounting for roughly 366 mm and snowfall accumulation accounting for roughly 112.3 mm (Appendix 1). The average number of degree-days above 5 ^{0}C is 1628 with a frost-free period of 111 days. The calculated seasonal moisture deficit for the period between May and September ranges from 250 mm to slightly less than 200 mm for the R.M. of Winchester (MLRU 97-4) and to slightly in excess of 300 mm for the R.M. of Brenda (MLRU 97-3). The estimated effective growing degree days above 5 ^{0}C accumulated from date of seeding to date of the first fall frost decreases from 1500 at lower elevations to less than 1400 at higher elevations in the Turtle Mountain uplands (MLRU 97-4).

The daily average temperature is 2.1 ^{0}C, with a mean daily maximum temperature of 8.1 ^{0}C and a mean daily minimum temperature of -3.9 ^{0}C for the International Peace Gardens which is situated on the southeast border of the ESR study area (Appendix 2). On average the annual precipitation for the area is 606.6 mm with rainfall accumulation accounting for approximately 438.9 mm and snowfall accumulation accounting for approximately167.7 mm (Appendix 2).

Weather data from Souris, situated on the northern border of the ESR study area has indicated that the mean annual temperature is 2.5 ^{0}C with a mean daily maximum temperature of 8.9 ^{0}C and a mean daily minimum temperature of -3.8 ^{0}C (Appendix 3). The annual precipitation average is 516.2 mm with rainfall accumulation accounting for roughly 389.4 mm and snowfall accumulation accounting for roughly 126.1 mm (Appendix 3). The degree-days above 5 ^{0}C average 1697 with a frost-free period of 105 days. The calculated seasonal moisture deficit for the period between May and September ranges from 250 mm to 300mm (MLRU 96-6). The estimated effective growing degree days above 5 ^{0}C accumulated from date of seeding to date of the first fall frost is approximately 1500 (MLRU 96-6).

The following reports were used in preparing the Climate Section

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Manitoba Land Resource Unit (MLRU) 97-7. 1998. Rural Municipality of Cameron, Information Bulletin 97-7; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

Waterways and Riparian Areas

Submitted by Kevin Teneycke (MHHC) and Dave Dobson (DUC)

Background
Riparian areas are the transitional zones that are found along our waterways, stream banks, lake shores and wetlands. Healthy riparian areas may have any combination of trees, shrubs and grasses, depending on the local conditions. They produce vegetation that is lusher than the surrounding dry land because of better soils and water availability. Healthy riparian areas have many important functions in our watersheds.

When it comes to water quality, riparian areas are the last line of defence for water that's running off the land into our lakes and streams. They are also extremely important for wildlife. Healthy riparian areas provide a number of important functions. They act to trap sediment, filter and buffer water, build and maintain stream banks, store floodwater and energy, recharge groundwater, maintain biological diversity and create primary productivity.

A healthy riparian area is one that carries out the ecological functions described above. In a healthy riparian area there is vigorous growth trees, shrubs or grasses, stream banks are not eroding beyond what would be considered a normal amount, disturbance by humans or livestock is not excessive, and the watercourse can spill water into the riparian vegetation during a normal flood event.

Some of the key signs that point to the loss of riparian area health include the loss of natural vegetation (quantity, numbers of species and width of the riparian zone) and excessive erosion of the stream banks.

Given that riparian areas are crucial to the health of our surface waters and they are often our only remaining natural areas in some regions, it is especially important that appropriate land use practices are used to maintain or enhance their functions and values.

Waterways
The East Souris River watershed contains a total of 1,127.6 miles of surface channels including 100.6 miles of the Souris River (Table 3 and Figure 6). The majority of the waterways are represented by those that are classified as Class 3 or less (83.1%). A class 1 waterway is a waterway that drains an area of land 1 mi2 or less, a class 2 waterway is a waterway where at least 2 class 1 waterways flow into it, a class 3 waterway is a waterway where at least 2 class 2 waterways flow into it, etc

Table 3. Length and percentage of waterways for each drain order for each sub-watershed within the East Souris River IWMP study area.

Order	Waskada Creek		Medora Creek		Chain Lakes		Whitewater Lake		Miles	% of Total
	Miles	%	Miles	%	Miles	%	Miles	%		
0	202.5	44.0							202.5	18.0
1	77.3	16.8	25.8	20.9	26.1	13.7	128.8	36.3	257.9	22.9
2	85.2	18.5	33.1	26.8	79.5	42.0	110.9	31.3	308.7	27.4
3	54.4	11.8	15.1	12.2	4.1	7.8	89.7	25.3	166.9	14.8
4	13.6	3.0	34.7	28.0	17.1	9.0	25.5	7.1	90.8	8.1
7*	26.7	5.8	15.1	12.2	58.9	31.1			100.6	8.9
TOTAL	**459.7**		**123.8**		**185.7**		**354.9**		**1127.6**	

* Souris River

Waskada Creek sub-watershed has been identified as containing 202.2 miles of Class 0 waterways which represents 44% of the waterways identified with its boundaries. This represents 100% of the Order 0 waterways in the ESR watershed and this class is described as field or surface drain. The reason for the identification of Class 0, "field drains" in the Waskada Creek sub-watershed only should be examined to determine if these waterways are missing in other sub-watershed, therefore under-representing waterways, or have been incorporated into other Order classes.

The Medora Creek sub-watershed contains a total of 123.8 miles of waterway, representing the shortest total of the sub-watersheds and again is dominated by the Order 1 and 2 channels. The Chain Lakes sub-watershed is comprised of 58.9 miles of the Souris River (58.5% of the total length in the ESR watershed). The Whitewater lake sub-watershed is the only sub-watershed in the ESR watershed which does not report into the Souris River, instead reporting to Whitewater Lake. The waterways that make up the Whitewater sub-watershed are those responsible for carrying surface water off of the Turtle Mountain to the lake Figure 6.

The Riparian Tax Credit Program is applicable the riparian areas in association with major rivers, or waterways designated as an Order 4, 5, 6, 7 or 8 drain or a natural water channel designated as an Order 3 drain (Figure 7). Grassed waterways, seasonal creeks and dry riverbeds do not qualify. Under these criteria 17% of the waterways (4,641 acres) are eligible for this program.

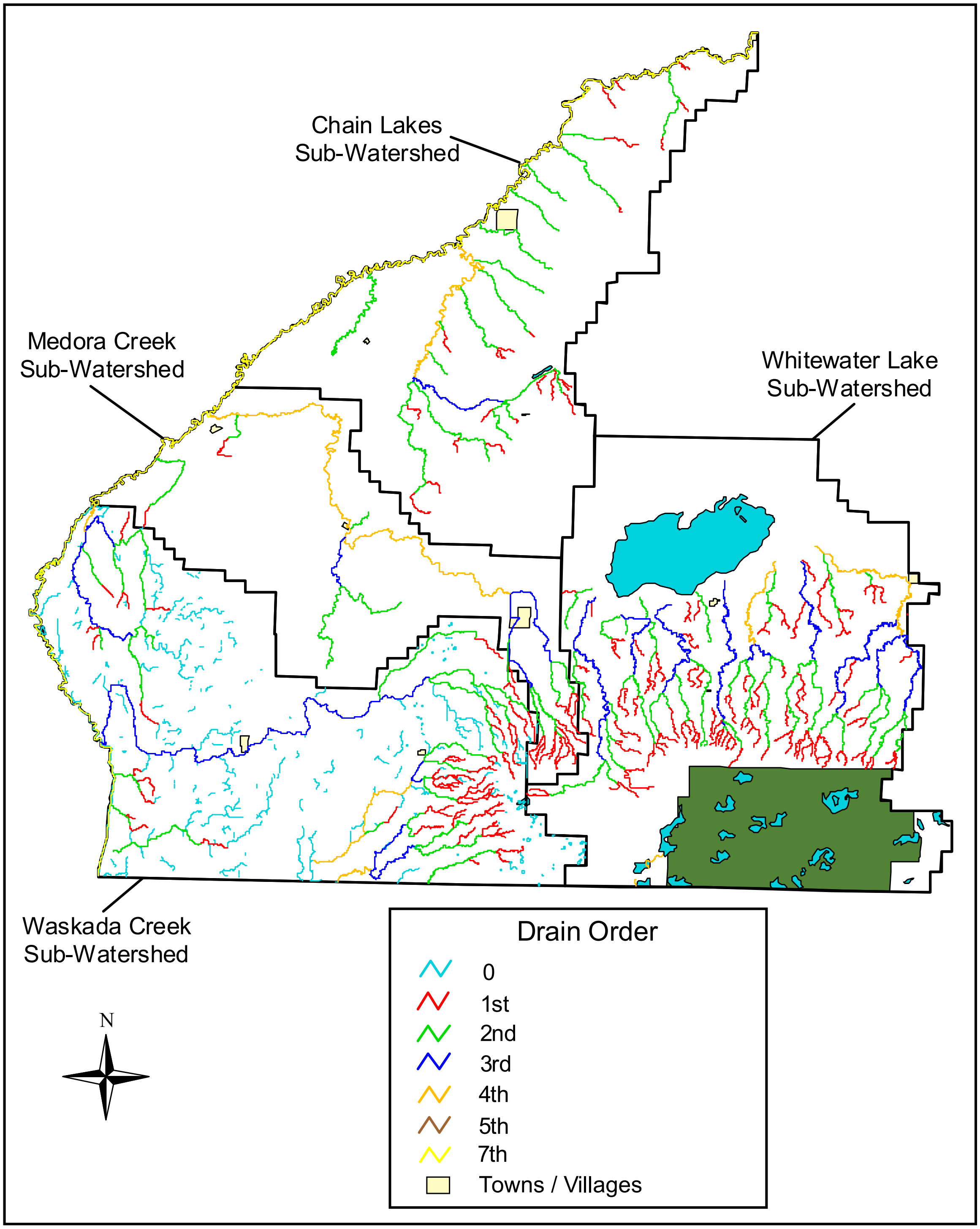

Figure 6. Waterways within the East Souris River IWMP study area classified according to their respective drain order.

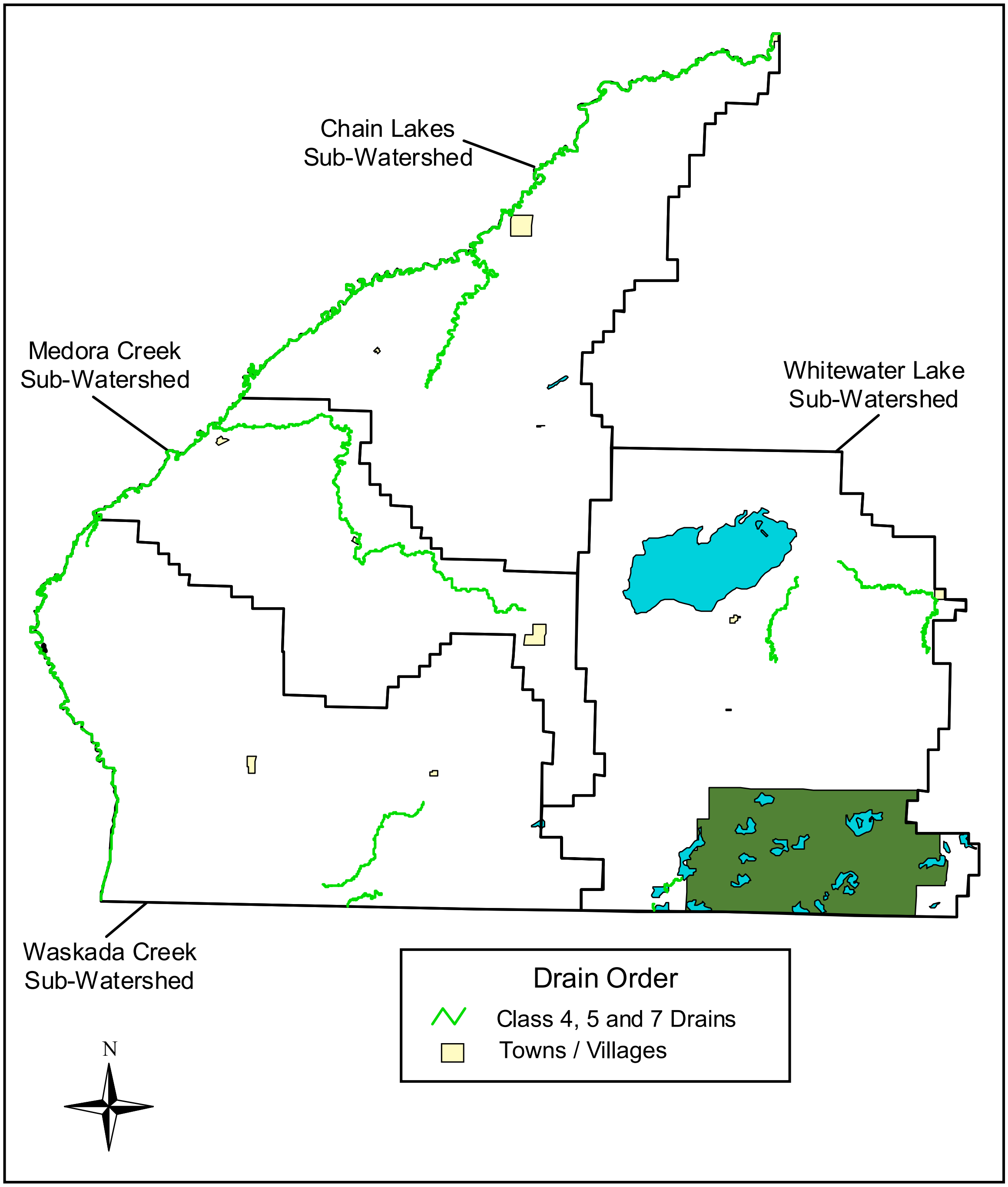

Figure 7. Waterways eligible for the Manitoba Riparian Tax Credit Program within the East Souris River IWMP study area.

Riparian Areas
To determine the land cover types with the riparian areas of the ESR watershed and its sub-watersheds, 30 meter (100ft) buffers were created alongside the watercourses. 2000 PFRA land cover data was then used to determine land cover types (cultivated, native, permanent cover or other). Figure 8 shows land cover within the ESR watershed and sub-watershed boundaries.

Of the total 24,555 acres of riparian buffer, native cover (grass, trees, shrubs) make up 66.2% of all land cover types in the ESR watershed (Table 4). 7,383 acres of the total riparian buffer is classified as being cultivated with Permanent Cover and the Other category representing less than 5% (1.4% and 2.3% respectively). It is assumed that the Other category is dominated by "cultural features", most likely roads.

The Waskada Creek sub-watershed contains 9,425 acres of 100 ft buffer which is the largest total of the sub-watersheds in the ESR watershed, 5,003 or 52.9% of which is classified as being in native cover. 43.6% (4 123 acres) of the land cover is classified as cultivation, representing the highest percentage of any other single basin. This may be a reflection of the topography of the basin and the higher percentage of lower order (Orders 0 – 3) waterways.

Table 4: Land cover acreage and percent for each sub-watershed within the East Souris River IWMP study area.

Land cover	Waskada Creek		Medora Creek		Chain Lakes		Whitewater Lake		Acres	% of Total
	Acres	%	Acres	%	Acres	%	Acres	%		
Cultivation	4123	43.6	822	28.4	1299	30.9	1139	14.2	7383	30.1
Native Cover	5003	52.9	1940	67.1	2775	66.1	6531	81.6	16249	66.2
Permanent Cover	76	0.8	29	1.0	59	1.3	194	2.4	358	1.4
Other	250	2.7	101	3.5	71	1.7	143	1.8	565	2.3
TOTAL	**9425**		**2892**		**4204**		**8007**		**24555**	

The Medora Creek sub-watershed contains the smallest total buffer area at 2,892 acres and also the highest percentage in native cover (67.1%). The Chain Lakes sub-watershed contains 4,204 acres of riparian buffer of which 2,775 acres or 66.1% are classified as Native Cover. 30.9% are classified as cultivation meaning 1,299 acres of 100 ft buffer are cultivated. The Whitewater Lake sub-watershed has the lowest percentage of buffer that is classified as being in cultivation at 14.2% and the greatest amount in native cover at 6,531 acres or 81.6% of the acreage.

The data presented here provides some indication of the land cover within the 100 ft riparian buffers within the ESR watershed study area. When considering the functions of riparian areas in maintaining water quality and quantity it provides some opportunity to recognize some opportunities for the development and targeting of programs intended to promote and reward landowners for practices that are complimentary to maintaining and enhancing riparian functions.

While this data can provide some indication of the amount of land cover types, it provides no information as to the condition of the respective land cover types. This information would be valuable in further establishing the overall health of the riparian buffers of the ESR watershed and their abilities to provide the desired protection and enhancement of water quality and quantity.

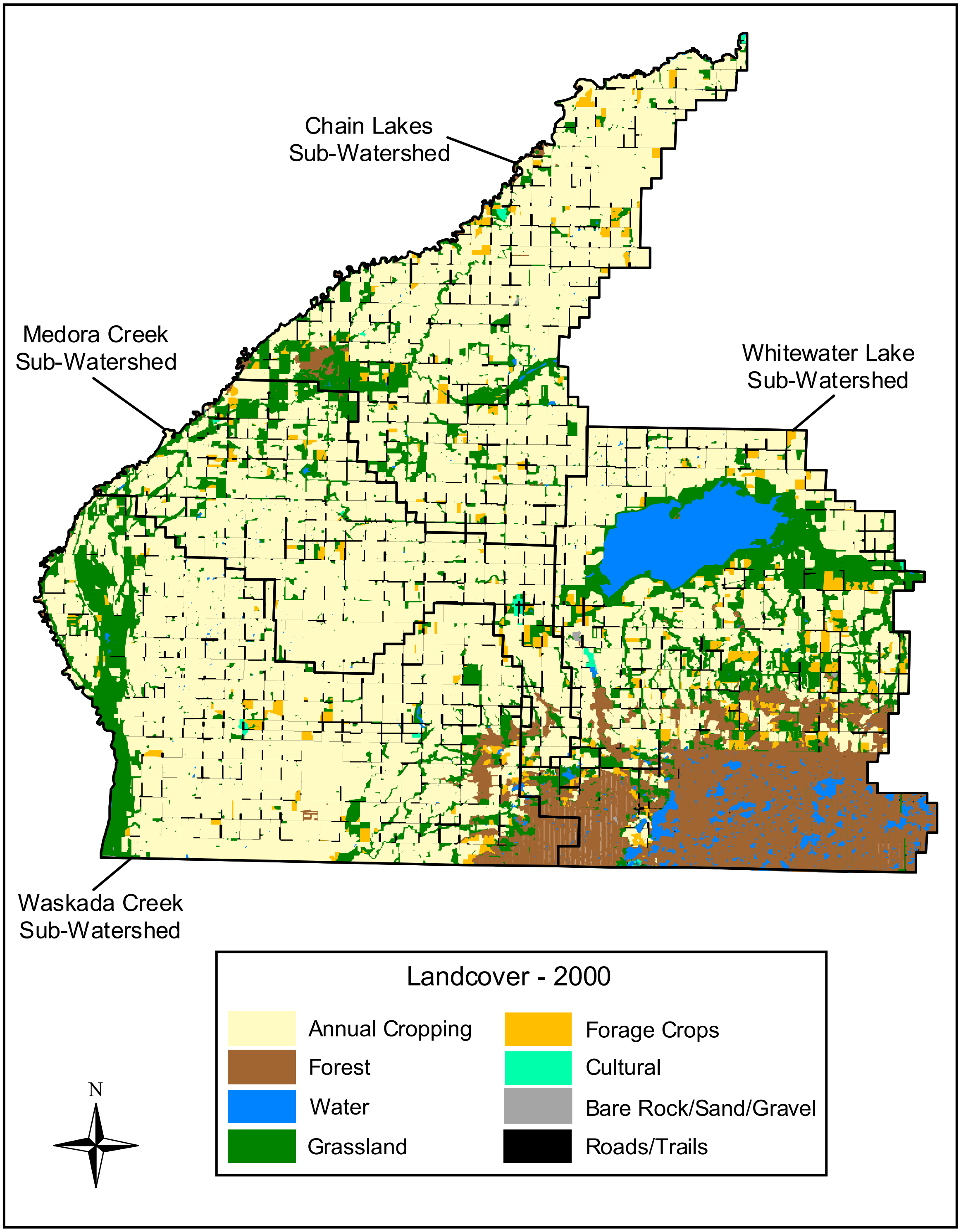

Figure 8. 2000 PFRA Land cover map for the East Souris River IWMP study area.

Wildlife and Wetlands

The watershed area provides diversity of wildlife habitat with some of the main features being the wooded Turtle Mountain, riparian areas surrounding the Turtle Mountain, Whitewater Lake and the pothole areas surrounding the lake, the wooded and grassland riparian habitat adjacent the Souris River, a mix of farmland and native prairie habitat in the Chain Lakes area, as well as a mix of intensively farmed area interspersed with remnant native habitat areas. Undeveloped right-of-ways provide important habitat for wildlife as well as reduced wind and water erosion.

Turtle Mountain

The Turtle Mountain is important for a variety of wildlife species. Ungulates include white-tailed deer, moose and elk. Populations vary depending on a number of factors including habitat quality, winter weather, disease and parasites. Predation is not a major factor for moose and elk however coyote predation on white-tailed deer occurs. Ungulates move throughout the area as well as back and forth from the United States. The ungulate capability map (Figure 9) displays the important areas utilized by ungulates throughout the ESR watershed.

A variety of furbearers including beaver, muskrat, mink, fox, coyote, pine marten and raccoon inhabit the Turtle Mountain and the area is divided into a number of registered trap lines.

Several hundred bird (200 +) species inhabit the Turtle Mountain including waterfowl, great blue heron, ruffed and sharp-tailed grouse, Hungarian partridge, wild turkeys, raptors and songbirds. The area to the north and west of the mountain supports a variety of grassland bird species some of which are considered rare, threatened or endangered. Waterfowl rely on the pothole areas (wetlands and adjacent uplands) as spring feeding sites, breeding areas and nesting cover. These habitats also support a variety of other wildlife including furbearers, small mammals, white-tailed deer, sharp-tailed grouse and Hungarian partridge.

Deer thrive in the area where the wooded zone blends into the farming area on the north, west and east sides of the mountain. Past aerial surveys indicate the population fluctuates between approximately four to six deer per square mile. During winter surveys deer are often observed in high densities in three main areas; the Turtlehead Creek reservoir drainage area, the western slope near PTH 21 and the farmland on the north slope of the mountain. In summer deer distribute throughout the mountain and move farther to the north and west into some of the more intensively farmed areas.

Moose are relative new comers to the area and can be found throughout the Turtle Mountain. Populations have fluctuated throughout the years varying from approximately 250 to 600 over the last 15 years. Populations are influenced by habitat quality as well as losses to winter ticks. In some years losses to ticks can be significant. To a lesser degree severe winter weather can impact moose. In recent years moose have regularly been observed in some of the farm country north of the Turtle Mountain.

Elk have been present in the Turtle Mountain for some time. They move throughout the Turtle Mountain and surrounding areas. The majority of elk can be found on the north slope of the mountain. In winter they tend to stay on the periphery of the mountain and in summer they disperse throughout the area. Groups of elk have been regularly observed moving from the Turtle Mountain north to the Wawanesa and Riverside areas.

Historically the Turtle Mountain provided a source of fuel wood and timber for construction. Demand for these wood products has diminished and consequently the habitat of the area is changing. Planned forest harvest and renewal could benefit a variety of wildlife species and enhance the biological diversity of the area.

Souris River and Blind Souris
The riparian habitat of the Souris River also provides important habitat for wildlife. White-tailed deer, raptors, songbirds, waterfowl and furbearers all rely on this riparian habitat. In particular the area known as the Blind Souris supports both flora and fauna listed as rare, threatened or endangered (See Appendix 9).

Whitewater Lake and surrounding area
Whitewater Lake is an important area to waterfowl and other wildlife. It is a major breeding and staging area for migratory waterfowl and provides excellent wildlife viewing and hunting opportunities both of which are important to the local communities in the area. Native grassland habitat adjacent to the lake provides important nest cover for waterfowl. The pothole areas surrounding the lake provides critical waterfowl habitat. Temporary ponds in the farmland area are important spring feeding areas and provides breeding habitat for waterfowl. Other wildlife species also rely on these wetland areas. Permanent wetlands provide rearing areas for waterfowl. Drainage of these wetlands poses a significant threat to waterfowl populations in the area.

Other Areas
Remnant habitat areas in the open farm country to the north and west of the Turtle Mountains supports a diverse population of wildlife including deer (primarily in summer), upland game birds, small mammals, furbearers, numerous bird species including some grassland bird species. Remnants of mixed-grass prairie can be found throughout the watershed area and this threatened habitat is important for wildlife, in particular grassland bird species that are listed as rare, threatened or endangered species. The Chain Lakes area provides waterfowl habitat and areas of mixed-grass prairie adjacent to the Chain Lakes are also important.

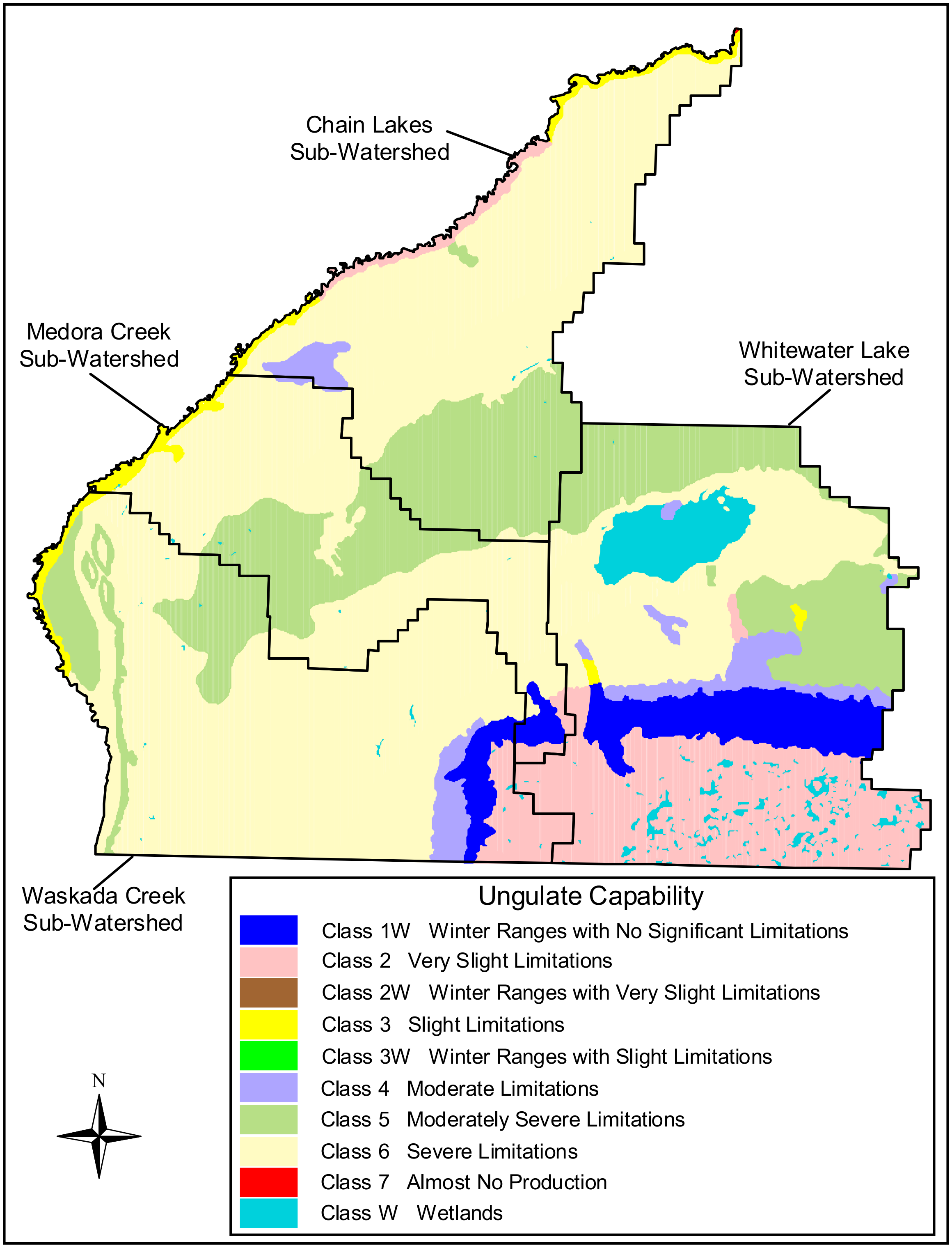

Figure 9. Canada Land Inventory – Ungulate Capability map for the East Souris River IWMP study area.

MIXED-GRASS PRAIRIE IN EAST SOURIS RIVER STUDY AREA

Blind Souris

The Blind Souris region was a focus of the Mixed-grass Prairie Inventory project in 2002. The portion of this region that falls east of the Souris River is within the Waskada Creek sub-district of the TMCD-IWMP area. In the same year, a partner study by Manitoba's Conservation Data Centre was conducted to determine the status of buffalograss, a species that is threatened under COSEWIC. This area is significant because it is the only location of current buffalograss records in Manitoba and one of only two locations of this species in Canada. This area is also part of the true Mixed-grass Prairie zone according to some maps; where as most of the Prairies Ecozone in Manitoba is considered Aspen Parkland.

A number of these sites were surveyed in 1991. Although it was recognized as containing extensive tracts of native prairie, this area was not initially targeted for inventory because preliminary visits indicated that only a very small amount could be considered prairie of very good quality. However, given the extent of buffalograss, the uniqueness of the landscape, the size and continuity of unbroken land and the low likelihood that this area would be broken or seeded, it was considered valuable to conduct inventory activities in the Blind Souris region.

The inventory found that although there were few sites of very good quality prairie, there were also relatively few sites of very poor quality prairie. Most of this land is in its native state although much of it appeared to be under very heavy grazing. Leafy spurge is a problem in the area, if not on these specific sites. Thirty-nine sites were surveyed in this region, totalling 5465 acres. Approximately 78% was graded as "C-" or better, which is considered good quality prairie. This includes poorer quality prairie with the potential to recover to a higher quality state with improved management.

Heavy grazing is perhaps less of a concern in this area because buffalograss does well under these conditions, and requires moderate to heavy grazing to survive in this northern part of its range where competing grasses are relatively tall. However, it is important not to overgraze as this can lead to long-term, irreversible degradation of the habitat.

Lauder area

Sites have also been surveyed within TMCD-IWMP area near the community of Lauder. A number of these were inventoried in 1993, others in 2002. For a number of the recent records, sites were surveyed from the road without accessing the properties. The grassland in this area was typically moist, towards wet meadow habitat. Overall these sites were generally of poorer quality prairie habitat. A typical problem observed in this area was trampling by cattle, creating an uneven, hummocky ground surface in the wet areas. Leafy spurge is also a problem in this general area, and identified on a portion of these sites.

The records from 1993 indicate that heavy grazing has decreased the quality of some of these sites. These surveys were conducted by a different staff member, so there are some judgment differences between the 1993 and 2002 data. In general, grades assigned for sites visited in 1993 were slightly higher. This should not necessarily be interpreted as a decrease in overall quality of the sites in this area. Also, a different sampling method was employed, so most prairie area measurements are generalized to include the entire quarter section.

Wetlands and Waterfowl Population Summary
Portions of this watershed are an important waterfowl production area for the prairie pothole region of Canada. A mixture of temporary, seasonal, and semi-permanent and permanent wetlands characterizes the watershed. This abundance of shallow productive wetland types is important to the waterfowl life cycle. The variety of wetland types provides important pair, breeding, and brood rearing sites. In addition, Whitewater Lake and associated marshes and the Turtle Mountain lakes are important staging areas for migratory waterfowl each spring and fall.

The Canada Land Inventory (CLI) land capability for waterfowl (Figure 10) has rated the watershed as follows:

- **2% Class 2** -Very slight limitations to the production of waterfowl. Capability on these lands is high but less that Class 1. Slight limitations are due to climate, fertility, or permeability of the soils. Topography tends to be more undulating, than rolling; a higher proportion of the water areas than in class 1 are small temporary ponds or deep, open water areas with poorly developed marsh edges.
- **31 % Class 3-** Slight limitations to the production of waterfowl. Capability on theses lands is moderately high, but productivity may be reduced in some years because of occasional droughts. Slight limitations are due to climate or to characteristics of the land that affect the quality and quantity of habitat. These lands have high proportions of both temporary and semi permanent shallow marshes poorly interspersed with deep marshes and bodies of open water.
- **25 % Class 4** -Moderate limitations to the production of waterfowl. Capability on these lands is moderate. Limitations are similar to those in Class 3, but the degree is greater. Water areas are predominantly temporary ponds, or deep, open waters with poorly developed marsh edges, or both.
- **34 % Class 5** -Moderately severe limitations to the production of waterfowl. Capability on these lands is moderately low. Limitations are usually a combination of two or more of the following factors: climate, soil moisture, permeability, fertility, topography, salinity, flooding, and poor interspersion of water areas.
- **7 % Class 6** -Severe limitations to the production of waterfowl. Capability on these lands is very low. Limitations are easily identified. They may include aridity, salinity, very flat topography, steep-sided lakes, extremely porous soils, and soils containing few available minerals.
- **1% Class 7**- Land in this class has such severe limitations that almost no waterfowl are produced. Capability on these lands in negligible or non-existent. Limitations are so severe that waterfowl production is precluded or nearly precluded.

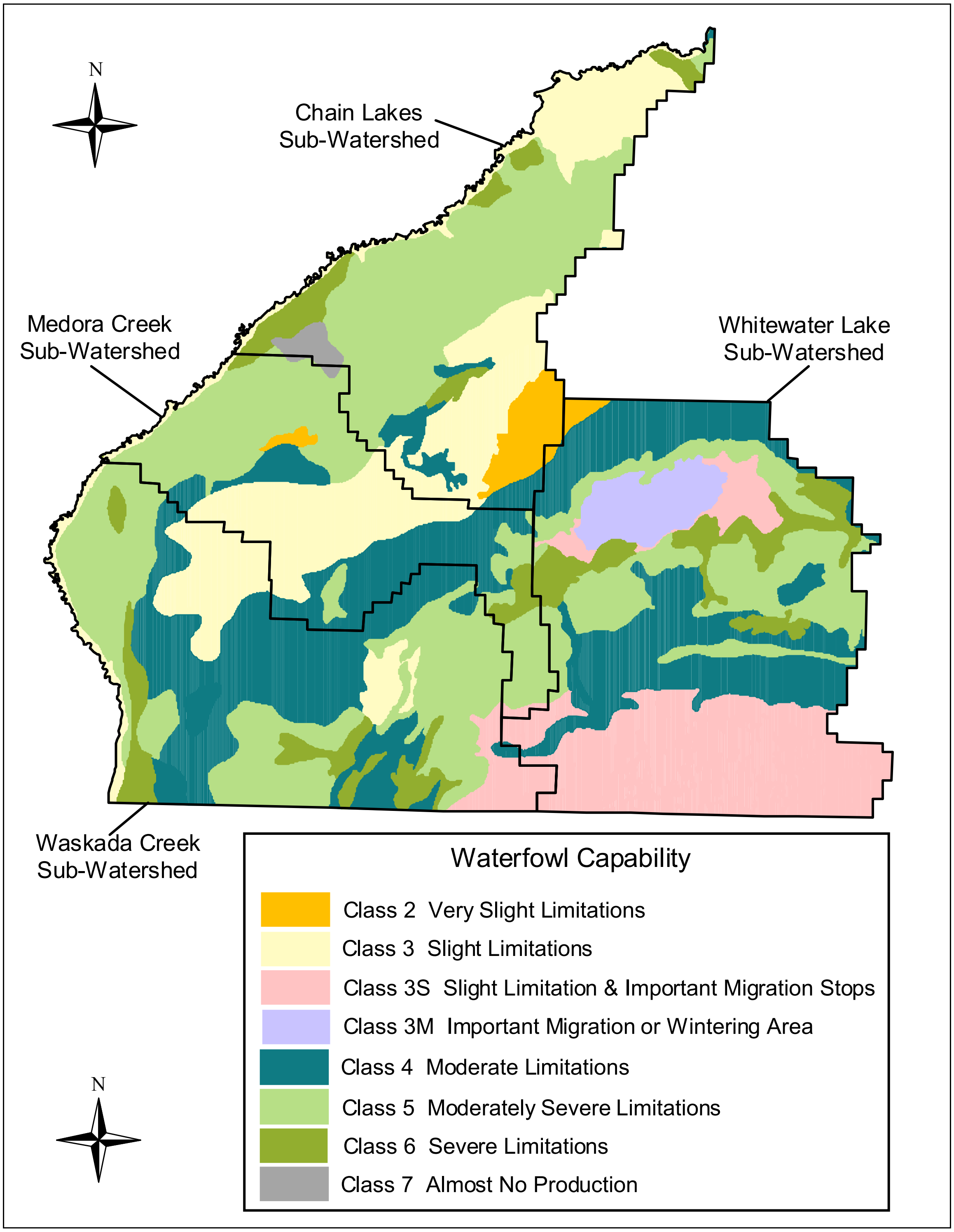

Figure 10. Canada Land Inventory – Waterfowl Capability map for the East Souris River IWMP study area.

Waterfowl production varies with wetland condition and in years of high run-off, waterfowl are abundant. The long-term average breeding pair density of ducks varies across the watershed from a low of <10 pairs per square mile in the areas of lower wetland density, to 70 pairs per square mile in areas of higher wetland density (Figure 11). As illustrated by Figures 10 and 11, waterfowl habitat is present in some degree in all the sub watersheds. The Whitewater sub watershed, with the inclusion of Whitewater Lake, Turtle Mountains and many small wetlands has by far the most abundant waterfowl habitat.

A wide variety of ducks utilize this watershed for breeding including mallards, northern pintail, blue-winged teal, gadwall, northern shoveler, green-winged teal, American wigeon, lesser scaup, canvasback, redheads, ring-necked ducks and ruddy ducks. As well, Whitewater Lake and the Turtle Mountain lakes and wetlands are significantly important for staging waterfowl.

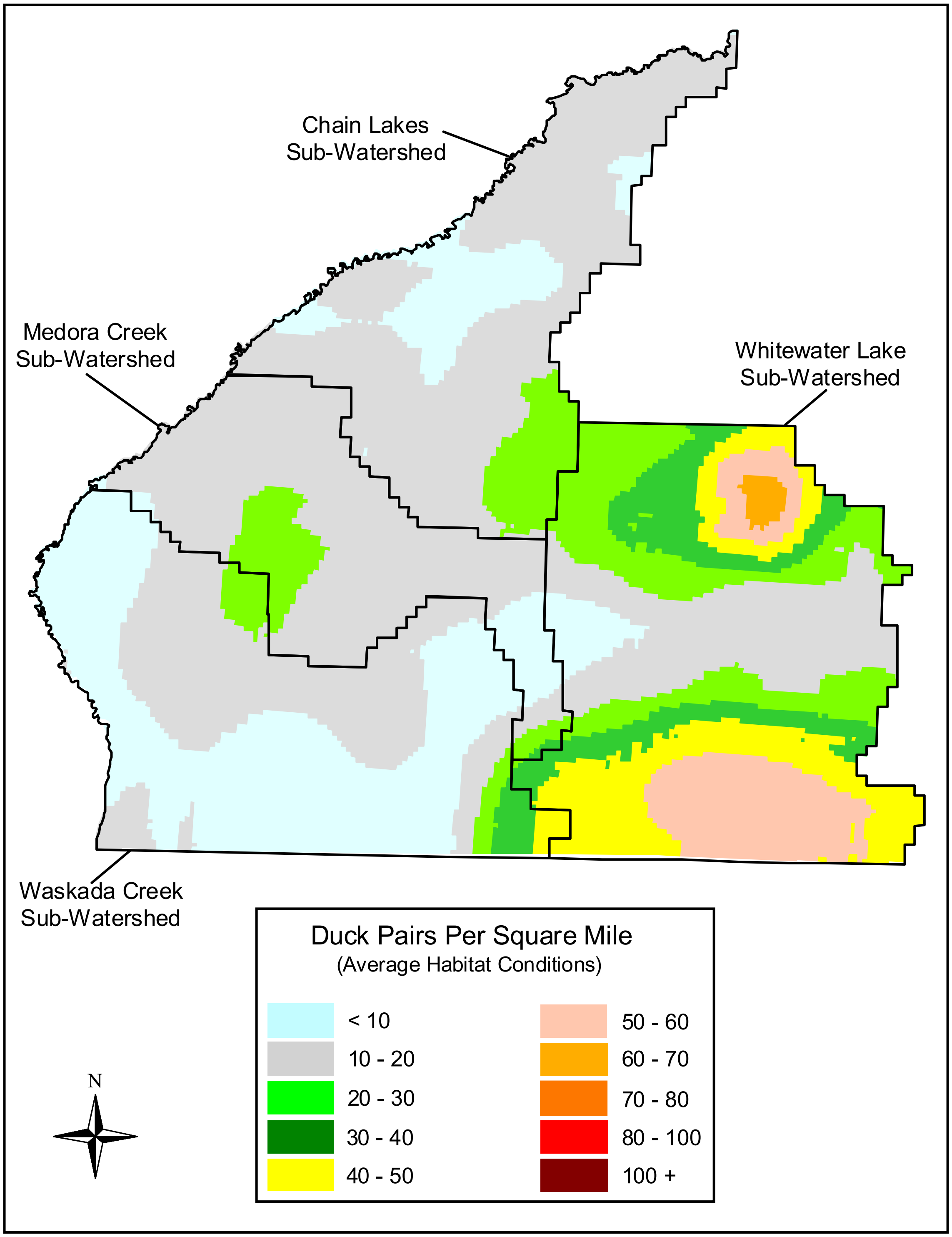

Figure 11. Waterfowl use map (duck pairs per square mile) for the East Souris River IWMP study area.

Wetland Inventory

There are at least 3 data sets for the wetlands in this watershed. Ducks Unlimited Canada (DUC) habitat inventory based on 1986 landsat data indicates 77,144 acres of wetlands comprised of 19,641 basins. PFRA landcover data, based on 2000 landsat indicates 45,764 acres, comprised of 8302 wetlands, 1:20,000 topographic map data set indicates 30,571 acres, comprised of 7703 wetlands. The discrepancies between the data sets are due to differences in classification, classification error and differences in water conditions at time of photography. This illustrates the need for an accurate up to date inventory of the water resources in this watershed in order to make informed management recommendations.

The Canadian Wildlife Service has 4 Air Ground transects within the East Souris River IWMP study area. These transects are used to monitor waterfowl populations and wetland loss. The transect locations are displayed in Figure 12. Alternate quarter sections along the transects were examined and up to 18 different types of habitat polygons were delineated on each quarter. All of the work was done from air photos and then ground truthed in 1985. Drainage or habitat alteration carried out prior to 1985 was not noted on the airphotos. These transects were again ground truthed in 1999-2003 and differences in the habitat polygons were noted. The overall summary of the transects in the East Souris River IWMP study area indicates an overall net loss of 5.6 percent in wetland area (Table 5). The raw data used to generate the overall summary of the 4 transects is listed in Appendix 10. This is an adjusted figure that accounts for any additions in wetland area such as stock ponds, borrow pits and drainage ditches that may hold water past May that were added since 1985.

Table 5: Overall summary statistics for the Air Ground transects from Hartney, Boissevain, Melita East and Melita West.

Number of Transects: 4

Base Year	**Total Wetland Area:**	443.12 **Ha**	**Gross Wetland Loss:**	35.32 **Ha**	7.97 **%**
Update Year	**Total Wetland Area:**	418.29 **Ha**	**Gross Wetland Gain:**	10.49 **Ha**	2.37 **%**
	Net Change:	24.83 **Ha** 5.60 **%**	**Net Change:**	24.83 **Ha**	

The ESR IWMP study area is 2,922 km^2. According to DUC landsat wetland inventories that were carried out in 1986 in the ESR IWMP study area there were approximately 77,144 wetland acres and a loss of 5.6 percent of the wetland acres since 1985 would translate into a loss of 4,320 acres of wetlands. That loss of wetland habitat would result in a loss of a minimum 4,320 acre feet of water (1ft. x acres) that historically was stored in wetlands. Assuming that these wetlands fill and drain each spring, 4,320 acre-feet of water which historically didn't drain is now being added to the drainage system on a regular basis or put another way, the permanent storage in the ESR watershed has been reduced by a minimum of 4,320 acre-feet since 1985. This is a significant amount of water that is now flowing into existing infrastructure since 1985. It also does not take into account all previous drainage activities that have taken place prior to 1985 or its impact on watershed infrastructure. Continued drainage of wetlands in the East Souris River watershed will compound existing water management problems in the area.

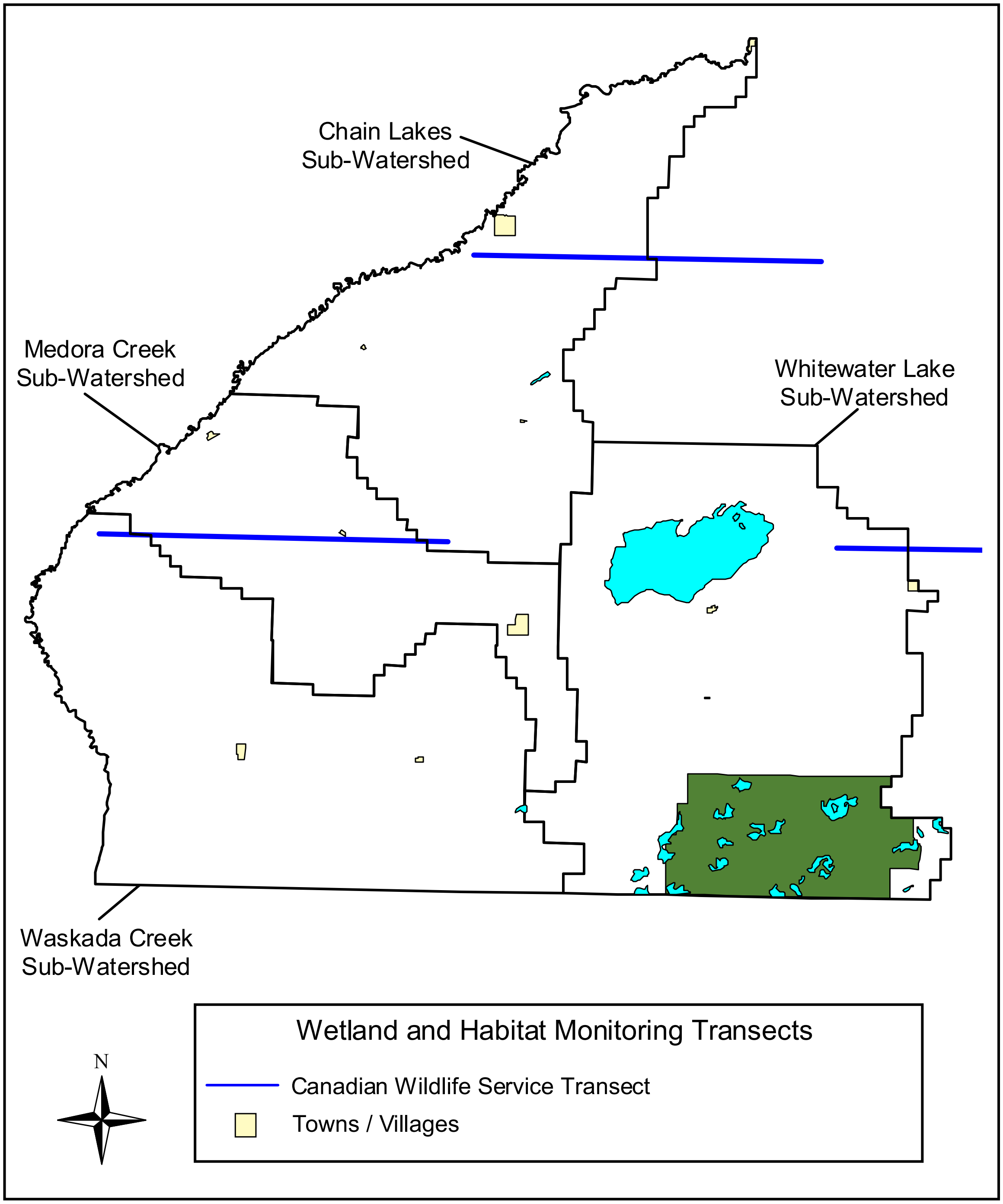

Figure 12. Canadian Wildlife Service wetland and waterfowl transects within or in close proximity to the East Souris River IWMP study area.

Notable/Important Wetlands in Turtle Mountain CD Watershed
Given the importance of wetlands in providing both ecological and societal benefits, all wetlands need to be restored, maintained and conserved by the public, private and industrial sectors of society. DUC has developed 20 conservation projects within the watershed and continues to

maintain these through conservation agreements with 77 private landowners, 5 municipalities and the province of Manitoba. These projects represent approximately 6,425 acres and include 4,550 acres of wetland and 1,875 acres of upland habitat. The largest and most significant project is the Whitewater Lake Project, located on the east end of Whitewater Lake. This marsh is extremely important to breeding waterfowl and serves as crucial breeding and staging habitat to a multitude of waterfowl species. The marsh also serves as habitat to many species of wildlife and plant species making it important for biodiversity in the area. To date Ducks Unlimited Canada has invested approximately $3.16M in these projects.

Wetland Values

Wetlands and associated riparian areas provide a multitude of ecological and societal values ranging from providing wildlife habitat to moderating flooding and maintaining water quality. A recent report prepared by Ducks Unlimited Canada for the Walkerton Inquiry in Ontario titled Beyond the Pipe provides a comprehensive and technical overview of the importance of wetlands and upland conservation practices in watershed management (See Gabor et al. 2001). This report includes an extensive review of research conducted on wetlands and associated uplands from North America and the world.

The following synopsis of wetland and riparian values is cited information from the review provided by Gabor et al (2001):

Wetlands as Flood Control

> The hydrological functions of wetlands include storage and eventual release of surface water, recharge of local groundwater supplies, reduction of peak floodwater flows, offsetting flood peaks and erosion protection. Position in the landscape, location of the water table, soil permeability, slope and moisture conditions all influence the ability of wetlands to attenuate floodwaters.
>
> Wetland drainage reduces the capability of a watershed to attenuate runoff during flood conditions. Maintaining and restoring wetlands on the landscape reduces overland flow rates and therefore potential flooding.

Wetlands and Groundwater

> Recharge of groundwater is an extremely important function of some wetlands: water percolates slowly from wetlands to aquifers. Interactions between wetlands and local or regional groundwater supplies are complex and site-specific and are affected by the position of the wetland with respect to groundwater flow systems and the geologic characteristics of the substrate and climate.

Wetlands as Nutrient Sinks

> Wetlands are extremely complex systems and several characteristics contribute to their roles as nutrient sinks. They retain nutrients in buried sediments, convert inorganic nutrients to organic biomass, and their shallow water depth maximizes water-soil contact and therefore microbial processing of nutrients and other material in the overlying waters. Wetlands can be effective nitrate sinks in agricultural landscapes (80% removal). Phosphorus retention in wetlands can also be significant (up to 92%) and is accomplished through adsorption onto particles, precipitation with metals and incorporation into living biomass.

Wetlands and Sedimentation

Wetlands can reduce the impacts of sedimentation on water quality within watersheds. Hydrology is a primary determinant of the sediment-retention capacity of a wetland and controls the source, amount, and spatial and temporal distribution of sediment inputs. The amount of wetland area and position in the landscape are important factors for reducing sediment loads in water passing through the system.

Wetlands and Pathogens

Limited information exists on the effects of the ability of natural wetlands to reduce microbial populations in water. The effectiveness of constructed wetlands to reduce pathogenic organisms from wastewater is high (up to 90% for coliforms). Wetlands in nature are dominated by microbes (bacteria, fungi and algae) and plant life that are important for reducing pathogens.

Wetlands and Pesticides

Pesticide loss and dissipation occurs by degradative processes such as photolysis, abiotic hydrolysis and biodegradation, as well as by volatilization into air, adsorption onto soil, and outflow from the wetland. Pesticide fate is poorly understood, however, common pesticides disappear rapidly from wetlands primarily due to absorption to organic matter.

Wetlands as Wildlife Habitat

Wetlands are considered to be some of the most biologically productive natural ecosystems in the world and rival tropical rain forests and coral reefs in the diversity of species they support (USEPA 1999). Common wildlife species associated with wetlands include waterfowl, shorebirds, blackbirds, muskrat, beaver, mink and moose. It is often not recognized that wetlands in Canada are home to more than 200 bird species, at least 50 mammal species and numerous reptiles, amphibians, insects and other aquatic denizens (Canadian Geographic 2000).

Riparian Zones

Riparian zones are the area of transition between terrestrial and aquatic ecosystems and include vegetation that requires free, unbound water, or conditions that are more moist than normal. Riparian areas are some of the most important habitats for wildlife in that they provide food, water and cover for many species.

A review of information on riparian areas provided by Gabor et al. (2001) outlines notable watershed level values of maintaining and establishing riparian buffer strips with particular relevance to agricultural settings.

Riparian buffer strips can effectively control erosion by forming a physical barrier that slows the surface flow of sediment and debris, by stabilizing wetland edges and stream banks, and by promoting infiltration. The bulk of sediment removal occurs in the first few meters of the buffer zone and overall sediment removal can be greater than 75%.

Buffer strips can effectively remove nutrients from surface water flow. The variety of vegetative cover in a buffer strip determines its efficiency in intercepting nutrients and sediments. Buffers can be effective in reducing both nitrogen (67-96%) and phosphorus (27-97%). Buffer strips can also trap a significant proportion of the pathogens (up to 74% of fecal coliforms). The key process for pesticide retention in buffer strips is infiltration. Buffer strips can reduce significant amounts of pesticides.

Issues
The following is a list of issues that pertain to the conservation and maintenance wetlands and opportunities that exist to address these issues.

Wetland Drainage

Despite the multitude of ecological and societal values that wetlands provide wetlands continue to be drained. It is estimated that more than 70% of the wetlands in the Canadian prairies have been altered lost and the greatest threat to wetlands is drainage. As noted, the loss of wetlands and adjacent upland areas can result in reduced biodiversity and wildlife habitat, increased flood potential, reduced ground water recharge, increased sedimentation, and a reduced ability for the ecosystem to control the effects of pathogens and pesticides. Although a variety of activities can impact wetlands the greatest threat remains the influence of agricultural drainage.

Land-use Practices and Development

Land-use practices and infrastructure development located remotely from wetlands including water diversions, the improper sizing of road culverts and agricultural practices can indirectly impact wetlands. These activities can promote increased runoff and erosion, increased flood frequency and drainage of wetland systems. The results of these activities can result in similar impacts to those noted above.

Riparian Habitat Protection

Riparian areas, which are the area of transition between terrestrial and aquatic ecosystems, are important components of the landscape and provide a variety of ecological and societal values. Riparian refers not only to river and stream systems but standing water areas such as lakes and wetlands. The loss or degradation of riparian areas is an issue primarily on agricultural lands where clearing for annual cropping and grazing can have significant impacts. In this watershed, clear-cut logging in the Turtle Mountain and area has the potential to degrade riparian areas and impact associated wetlands. Riparian zones are natural buffers between upland and wetland habitats providing erosion control and reducing the input of sediments into streams and wetlands and provide natural water quality protection measures. Riparian zones provide significant biodiversity and wildlife habitat values and serve as linkages and corridors for wildlife to travel from one area to another.

Fisheries

Native Fish Species

Within the Whitewater Lake sub-watershed numerous waterbodies are annually stocked with walleye, northern pike and perch. Some have been stocked or have non native species such as small mouth and large mouth bass, brown trout and rainbow trout inhabiting them. Numerous minnow species also inhabit these waters.

Native species of the Souris River are northern pike, bullhead, walleye, shorthead redhorse sucker and white sucker. Numerous minnow species also inhabit the Souris River.

Lake 8 located upstream on Deloraine on the West Branch of Medora Creek has been used as a walleye rearing pond but this practice was discontinued. In the lower reaches of the Medora Creek sub-watershed, near the Souris River, species composition would be similar the species found within the Souris River. Minnows would possibly inhabit most to the watershed probably during high water events.

Middle Chain Lake located within the Chain Lakes sub-watershed is occasionally stocked with northern pike in the spring. Similar fish species as those found within the Medora Creek and Waskada Creek sub-watersheds would inhabit this sub-watershed. The Adair Dam used to be utilized as a walleye rearing pond but that was also discontinued. Minnows would inhabit most of these waters during high water events.

Non-Native Fish

Non native species that exist in the four watersheds are small and large mouth bass, brown and rainbow trout.

Lake Metigoshe has an interesting combination of species that have been stocked by the State of North Dakota including various species of bass and pumpkinseeds; however the Province of Manitoba does not stock the waterbody. Walleye and northern pike are also stocked by the State of North Dakota.

Fish Barriers

Fish barriers such as illegal and legal non-fish friendly dams, perched culverts and dirt plugs all impede fish migration. The types and locations of such blockages are impossible to list.

Critical Habitat

All habitat are "key habitat" to different fish species at different times of year. Habitat areas change from spawning areas, nursery areas, migration routes and critical overwintering habitat areas. Some areas are intermittent and serve as only a conduit for food. Specific key fisheries habitat areas would be impossible to identify.

Sport Fishing Locations

The waterbodies that support sportfishing throughout the study area are: Lake Metigoshe, Deloraine Reservoir, Derksen-Heide Reservoir and all its tributaries and lakes in the Turtle Mountain Provincial Park such as Lake Max, Bower Lake and Lake Adam within the Whitewater Lake sub-watershed. Within the boundary of the Waskada Creek sub-watershed the Waskada Reservoir, Souris River support sportfish. Within both the Medora Creek and Chain Lakes sub-watersheds sportfishing locations are the Souris River and its tributaries.

Water Resource Features and Concerns

Within the East Souris River watershed there are a variety of water resource features and concerns. The first category is dugouts and within the ESR watershed there are 1748 (source: provincial 1:20,000 topographical layer) in total (Figure 13). The second category are dams, man made, and there are 129 (source: TMCD data and provincial 1:20,000 topographical layer) within the ESR watershed. The third and last category is beaver dams and there are 110 (source: provincial 1:20,000 topographical layer) within the watershed boundaries. This number may vary on a yearly basis as beavers construct new dams on a regular basis.

Other water resource features include drainage ditches. Drainage ditches are not all of the same and they have differing abilities to handle water flows which are why they have been broken down into various drain order classes. The classes range from one to seven, with one being the smallest waterways and class seven being the largest waterways. Within the ESR watershed there are 732 km of class one, 852 km of class two, 326 km of class three, 200 km of class four, 1 km of class five and 153 km of class seven drains.

As of January 2005 there were a total of 46 Water Rights Licenses issued and a total of 10 licenses are ongoing (Figure 14).

There are also nine municipal sewage lagoons, ten active garbage dumps and one inactive garbage dump within the ESR study area (Figure 15). There are also two agricultural lagoons within the R.M. of Morton, 1 within the R.M. of Arthur and seven agricultural/household lagoons within the R.M. of Cameron.

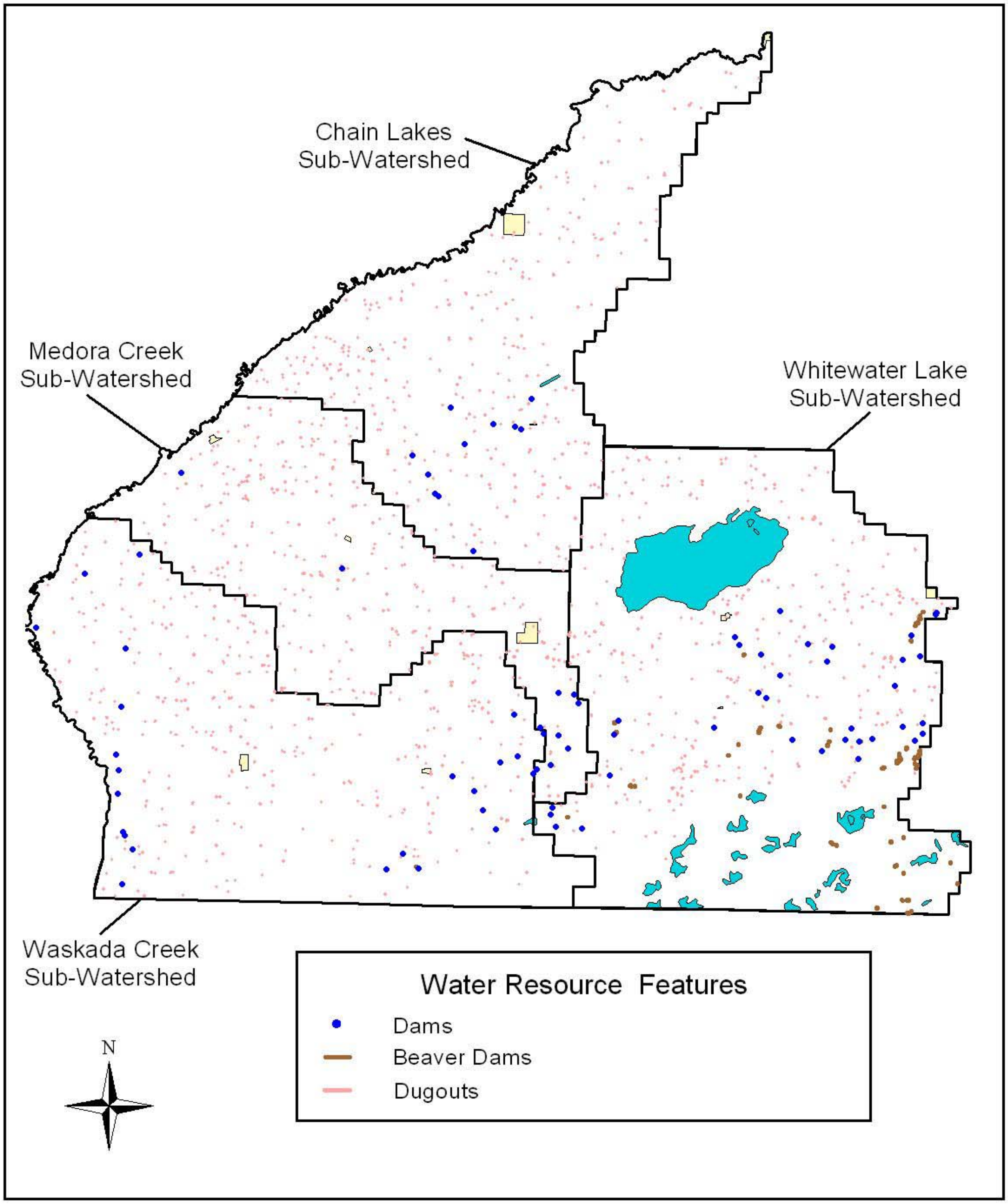

Figure 13. Water resource feature map for the East Souris River IWMP study area.

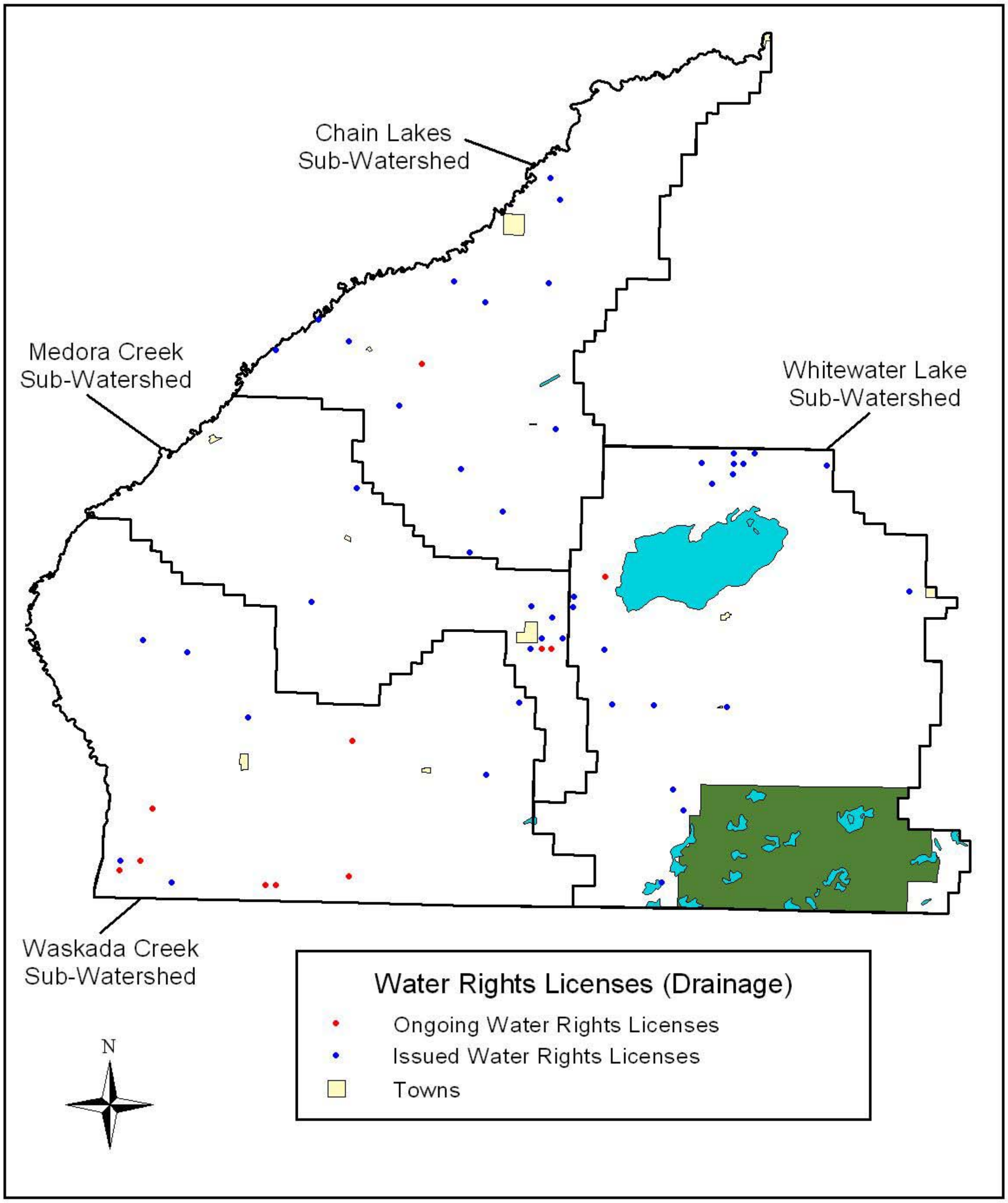

Figure 14. Location of ongoing water rights license (drainage) applications and issued water rights licenses (drainage) up until January, 2005 for the East Souris River IWMP study area.

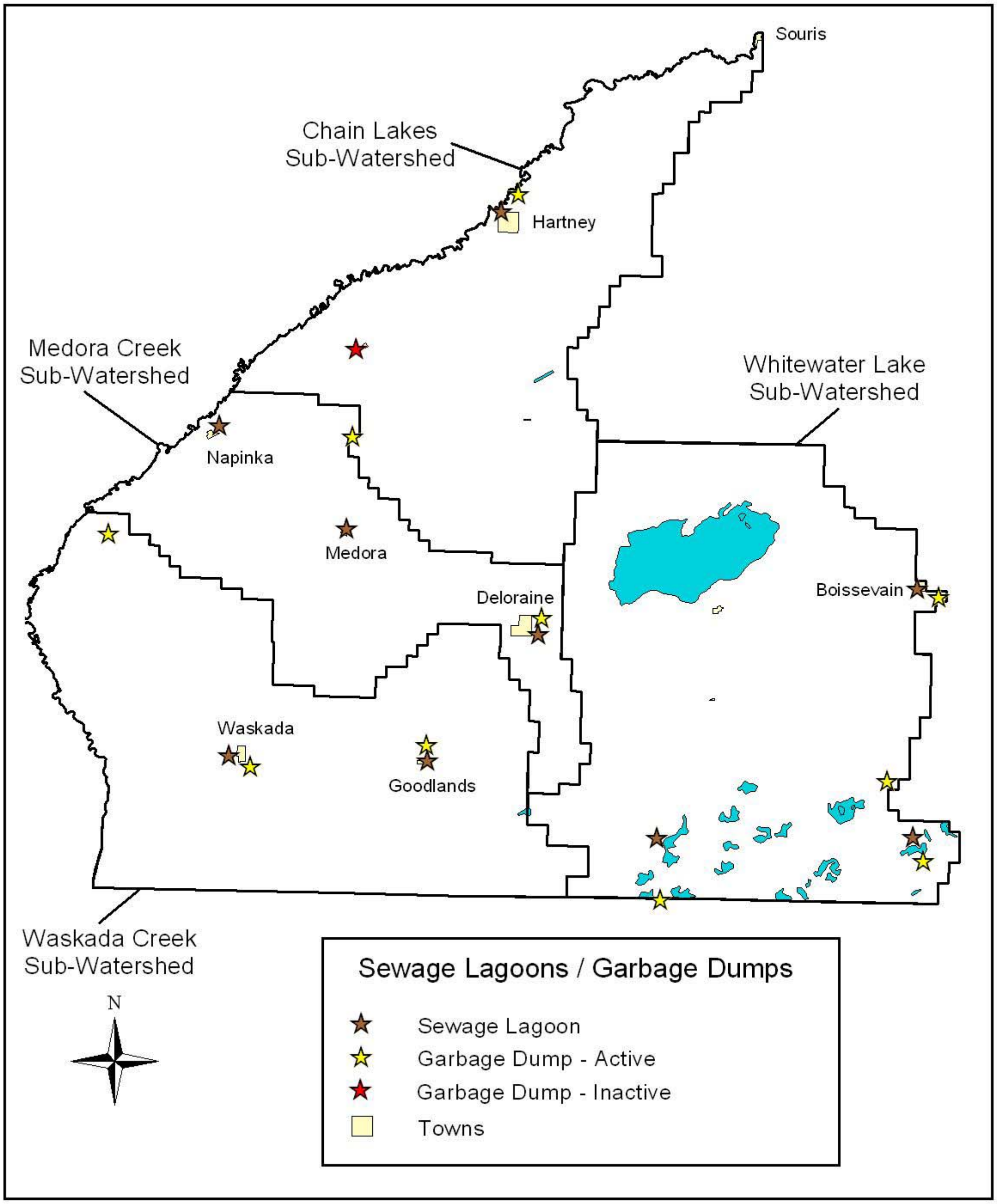

Figure 15. Locations of sewage lagoons and garbage dumps within the East Souris River IWMP study area.

Surface Water: Hydrology

Climate

The East Souris River Watershed (ESRW) has a continental semi-humid climate characterized by significant variations in seasonal and annual temperatures, and precipitation. It is warm and relatively humid in the summer, and very cold and dry in the winter. The mean annual precipitation decreases in a northwesterly direction from 550 mm in the Turtle Mountain Provincial Park to 500 mm at the Souris River[1]. Approximately three-quarters of this precipitation falls as rain, the rest falls as snow. Less than 10% of the average, annual total precipitation results in streamflow. The potential mean annual evapotranspiration loss is about 850 mm[2]. As potential gross evaporation losses are greater than the annual precipitation, the area is generally considered 'water deficient'. The southwest corner is normally the driest corner of the Province.

Water Courses

ESRW has four main watercourses: Waskada, Medora and Chain Lakes creeks and the Blind River that flow into the Souris River. It also has the headwater of the Boundary and Willow creeks that originate on the southern slopes of the Turtle Mountain and flow into North Dakota. Whitewater Lake is considered a closed basin. A map of the various creeks' watershed boundaries is shown on Figure 16 and their respective drainage areas are listed in Table 6.

As shown on Figure 16, all the tributaries in the ESRW drain into the Souris River. Waskada Creek, and the unnamed creek south of it, originate on the western slopes of the Turtle Mountain and flow in a westerly direction into the Souris River near Coulter. It has been reported that Waskada Creek can overflow to Medora Creek at high flows. Medora Creek originates on the northern slopes of the Turtle Mountain and flows northwesterly into the Souris River near Napinka. It has the largest drainage as shown in Table 6. The Blind River enters the Souris River near Melita, whereas, the Chain Lakes Creek enters the Souris River near Hartney. The Blind River and Chain Lakes are entirely on the prairie region. The topography in the prairie region is nearly level resulting in a majority of the soils being imperfectly drained. Willow and Boundary creeks run off the southern slopes of the Turtle Mountain into the Souris River near Upham, ND.

Table 6. Drainage areas within the East Souris River IWMP study area.

Water Course	**Drainage Area in km²**
Waskada Creek	**177.5**
Medora Creek	**436.3**
Unnamed Creek	**122.7**
Blind River	**221.7**
Chain Lakes Creek	**353.9**
Willow Creek	**188.2**
Boundary Creek	**201.0**
Whitewater Lake	**732.6**

[1] Agriculture and Agri-Food Canada, Mean Annual Precipitation in the Canadian Prairies for the Standard 30 Year Period 1971- 2000.
[2] Agriculture and Agri-Food Canada, Mean Annual Gross Evaporation in the Canadian Prairies for the Standard 30 Year Period 1971- 2000.

Hydrometric Data

Streamflow and lake level data has been collected at 11 hydrometric gauging stations within the ESRW for varying time periods since the mid 1960s. The locations of the 11 hydrometric gauging stations are shown on Figure 17. Table 7 indicates that for each of the stations, the type of data collected, the period of record and the gross drainage of the gauge.

Historic streamflow data is available on Waskada, Medora and Turtlehead creeks. Their respective gross drainage areas are shown on Figure 17. The gauging stations operated annually during the period March through October from the mid 1960s to the mid 1990s. In 1994, the operating period of the Waskada and Medora creek gauges were reduced to the spring freshet period, March through May. The Waskada Creek station was discontinued in 2002. The operation of the Turtlehead Creek station was discontinued in 1996. The Medora Creek is the only gauging station still operating. The three gauges have a minimum of approximately thirty years of data.

Realtime water level data is available for Medora Creek near Napinka (05NG020) and Whitewater near Boissevain (05NG023) from Environment Canada's website.

http://scitech.pyr.ec.gc.ca/waterweb/selectProvince.asp

Streamflow Characteristics

The daily discharge data for the gauging stations on Waskada, Medora and Turtlehead creeks were statistically analyzed to determine runoff characteristics of the ESRW. The results of the analysis are presented as follows:

a) Waskada Creek

The combined streamflow data for Waskada Creek near Cranmer (05NF014) and north of Cranmer (05NF011) is representative of streams running off the Turtle Mountain Escarpment. The gross drainage area of station 05NF014 is 108.9 km^2. The station has an effective to gross drainage area ratio of 0.81. The gross drainage area boundary is defined as the area at a specific location, enclosed by its drainage divide, which might be expected to entirely contribute runoff to that specific location under extremely wet conditions. The effective drainage area is that portion of a drainage area which might be expected to entirely contribute runoff to the main stream during a median (1:2 year event) runoff year. This area excludes marsh and slough area and other natural storage areas, which would prevent runoff from reaching the main stream in a year of average runoff. The effective to gross drainage area ratio is an indication of how well an area is drained. A perfectly drained area has a ratio of one.

The mean monthly discharge data for Waskada Creek is shown in Table 8. Based on available data, Waskada Creek has an average runoff during the 1965 to 2002 period of 1,900 dam^3 or 18 mm over the entire watershed. The annual runoff depths for Waskada Creek from 1966 to 1994 are shown on Figure 18. They range from a minimum of 0 mm in 1977 to a maximum of 80 mm to 1976. This figure also illustrates the variability in runoff from year to year, as well as the years of above and below average runoff.

Table 7. ESRW hydrometric data.

Station Number	Station Name	Years of Operation	Period of Operation	Type of Data	Gross Drainage area in km^2
05NG810	Coatstone Reservoir near Deloraine	1989 to present	April to October	Water level	4.7
05NG814	Deloriane Reservoir near Deloraine	1963 to present	Annual	Water level	76.7
05NF804	Metigoshe Lake near Metigoshe, ND	1953 to 1972 1973 to present	Annual April to October	Water level Water level	165.6
05NG020	Medora Creek near Napinka	1966 to 1993 1994 to present	March to October March to May	Discharge Discharge	1046.2
05NF014	Waskada Creek near Cranmer	1974 to 1993 1994 to 1996 2000 to 2002	March to October March to May March to May	Discharge Discharge Discharge	108.5
05NG023	Whitewater lake near Boissevain	1970 to present	March to October	Water level	732.6
05NF011	Waskada Creek north of Cranmer	1965 to 1973	March to October	Discharge	97.7
05NG011	Turtlehead Creek near Deloriane	1959 to 1963	March to October	Discharge	92.4
05NG016	Turtlehead Creek above Deloraine Reservoir	1964 to 1996	March to October	Discharge	75.0
05NG017	Turtlehead Creek below Deloraine Reservoir	1964 to 1996	March to October	Discharge	76.7
05NF807	Sharpe Lake near Deloraine	1972 to present	March to October	Water level	21.8

Table 8. Mean monthly discharge in cms for Waskada Creek near Cranmer (05NF011 and (05NF014).

	Recorded Mean Monthly Discharge in cms												Annual Volume
Year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	dam^3
1965	-	-	0.00	0.14	0.17	0.05	0.00	0.12	0.12	0.00	-	-	1,590
1966	-	-	0.25	0.02	0.12	0.04	0.29	0.00	0.00	0.00	-	-	1,940
1967	-	-	0.15	0.08	0.02	0.00	0.00	0.00	0.00	0.00	-	-	660
1968	-	-	0.01	0.00	0.00	0.00	0.00	0.02	0.02	0.00	-	-	130
1969	-	-	0.00	1.35	0.01	0.00	0.01	0.00	0.00	0.00	-	-	3,560
1970	-	-	0.25	0.53	0.07	0.00	0.00	0.00	0.00	0.00	-	-	2,240
1971	-	-	0.00	0.05	0.00	0.36	0.19	0.00	0.00	0.00	-	-	1,600
1972	-	-	0.34	0.14	0.00	0.44	0.00	0.00	0.00	0.00	-	-	2,410
1973	-	-	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	40
1974	-	-	0.00	1.68	0.25	0.05	0.17	0.00	0.00	0.00	-	-	5,610
1975	-	-	0.00	1.78	0.28	0.05	0.00	0.00	0.00	0.07	-	-	5,680
1976	-	-	1.44	1.85	0.02	0.00	0.00	0.00	0.00	0.00	-	-	8,730
1977	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0
1978	-	-	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	-	-	180
1979	-	-	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	-	-	2,090
1980	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.02	-	-	1,220
1981	-	0.24	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	730
1982	-	-	0.01	0.58	0.00	0.01	0.00	0.00	0.00	0.01	-	-	1,610
1983	-	-	0.26	0.33	0.00	0.00	0.00	0.00	0.00	0.00	-	-	1,580
1984	-	-	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	-	-	120
1985	-	-	1.77	0.13	0.00	0.10	0.01	0.00	0.00	0.00	-	-	5,380
1986	-	-	0.20	0.09	0.03	0.00	0.02	0.00	0.00	0.00	-	-	900
1987	-	-	0.46	0.03	0.00	0.00	0.00	0.00	0.00	0.00	-	-	1,310
1988	-	-	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	30
1989	-	-	0.40	0.48	0.00	0.00	0.04	0.00	0.00	0.00	-	-	2,450
1990	-	-	0.00	0.03	0.00	0.01	0.08	0.00	0.00	0.00	-	-	340
1991	-	-	0.01	0.00	0.00	0.00	0.43	0.00	0.00	0.00	-	-	1,190
1992	-	-	0.89	0.02	0.00	0.00	0.00	0.00	0.00	0.00	-	-	2,430
1993	-	-	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	90
1994	-	-	0.08	0.00	0.00	-	-	-	-	-	-	-	220
1995	-	-	1.08	0.24	0.01	-	-	-	-	-	-	-	3,540
1996	-	-	0.01	1.12	0.01	-	-	-	-	-	-	-	2,960
2000	-	-	0.01	0.00	0.02	-	-	-	-	-	-	-	60
2001	-	-	0.03	1.45	0.01	-	-	-	-	-	-	-	3,860
2002	-	-	0.00	0.00	0.00	-	-	-	-	-	-	-	0
Minimum	-	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0
Maximum	-	0.24	1.77	1.85	0.28	0.44	0.43	0.12	0.45	0.07	-	-	8,730
Mean	-	0.24	0.22	0.37	0.03	0.04	0.04	0.01	0.02	0.00	-	-	1,900

The bargraph on Figure 19 illustrates the distribution of annual runoff for Waskada Creek, an escarpmental stream. It can be seen that the majority of runoff, 85%, occurs as a result of snowmelt and early spring rains when the watershed is still saturated. The maximum daily discharge of each year, as well as the date it occurred, was reviewed. It revealed that in 20 of the 29 years, the annual peak flow occurred during the spring runoff, and in 9 out of the 29 years the peak flow occurred during the summer growing period.

The statistical analysis of the Waskada Creek data indicates, as shown in Table 9, the frequency of the expected annual and rainfall peak discharges and annual runoff volumes with their corresponding unit depths.

Waskada Creek recorded flow hydrographs for years representative of the 2%, 10%, 20% and 50% floods are plotted as shown on Figure 20. The spring runoff hydrographs show considerable variability concerning the date the peak discharge occurs. Normally, the larger the flood event the later the peak is expected to occur.

Table 9: Waskada Creek near Cranmer (05NF014) Frequency of Flood Flows and Runoff Volumes.

Flood Frequency	Annual Peak Discharge Coefficient	Annual Peak Discharge in m^3/s	Rainfall Peaks in m^3/s	Annual Runoff Volume dam3	Unit Runoff dam/km^2
1%	1.132	25.5	14.2	7300	67.0
2%	0.884	19.9	9.9	6400	58.8
10%	0.413	9.3	3.4	3900	35.8
20%	0.262	5.9	1.8	2800	25.7
50%	0.102	2.3	0.5	1200	11.0
70%		-	-	660	6.1
80%		-	-	440	4.0
90%		-	-	240	2.2

b) Medora Creek

The majority of the Medora Creek near Napinka (05NG020) drainage area is located on the prairie region. It is, therefore, a good index of the runoff from the prairie region. The drainage area at the gauging station is 313.6 km^2. The Medora Creek gauging station has an effective to gross drainage area ratio of 0.14 indicating the area is poorly drained.

The recorded mean monthly flows for Medora Creek are shown in Table 10. Based on available data, Medora Creek near Napinka has an average runoff during the 1966 to 2003 period of 4600 dam^3 or 14.7 mm over the entire watershed. The annual runoff depths for Medora Creek from 1966 to 1994 are shown on Figure 17. They range from a minimum of 0 mm in 1977 to a maximum of 77 mm in 1976. This figure also illustrates the variability in runoff from year to year, as well as the years of above and below average runoff. The bargraph on Figure 19 illustrates the distribution of annual runoff for prairie streams. It can be seen that the majority of runoff, 90%, occurs in the March to May period.

Table 10. Mean monthly discharge in cms for Medora Creek near Napinka (05NF020).

	Recorded Mean Monthly Discharge in cms												Annual Volume
Year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	dam³
1966	-	-	0.38	0.13	0.08	0.07	0.02	0.00	0.00	0.00	-	-	1,780
1967	-	-	0.00	0.22	0.10	0.00	0.00	0.00	0.00	0.00	-	-	840
1968	-	-	0.02	0.01	0.00	0.00	0.00	0.14	0.24	0.03	-	-	1,140
1969	-	-	0.00	3.00	0.41	0.12	0.17	0.02	0.00	0.00	-	-	9,700
1970	-	-	0.00	1.36	0.52	0.01	0.00	0.00	0.00	0.00	-	-	4,960
1971	-	-	0.00	0.18	0.01	0.37	0.39	0.00	0.00	0.00	-	-	2,480
1972	-	-	0.97	0.21	0.04	0.14	0.08	0.02	0.02	0.00	-	-	3,960
1973	-	-	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	-	-	100
1974	-	-	0.00	2.95	0.71	0.10	0.01	0.00	0.00	0.00	-	-	9,800
1975	-	-	0.00	3.62	1.10	0.14	0.03	0.12	0.10	0.21	-	-	13,910
1976	-	-	0.00	8.81	0.33	0.18	0.01	0.00	0.00	0.00	-	-	24,190
1977	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0
1978	-	-	0.00	0.38	0.01	0.00	0.00	0.00	0.00	0.00	-	-	1,010
1979	-	-	0.00	1.05	0.14	0.01	0.00	0.00	0.00	0.00	-	-	3,120
1980	-	-	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	30
1981	-	0.08	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	330
1982	-	-	0.00	1.85	0.00	0.01	0.00	0.00	0.00	0.00	-	-	4,820
1983	-	-	0.29	1.16	0.00	0.00	0.00	0.00	0.00	0.00	-	-	3,810
1984	-	-	0.07	0.00	0.07	0.01	0.00	0.00	0.00	0.00	-	-	420
1985	-	-	2.76	0.39	0.00	0.20	0.09	0.00	0.00	0.00	-	-	9,180
1986	-	-	0.45	0.13	0.12	0.00	0.00	0.00	0.00	0.00	-	-	1,860
1987	-	-	1.48	0.23	0.00	0.00	0.00	0.16	0.00	0.00	-	-	5,000
1988	-	-	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	-	-	100
1989	-	-	0.14	0.97	0.00	0.00	0.00	0.00	0.00	0.00	-	-	2,880
1990	-	-	0.00	0.06	0.00	0.00	0.04	0.00	0.00	0.00	-	-	270
1991	-	-	0.01	0.00	0.00	0.01	0.53	0.00	0.00	0.00	-	-	1,470
1992	-	-	2.15	0.07	0.01	0.00	0.00	0.00	0.00	0.00	-	-	5,970
1993	-	-	0.09	0.01	0.00	0.00	0.04	0.00	0.00	0.00	-	-	380
1994	-	-	0.40	0.05	0.00	-	-	-	-	-	-	-	1,200
1995	-	-	3.17	1.01	0.08	-	-	-	-	-	-	-	11,320
1996	-	-	0.00	3.31	0.25	-	-	-	-	-	-	-	9,250
1997	-	-	0.02	2.31	0.04	-	-	-	-	-	-	-	6,180
1998	-	-	1.24	1.35	0.03	-	-	-	-	-	-	-	6,920
1999	-	-	3.09	1.01	1.09	-	-	-	-	-	-	-	13,810
2000	-	-	0.01	0.00	0.00	-	-	-	-	-	-	-	30
2001	-	-	0.00	3.68	0.09	-	-	-	-	-	-	-	9,800
2002	-	-	0.00	0.00	0.00	-	-	-	-	-	-	-	0
2003	-	-	0.77	0.49	0.05	-	-	-	-	-	-	-	3,460
Minimum	-	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	0
Maximum	-	0.08	3.17	8.81	1.10	0.37	0.53	0.16	0.24	0.21	-	-	24,190
Mean	-	0.08	0.46	1.05	0.14	0.05	0.05	0.02	0.01	0.01	-	-	4,620

The maximum daily discharge of each year, as well as the date it occurred, was reviewed. It revealed that in 26 of the 29 years, the annual peak flow occurred during the spring runoff, and in 3 out of the 29 years the peak flow occurred during the summer growing period.

The statistical analysis of the Medora Creek data indicates, as shown in Table 11, the frequency of the expected annual peak discharges and annual runoff volumes with their corresponding unit depths.

Medora Creek recorded flow hydrographs for years representative of the 2%, 10%, 20% and 50% floods are plotted as shown on Figure 21. The spring runoff hydrographs show considerable variability concerning the date the peak discharge occurs. Normally, the larger the flood event the later the peak is expected to occur. The peak discharge on Medora Creek near Napinka (05NG020) normally occurs one to two days later in the year than on Waskada Creek near Cranmer (05NF014). This is due to its larger drainage area.

Table 11: Medora Creek near Napinka (05NG020) Frequency of Flood Flows and Runoff Volumes.

Flood Frequency	Annual Peak Discharge Coefficient	Annual Peak Discharge in m^3/s	Annual Runoff Volume dam3	Unit Runoff dam/km^2
1%	1.137	51.7	21500	68.6
2%	0.946	43.0	17400	55.5
5%	0.680	30.9	12200	38.9
10%	0.477	21.7	8600	27.4
20%	0.288	13.1	5320	17.0
50%	0.084	3.8	1790	5.7
70%	-	-	740	2.4
80%	-	-	400	1.3
90%	-	-	160	0.5

c) Turtlehead Creek

Turtlehead Creek above Deloraine Reservoir (05NG016) has a drainage area of 74.9 km^2 and is indicative of runoff from upland streams. The Turtlehead Creek gauging station has an effective to gross drainage area ratio of 1.0 indicating the area is well drained.

The mean monthly discharge data for Turtlehead Creek above Deloraine Reservoir is shown in Table 12. Based on available data from 1964 to 1996, Turtlehead Creek above Deloraine Reservoir has an average runoff of 2,350 dam^3 or 31 mm over the entire watershed. The annual runoff depths for Turtlehead Creek from 1966 to 1994 are shown on Figure 18. They range from a minimum of 0 mm in 1977 to a maximum of 121 mm in 1975. This figure also illustrates the variability in runoff from year to year, as well as the years of above and below average runoff. The bar graph on Figure 19 illustrates the distribution of annual runoff for upland streams. It can be seen that the majority of runoff, 88%, occurs in the March to May period.

The maximum daily discharge of each year, as well as, the date it occurred was reviewed. It revealed that in 26 of the 33 years the annual peak flow occurred during the spring runoff, and in 7 out of the 33 years the peak flow occurred during the summer growing period.

The statistical analysis of Turtlehead Creek data indicates, as shown in Table 13, the frequency of the expected annual and rainfall peak discharges and annual runoff volumes with their corresponding unit depths.

Turtlehead Creek recorded flow hydrographs for years representative of the 2%, 10%, 20% and 50% floods are plotted as shown on Figure 22. The spring runoff hydrographs show considerable variability concerning the date the peak discharge occurs. Normally, the larger the flood event the later the peak is expected to occur. The spring runoff on Turtlehead Creek has a tendency to occur later and be of a longer duration than the corresponding events on Waskada and Medora creeks.

Table 12. Mean monthly discharge in cms for Turtlehead Creek above Deloraine Reservoir (05NF016).

	Recorded Mean Monthly Discharge in cms												Annual Volume
Year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	dam^3
1964	-	-	0.00	0.57	0.65	0.03	0.01	0.00	0.00	0.00	-	-	3,310
1965	-	-	0.00	0.69	0.25	0.30	0.23	0.04	0.07	0.07	-	-	4,340
1966	-	-	0.30	0.50	0.26	0.05	0.03	0.00	0.00	0.00	-	-	3,010
1967	-	-	0.02	0.15	0.13	0.02	0.00	0.00	0.00	0.00	-	-	820
1968	-	-	0.02	0.03	0.02	0.01	0.01	0.20	0.02	0.01	-	-	880
1969	-	-	0.00	2.29	0.17	0.03	0.10	0.00	0.00	0.00	-	-	6,770
1970	-	-	0.00	0.57	0.52	0.02	0.00	0.00	0.00	0.00	-	-	2,900
1971	-	-	0.00	0.67	0.04	0.67	0.05	0.00	0.02	0.06	-	-	3,930
1972	-	-	0.78	1.54	0.23	0.19	0.00	0.01	0.00	0.00	-	-	7,240
1973	-	-	0.07	0.01	0.01	0.06	0.02	0.02	0.00	0.01	-	-	520
1974	-	-	0.00	1.50	0.79	0.15	0.02	0.00	0.00	0.00	-	-	6,480
1975	-	-	0.00	1.79	0.61	0.15	0.01	0.00	0.09	0.16	-	-	7,350
1976	-	-	0.12	2.38	0.17	0.03	0.00	0.00	0.00	0.00	-	-	7,030
1977	-	-	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	-	-	60
1978	-	-	0.02	0.07	0.02	0.01	0.01	0.00	0.00	0.00	-	-	310
1979	-	-	0.00	0.35	0.17	0.03	0.00	0.00	0.00	0.00	-	-	1,420
1980	-	-	0.01	0.04	0.00	0.00	0.00	0.00	0.01	0.01	-	-	180
1981	-	-	0.18	0.01	0.01	0.00	0.00	0.00	0.00	0.00	-	-	550
1982	-	-	0.04	0.50	0.07	0.04	0.00	0.00	0.00	0.00	-	-	1,700
1983	-	-	0.04	0.62	0.13	0.02	0.00	0.00	0.00	0.00	-	-	2,150
1984	-	-	0.07	0.01	0.12	0.01	0.00	0.00	0.00	0.00	-	-	540
1985	-	-	0.25	0.50	0.11	0.15	0.08	0.00	0.00	0.00	-	-	2,880
1986	-	-	0.23	0.44	0.46	0.01	0.00	0.00	0.00	0.00	-	-	3,030
1987	-	-	0.15	0.29	0.00	0.00	0.00	0.00	0.00	0.00	-	-	1,170
1988	-	-	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	-	-	90
1989	-	-	0.01	0.14	0.00	0.00	0.00	0.00	0.00	0.00	-	-	410
1990	-	-	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.00	-	-	170
1991	-	-	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	-	-	70
1992	-	-	0.11	0.04	0.00	0.00	0.00	0.00	0.00	0.00	-	-	420
1993	-	-	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	-	-	70
1994	-	-	0.12	0.06	0.02	0.01	0.00	0.00	0.00	0.00	-	-	570
1995	-	-	0.32	0.78	0.49	0.05	0.01	0.00	0.00	0.00	-	-	4,380
1996	-	-	0.02	0.76	0.27	0.03	0.00	0.00	0.00	0.00	-	-	2,830
Minimum	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	60
Maximum	-	-	0.78	2.38	0.79	0.67	0.23	0.20	0.09	0.16	-	-	7,350
Mean	-	-	0.09	0.53	0.17	0.06	0.02	0.01	0.01	0.01	-	-	2,350

Table 13: Turtlehead Creek above Deloraine Reservoir (05NG016) Frequency of Flood Flows and Runoff Volumes.

Flood Frequency	Annual Peak Discharge Coefficient	Annual Peak Discharge in m^3/s	Rainfall Peaks in m^3/s	Annual Runoff Volume dam3	Unit Runoff dam/km^2
1%	0.712	12.5	16.1	8900	118.8
2%	0.555	9.7	11.1	7900	105.5
10%	0.271	4.8	3.6	4900	65.4
20%	0.178	3.1	1.8	3700	49.4
50%	0.078	1.4	0.5	1600	21.4
70%	-	-	-	720	9.6
80%	-	-	-	420	5.6
90%	-	-	-	180	2.4

d) Summary

In summary, analysis of the available streamflow data in the ESRW indicates the following:

- Streamflow varies considerably over the months and years.
- Annual streamflow usually peaks in April and May, during the spring runoff period.
- On average, 85 to 90% of the annual runoff volume occurs in the period from the beginning of March to the end of May.
- Escarpment and prairie streams can experience years of no flow.
- All streams can experience periods of extended zero flow during the summer period. As a result, all streams in the ESRW are hydrologically classified as intermittent streams.
- The annual runoff from the three watercourses differs based mainly on their size and topography.
- Streams in the upland areas of the Turtle Mountain produce the greatest unit runoff depths.
- Unit runoff depths from escarpmental (Waskada) and prairie (Medora) streams are similar in moderate to wet runoff years.
- The unit runoff depth from escarpmental streams is much greater than prairie streams in below normal and drought years. This is because the effective to gross drainage area ratio an indicator of depressional storage is greater for escarpmental streams. That is, there is a greater percentage of the watershed of escarpmental streams contributing flow during below normal runoff years.
- The spring flood peak characteristics of escarpmental (Waskada) and prairie (Medora) streams are similar. It is their drainage area size that determines the magnitude and timing of annual peaks.
- On the major watercourses, spring flooding is more significant than flooding from summer precipitation events. It is the smaller drainage areas (less than about 30 km^2) that are sensitive to rainfall events. Localized flooding can occur in the smaller poorly drained areas from excessive rainfall.
- The southwest corner of the Province is generally considered a chronic drought area due to its low runoff rates.

Whitewater Lake Watershed[3]

Whitewater Lake Watershed has a drainage area of 732.6 km^2. Its main feature is Whitewater Lake, which varies in size from 130 km^2 (50 mi^2) in very, wet years to nil during times of extreme drought. The watershed is considered a closed basin, which means it, has no outlet except under extremely wet, high water conditions. The natural outlet is into Medora Creek to the west, with spillage occurring at about elevation 498.65 metres (1636 ft)[4]. The northern half of the Watershed is located in the prairie region in which the surface deposits consist of lacustrine silts and clays. The Turtle Mountain, reaching a height of about 230 m (750 feet) above the Lake, is the most prominent feature of the southern portion. Runoff from the Turtle Mountain is rapid and flows in well-defined channels. Channels in the vicinity of Whitewater Lake are poorly defined

[3] Report on Measures for Controlling High Levels on Whitewater Lake. (Manitoba, Whitewater Lake Interdisciplinary Committee, July 1977).
[4] PFRA Plan #70510

or non-existent due to the numerous small scattered potholes and sloughs in the area. High water table, salinized soils and poor surface drainage characterize the area surrounding the lake.

Whitewater Lake receives most of the surface inflow from the intermittent streams originating in the Turtle Mountain. Because of the elevation of the outlet, lake levels rise if rainfall and inflow are greater then evaporation and drop when evaporation is greater. Mean monthly recorded water levels for Whitewater Lake are shown in Table 14. Mean monthly reconstructed and recorded levels for the Lake for the period 1921 to 2003 are shown on Figure 23. As indicated by the plot, the Lake was virtually dry from the fall of 1934 until the spring of 1941. This period corresponds to a time of 1930's drought. Levels were below average during most of the 1960's and the early 1980s to mid 1990s. The highest recorded level of 497.55 m (1632.4 feet) was from May 5 to 11, 1976, after a series of wet years. High water levels cause extensive flooding.

The Lake is very shallow, having an average depth of 0.76 m (two and a half feet) at elevation 495.9 m (1627 ft) and is therefore, greatly influenced by wind. A wind setup of 0.3 m to 0.6 m (one or two feet) can result in flooding as far as three kilometres (two miles) inland. It can take several weeks for this water to drain because of the flatness of the area surrounding the lake.

The following listed studies have indicated that projects proposed for the control and development of Whitewater Lake were not economically viable.
Report on Hydrologic and Hydraulic Investigations, Whitewater Lake Area (Manitoba 1971).
Resource Management Alternatives in the Whitewater Lake Area (Ransom, 1972)
Report on Measures for Controlling High Levels on Whitewater Lake. (Manitoba, Whitewater Lake Interdisciplinary Committee, July 1977).

Table 14. Mean monthly water levels in metres for Whitewater Lake near Boissevain (05NG023).

	Recorded Mean Monthly Water Level in Metres												Average Level
Year	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec	metres
1970	-	-	-	-	-	-	-	-	496.004	495.974	495.980	-	495.986
1971	-	-	-	-	496.163	-	496.172	496.071	496.007	496.025	-	-	496.088
1972	-	-	-	-	496.373	496.419	496.379	496.342	496.266	496.211	496.202	-	496.313
1973	-	-	-	-	496.245	496.248	496.269	496.263	496.230	496.211	496.193	-	496.237
1974	-	-	-	-	-	-	-	-	-	-	-	-	-
1975	-	-	-	-	-	497.168	497.071	496.986	496.973	497.001	497.013	-	497.035
1976	-	-	-	-	497.519	497.458	497.367	497.245	497.132	497.034	-	-	497.292
1977	-	-	-	-	496.964	496.894	496.845	496.745	496.714	496.690	496.656	-	496.787
1978	-	-	-	-	496.763	496.726	496.678	496.483	496.437	496.382	496.336	-	496.544
1979	-	-	-	-	496.839	496.794	496.672	496.531	496.501	496.452	496.403	-	496.599
1980	-	-	-	-	496.397	496.236	496.169	496.211	496.242	496.239	496.269	-	496.252
1981	-	-	-	496.257	496.214	496.132	496.056	495.995	495.986	495.931	-	-	496.082
1982	-	-	-	496.230	496.208	496.175	496.105	496.022	495.916	495.958	495.983	-	496.075
1983	-	-	-	-	496.175	496.099	496.007	495.873	495.800	495.760	495.745	-	495.923
1984	-	-	-	495.803	495.855	495.775	495.605	495.452	495.346	495.394	-	-	495.604
1985	-	-	-	495.852	495.775	495.708	495.699	495.614	495.593	495.583	495.565	-	495.674
1986	-	-	-	-	495.928	495.846	495.782	495.675	495.580	495.577	495.565	-	495.708
1987	-	-	-	495.791	495.711	495.611	495.516	495.501	495.443	495.349	495.364	-	495.536
1988	-	-	-	495.327	495.321	-	-	-	-	-	-	-	495.324
1989	-	-	-	495.492	495.379	495.373	-	-	-	-	-	-	495.415
1992	-	-	-	495.452	495.428	-	-	-	-	-	-	-	495.440
1995	-	-	-	-	495.967	495.952	495.900	495.769	495.696	495.663	-	-	495.825
1996	-	-	-	496.147	496.202	496.220	496.178	496.181	496.096	496.062	-	-	496.155
1997	-	-	-	496.032	496.440	496.352	496.294	496.178	496.077	496.032	-	-	496.200
1998	-	-	-	496.403	496.355	496.330	496.358	496.339	496.245	496.230	496.230	-	496.311
1999	-	-	-	496.458	496.611	496.797	496.733	496.626	496.565	496.519	-	-	496.615
2000	-	-	-	-	496.181	496.129	496.117	496.032	495.980	495.928	495.913	-	496.040
2001	-	-	-	496.333	496.333	496.263	496.178	496.083	495.940	495.858	495.839	-	496.104
2002	-	-	-	495.907	495.870	495.827	495.757	495.836	495.812	495.763	496.330	-	495.888
2003	-	-	-	495.699	495.785	495.730	495.620	495.577	568.617	495.556	495.705	-	504.786
Minimu	-	-	-	495.327	495.321	495.373	495.516	495.452	495.346	495.349	495.364	-	495.324
Maximu	-	-	-	496.458	497.519	497.458	497.367	497.245	568.617	497.034	497.013	-	504.786
Mean	-	-	-	495.946	496.185	496.250	496.221	496.145	498.892	496.053	496.072	-	495.324

Water Allocation

The total spring volume of water available for allocation on intermittent streams is based on either the eight out of ten-year (80%) or the seven out of ten-year (70%) risk level.

Under the 80% risk level, one half of the water volume available on a given intermittent stream in eight out of ten years can be allocated. The eight out of ten-year volume is estimated as the 80th percentile value from a duration curve of spring (March to May) volumes. While one-half of the eight out of ten volume is allocated for use, the other half is allocated for maintenance of stream "health" or to maintain the ecological integrity of the stream system, referred to as Instream Flow Needs (IFN). For the 80% risk level, shortages can be expected in two out of 10 years on average.

Under the 70% risk level, the allocated volume is equal to the 70% spring volume minus one half of the 80% spring volume allocated to IFNs. For the 70% risk level, shortages can be expected in three out of 10 years on average.

The allocable spring volumes along with licensed water use in the ESRW are shown in Table 15. In total approximately 287 dam^3 could be allocated at the 80% risk level and 1194 dam^3 at the 70% risk level. Presently, licensed allocation in the ESRW is seven dam^3.

Table 15. Allocable spring volumes.

STREAM	Allocable Volume in dam^3		Licensed Volume in dam^3
	Risk Level		
	80%	70%	
WASKADA CREEK	26	101	7
BLIND RIVER	53	224	0
MEDORA CREEK	105	441	0
CHAIN LAKES CREEK	85	358	0
UNNAMED TRIBUTARY SOUTH	18	70	0
TOTAL	287	1194	7

Metigoshe Lake[5]

Metigoshe Lake, an international lake, is a highly developed resort area on both sides of the Canada-United States boundary. The lake covers an area of approximately 615 ha (1520 acres) of which 24.4 ha (60 acres) are in Canada. The maximum depth of Metigoshe Lake is 7.3 m. The Lake is controlled, with free overflow occurring at the fsl of 651.65 m (2138.0 ft) into Oak Creek, a tributary of Willow Creek. Dromore Lake upstream is connected to Metigoshe Lake. The drainage area of Metigoshe Lake is 165.6 km^2, which is almost entirely in Canada. Water levels have been recorded on Metigoshe Lake near Metigoshe, ND (05NF804) since 1953. A plot of the lake's mean monthly water levels are shown on Figure 24.

[5] Regulation of Sharpe, Dromore and Metigoshe Lakes, prepared by the Sharpe, Dromore and Metigoshe Lakes Regulation Committee, May 1975.

Deloraine Reservoir

Deloraine Reservoir was constructed on Turtlehead Creek in 1962 to provide a water supply for the Town of Deloraine and water for stock during drought periods. The dam is operated to maintain a full supply level (fsl) of 540.1 m (1772 ft). The Reservoir at the fsl has a maximum depth of 12 m, covers an area of 31 ha and contains 1730 dam^3 of water. The firm annual yield is estimated at 271 dam^3 or about one sixth of its storage capacity.

The riparian outlet normally remains closed. Riparian releases are made upon request if sufficient water is available for primary uses. Spring releases may be made from the riparian outlet to improve the water quality in the reservoir for water supply or fisheries purposes.

The drainage area of the reservoir is 76.7 km^2. Water levels have been recorded on Deloraine Reservoir near Deloraine (05NG814) since 1963. A plot of the lake's mean monthly water levels are shown on Figure 25. As shown on Figure 25, the reservoir does not annually fill. During extended drought period such as the 1980s water levels dropped 2.5 metres below fsl.

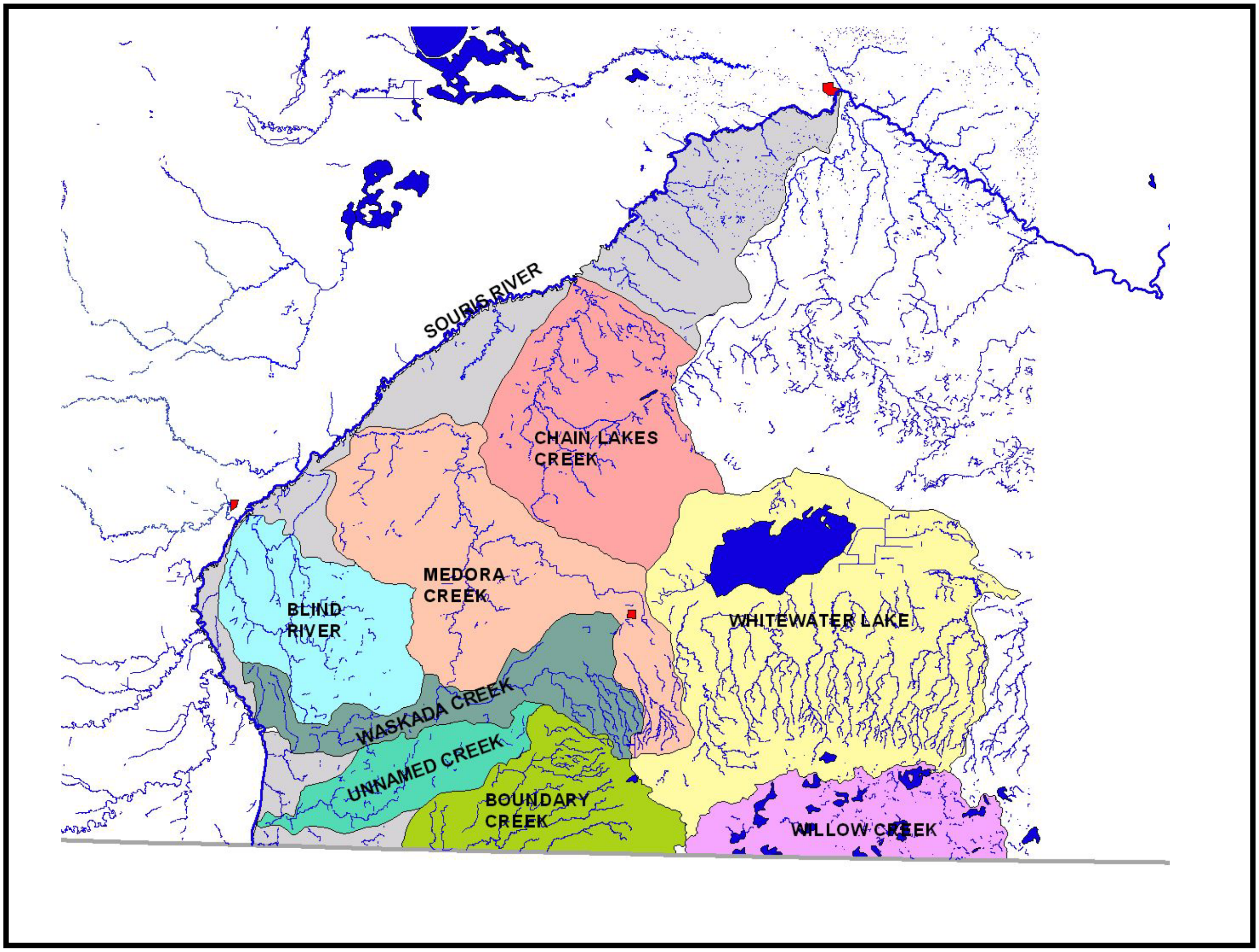

Figure 16. East Souris River Watershed drainage areas.

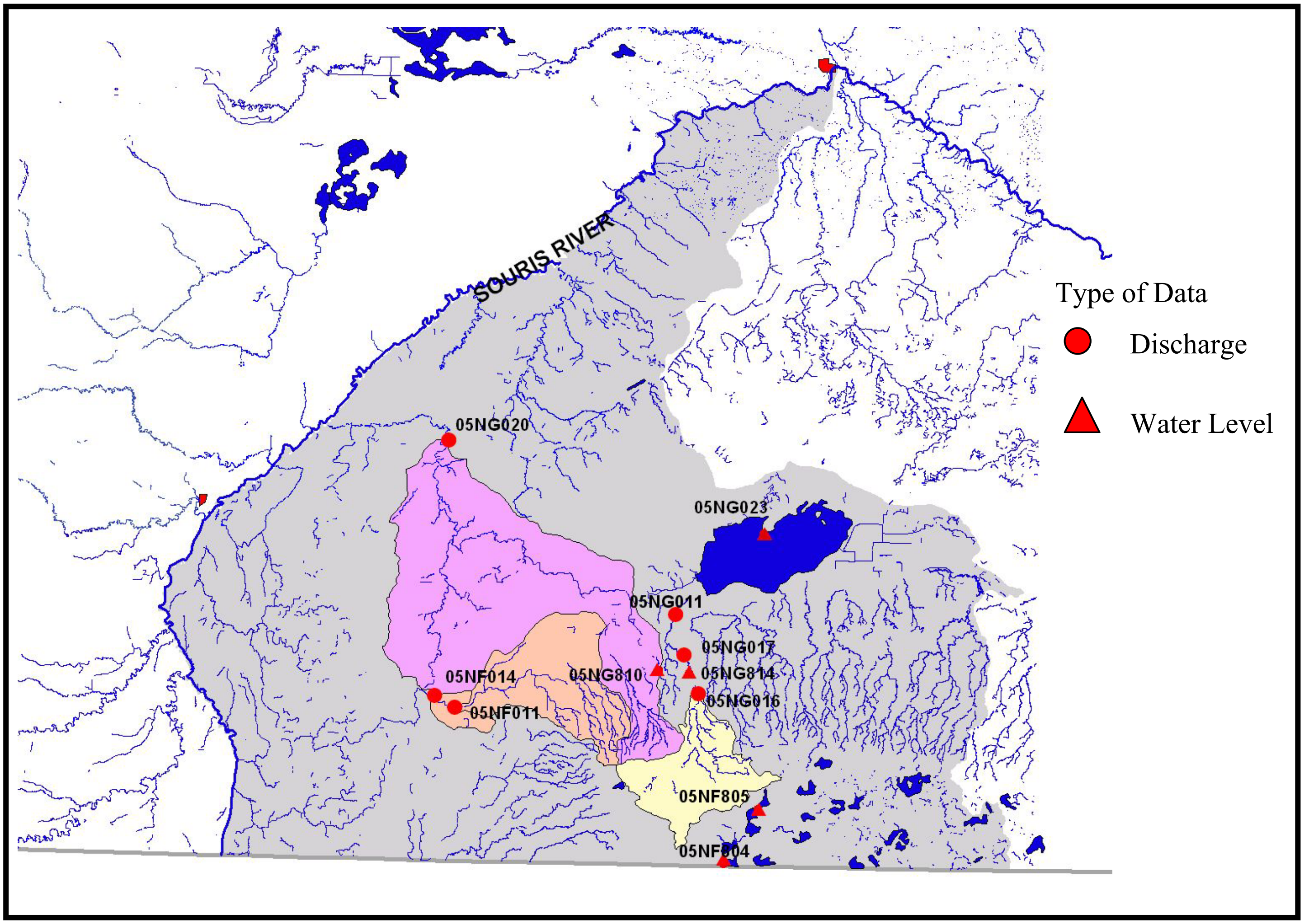

Figure 17. Location of hydrometric gauging stations and the drainage areas of Waskada, Medora and Turtlehead Creek streamflow gauging stations.

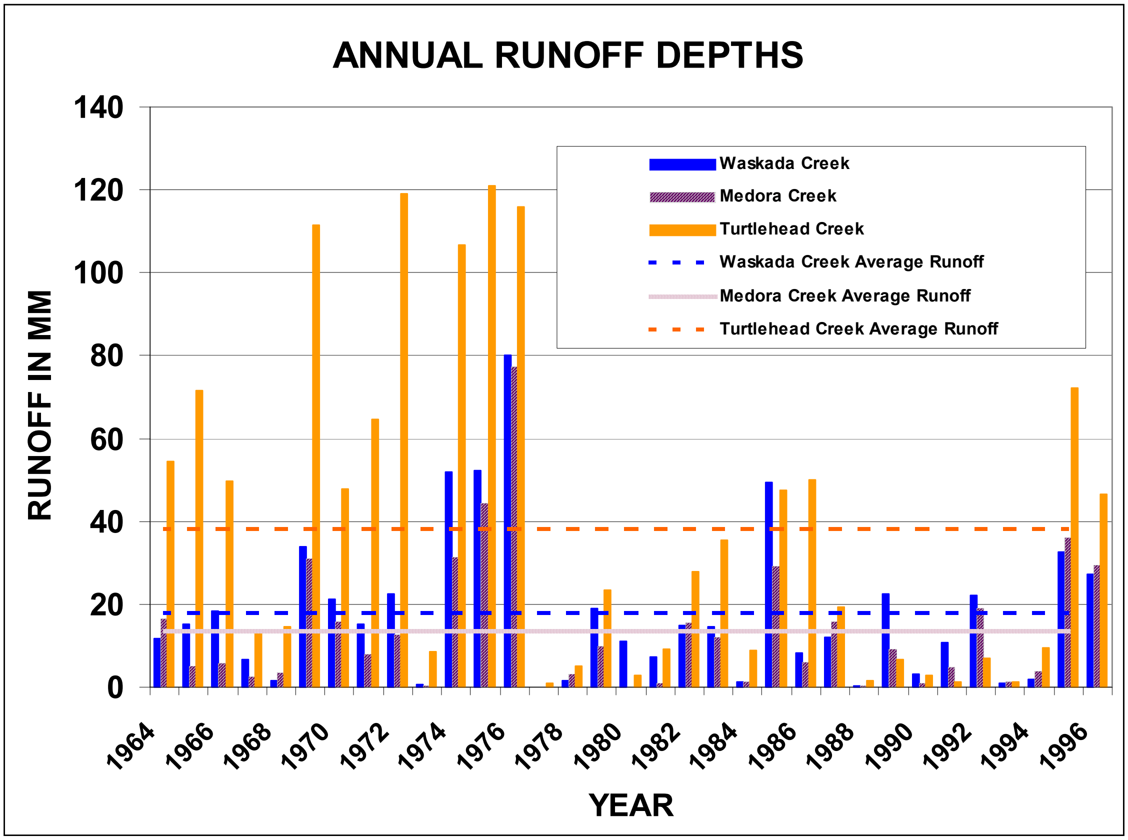

Figure 18. Annual runoff depths for Waskada, Medora and Turtlehead creeks.

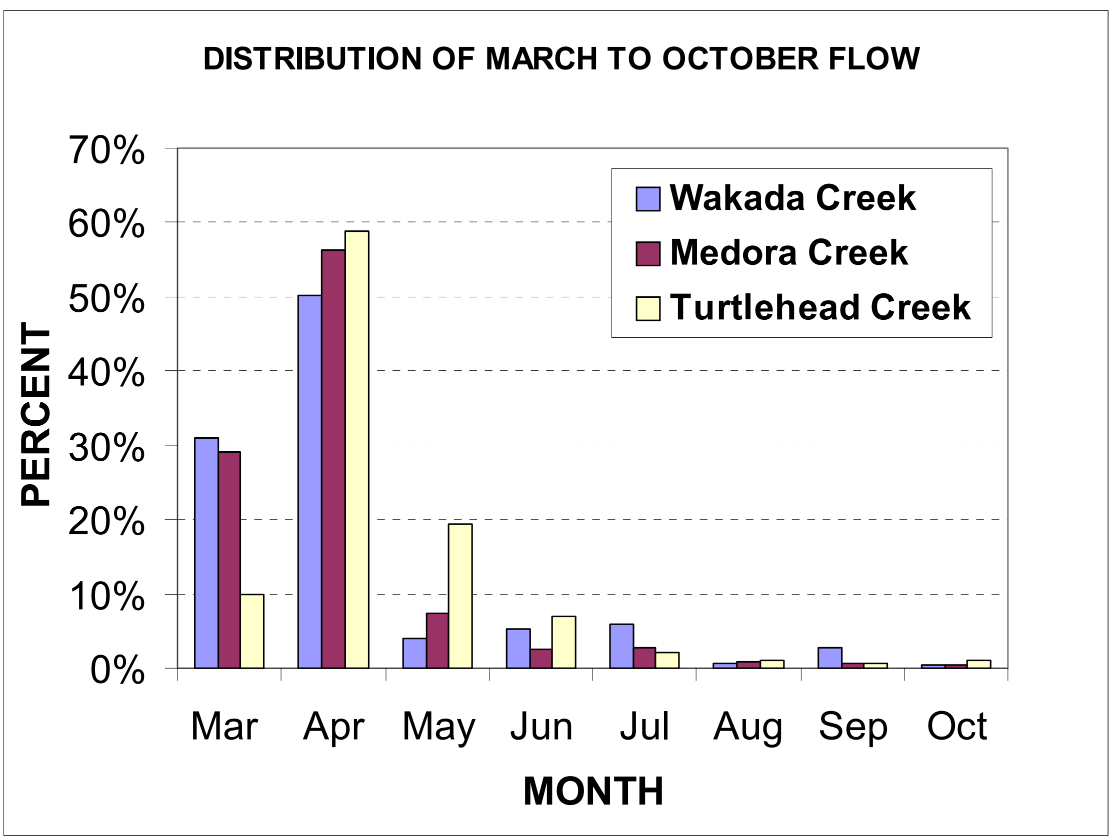

Figure 19. March to October flow disctribution for Waskada, Medora and Turtlehead creeks.

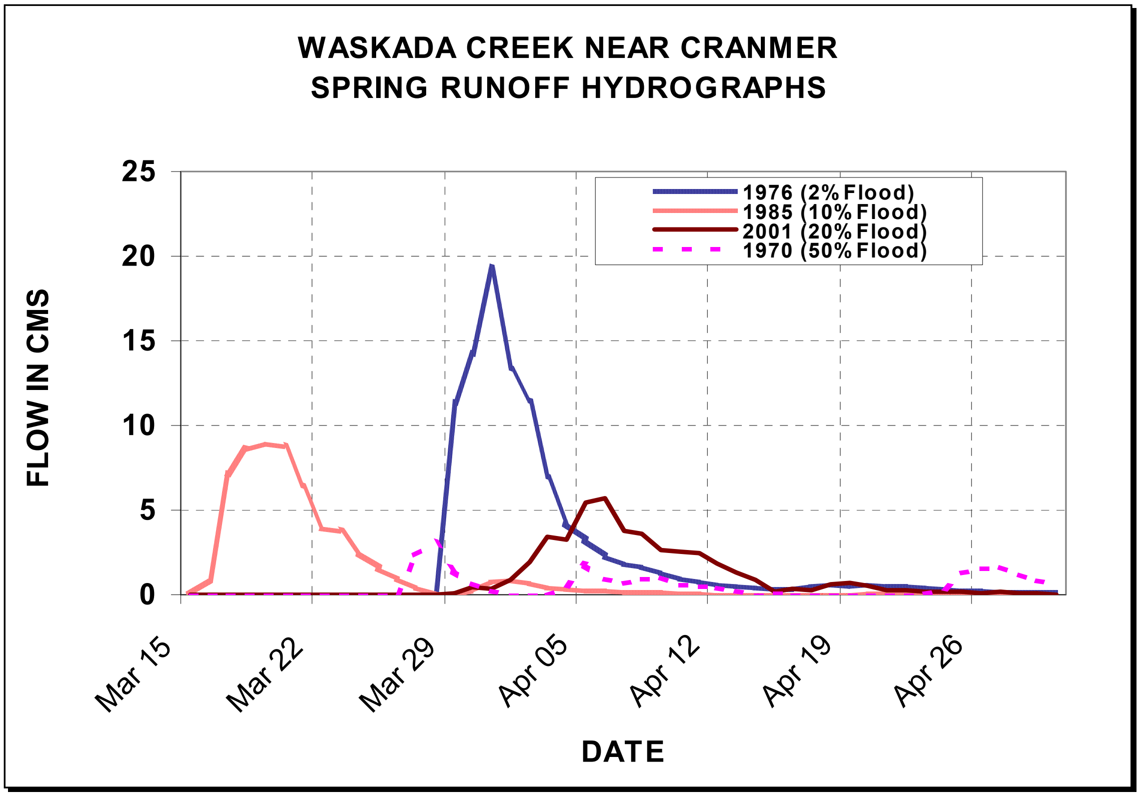

Figure 20. Waskada Creek near Cranmer (05NF014) spring runoff hydrographs.

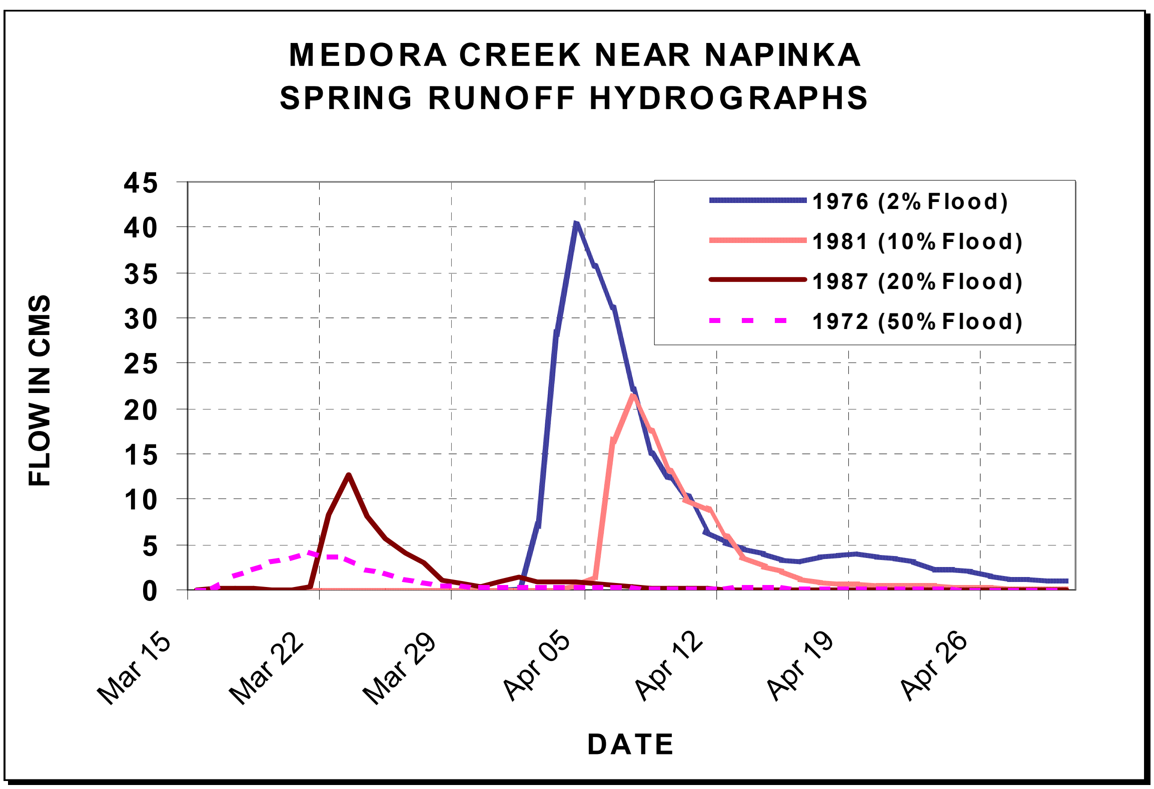

Figure 21. Medora Creek near Napinka (05NG020) spring runoff hydrographs.

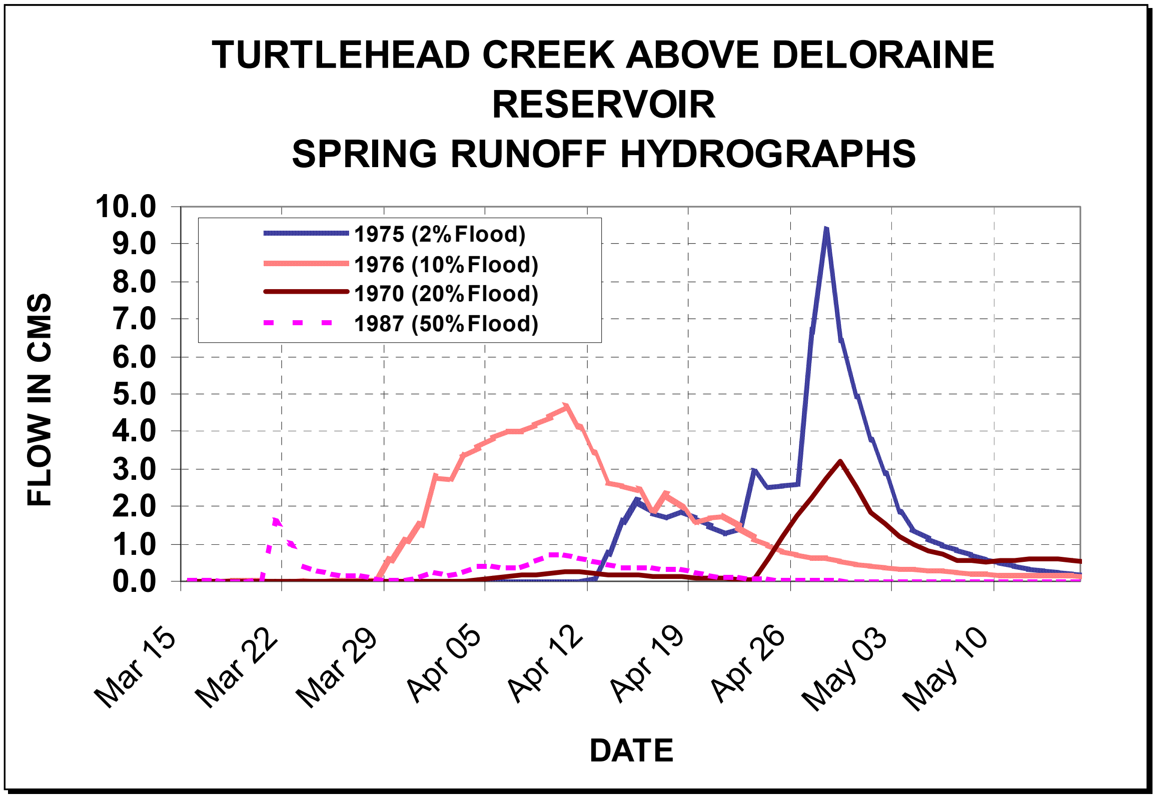

Figure 22: Turtlehead Creek above Deloraine Reservoir (05NG016) spring runoff hydrographs.

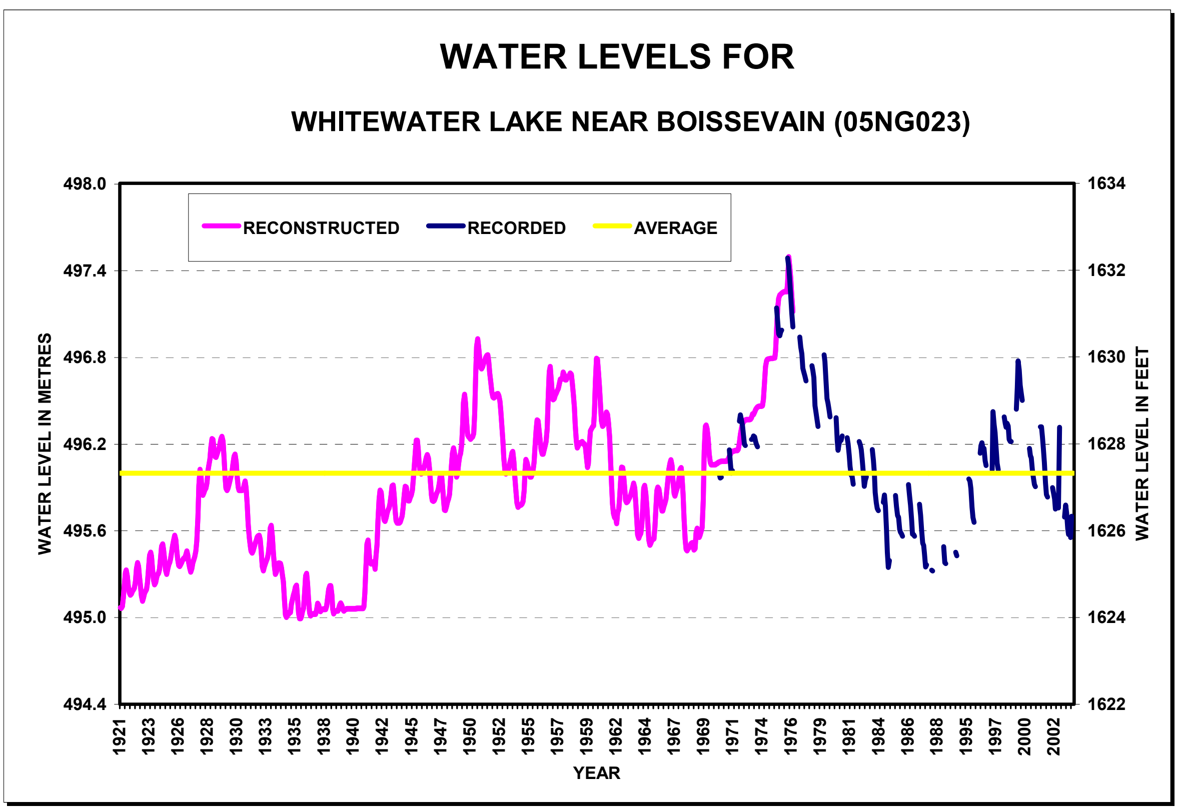

Figure 23. Whitewater Lake recorded and reconstructed mean monthly water levels.

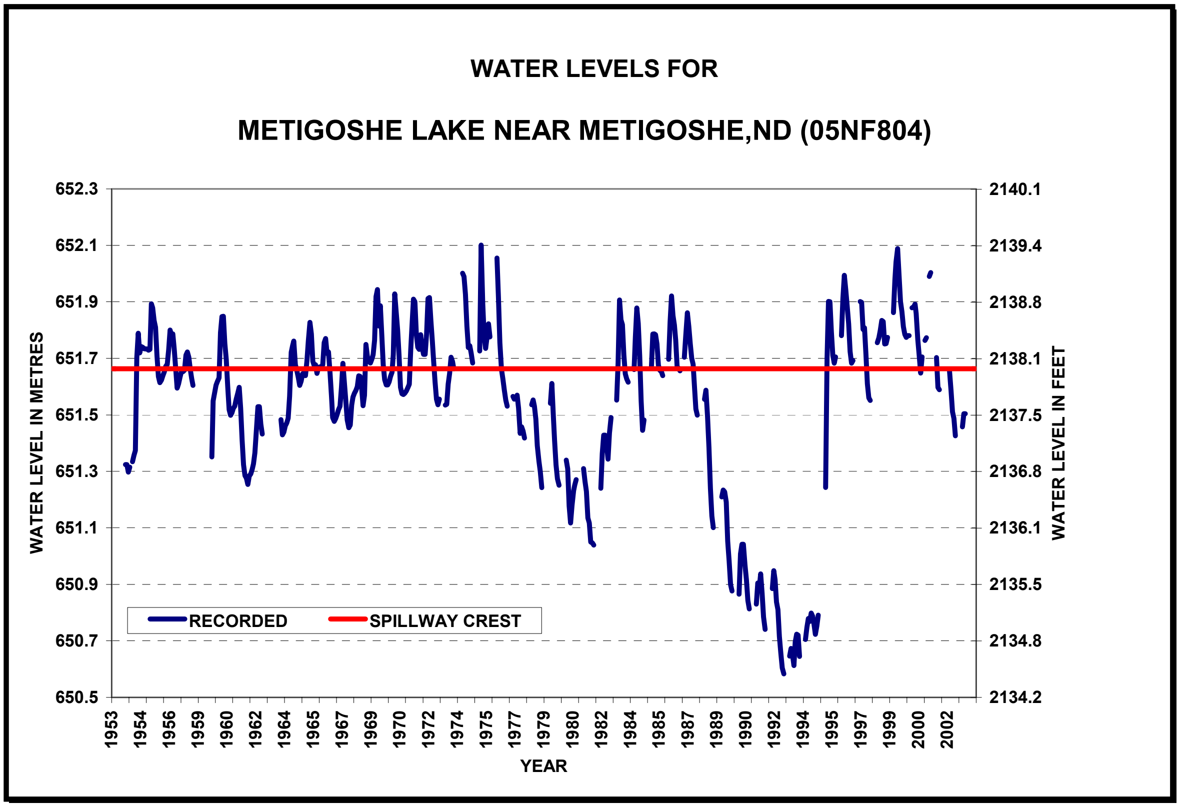

Figure 24. Metigoshe Lake recorded mean monthly water levels.

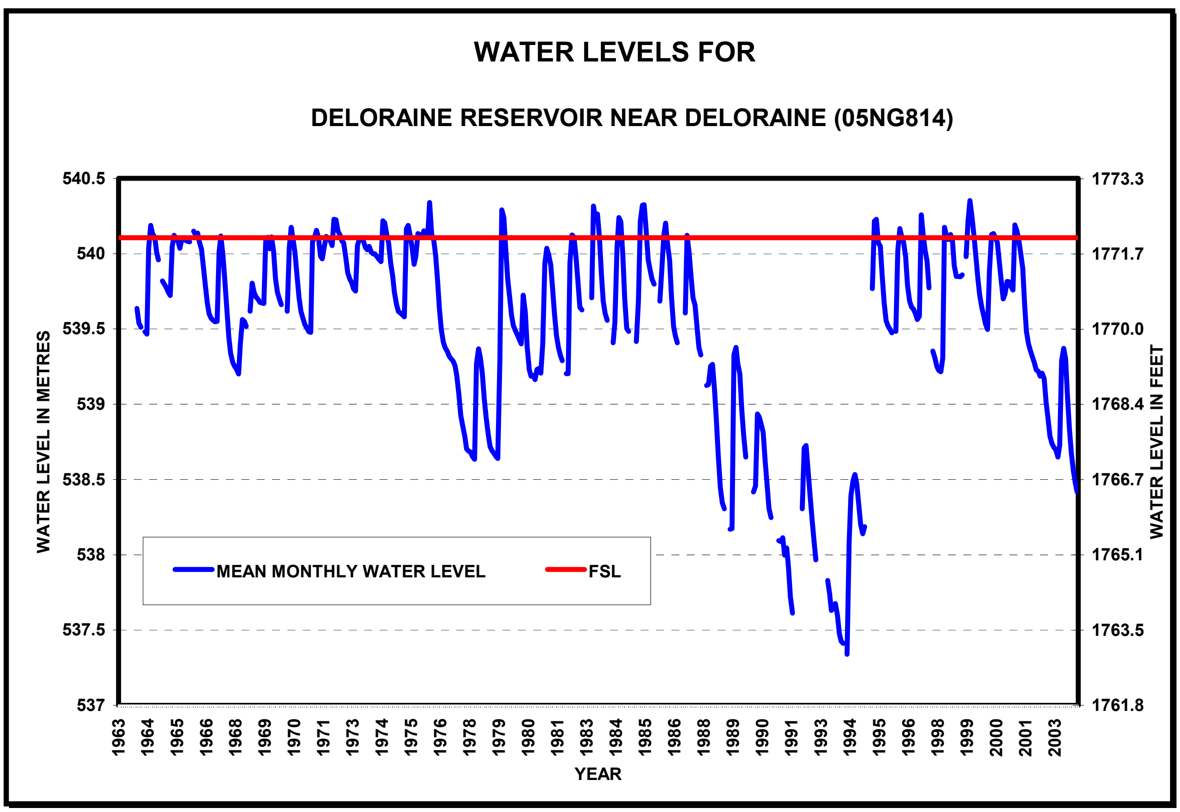

Figure 25. Deloraine Reservoir recorded mean monthly water levels.

Surface Water Quality

Nutrients and Water Quality in the East Souris River Watershed

Phosphorus and nitrogen occur naturally and are important plant nutrient sources in water bodies. However, several human factors have created an excess of nitrogen and phosphorus in many water bodies. Factors contributing to excess nitrogen and phosphorus concentrations include:

- Inadequate sewage treatment
- Malfunctioning private septic systems
- Accelerated soil erosion
- Application of inorganic field and lawn fertilizers
- Runoff from animal waste
- Enhanced drainage and reduced riparian vegetation
- Use of household cleaning products than contain phosphorus
- Decomposing vegetation (*i.e.,* leaves) deposited in rivers and streams

Like many rivers in southern Manitoba, activities within the Souris River watershed greatly affect the water quality of the river water. Numerous studies have investigated various aspects of the water quality and quantity in the Souris River and its surrounding drainage area (*e.g*., Environment Canada 1978, EMD 1979, Beck 1981, Chacko 1986, Blachford 1987, Beak Associates Consulting Ltd. 1991, Jones *et al.* 1998, Hughes 1999a). The general consensus of these studies is that the river and many of its tributaries contain high concentrations of nitrogen and phosphorus. Sources of these nutrients include wastewater discharges from communities in North Dakota, such as Minot, Velva, and Towner (Chako 1986), and several communities in Manitoba, including Melita, Souris, and Wawanesa (EMD 1979). As well, significant amounts of nutrients are believed to originate from non-point sources such as run-off from agricultural land (EMD 1979, Blachford 1987, Beak Associates Consulting Ltd. 1991).

Manitoba Water Stewardship's Water Quality Management Section examined trends in total nitrogen and phosphorus concentrations in steams across Manitoba (Jones and Armstrong 2001) with the United States Geological Survey's *QWTrend* program (Vecchia 2000). *QWTrend* was used on data sets with over 60 data points and more than 15 years of data. The program uses relatively complex statistical methods to identify trends in concentration data after accounting for variation due to flow. Data from the water quality sampling station on the Souris River at the town of Souris (WQ0371) in the East Souris River watershed (Figure 26) was included in the trend analysis. Flow data for the analysis were provided by Environment Canada from the hydrometric station MB05NG021 which is located in the immediate vicinity of WQ0371.

In the Souris River at the Town of Souris, there was a significant increase ($p = 0.0024$) in flow-adjusted TN concentration from 1978 to 1997 (Figure 27). Although some relatively high TP concentrations were recorded in the latter half of the reporting period, these were highly positively correlated with flow and no significant trend ($p = 0.3351$) was found once the influence of flow had been taken into account (Figure 28).

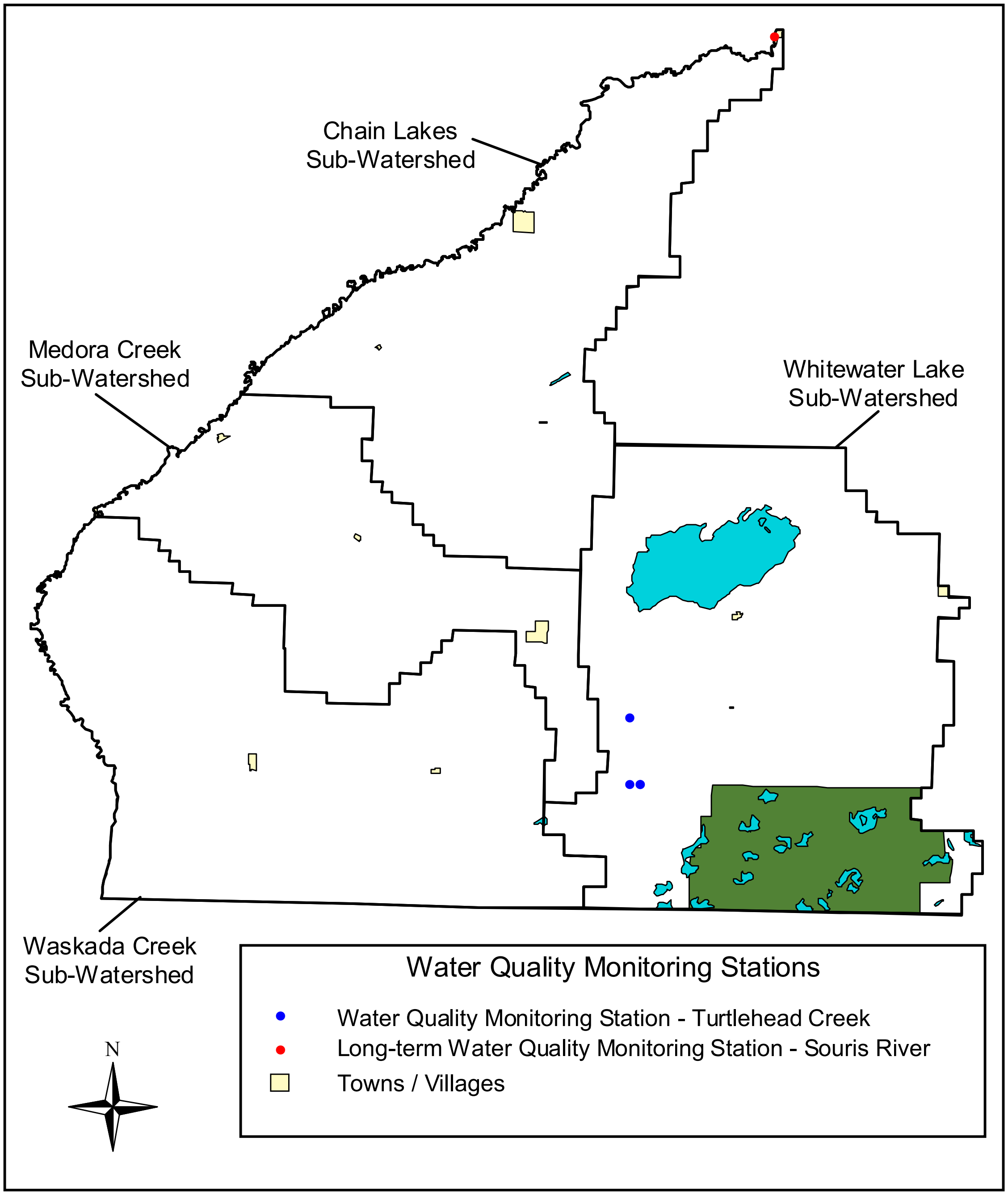

Figure 26. Locations of water quality monitoring stations within the East Souris River IWMP study area.

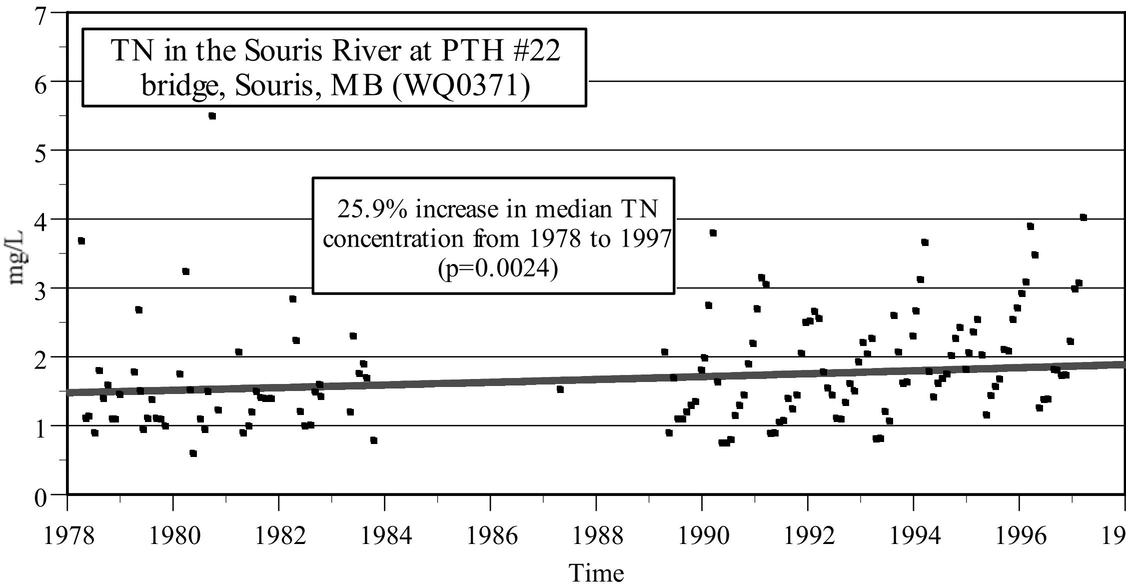

Figure 27. Trend in TN concentration in the Souris River at PTH #22, Souris, MB, 1978 to 1997 (inclusive). Dots represent measured concentrations, while the solid line represents the trend in flow-adjusted concentrations. The % change in median concentration refers to the median concentration of the flow-adjusted trend line.

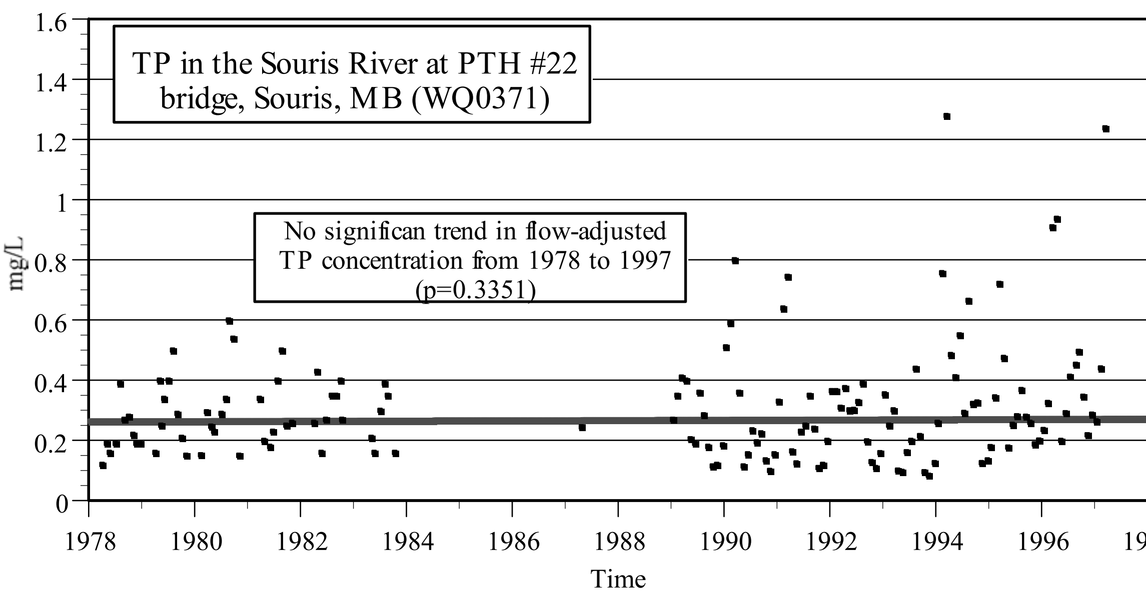

Figure 28. Trend in TP concentration in the Souris River at PTH #22, Souris, MB, 1978 to 1997 (inclusive). Dots represent measured concentrations, while the solid line represents the trend in flow-adjusted concentrations.

More information on the Souris River and watershed can be obtained from the Water Quality Management Section's long-term water quality station (WQ0350) located at PR #530, near the community of Treesbank. The site is approximately 70 km downstream of the water quality station at the Town of Souris and is about 8 km upstream of the river's confluence with the

Assiniboine River. Flow data for the analysis were supplied by hydrometric station MB05NG001 near Wawanesa, about 9 km upstream of the water quality monitoring station.

Both flow-adjusted TN and TP concentrations increased significantly ($p < 0.0001$) over approximately 30 years (Figures 29 and 30). The degree of increase over the entire period of record was relatively substantial, with the median of the trend increasing over 45 % for TN, and over 50 % for TP.

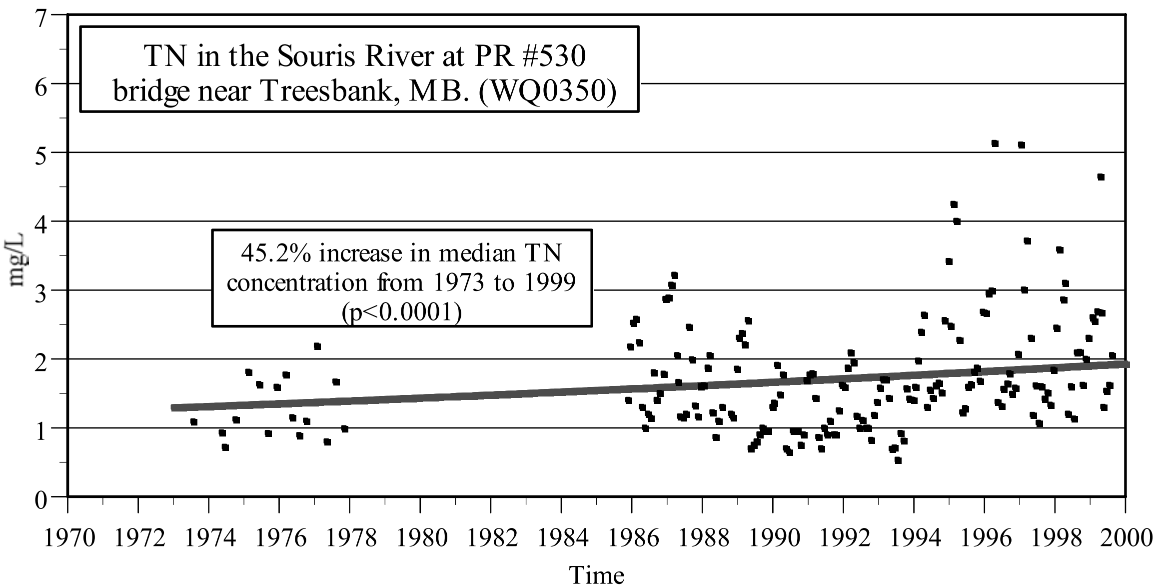

Figure 29. Trend in TN concentration in the Souris River at PR #530 near Treesbank, MB, 1973 to 1999 (inclusive). Dots represent measured concentrations, while the solid line represents the trend in flow-adjusted concentrations. The % change in median concentration refers to the median concentration of the flow-adjusted trend line.

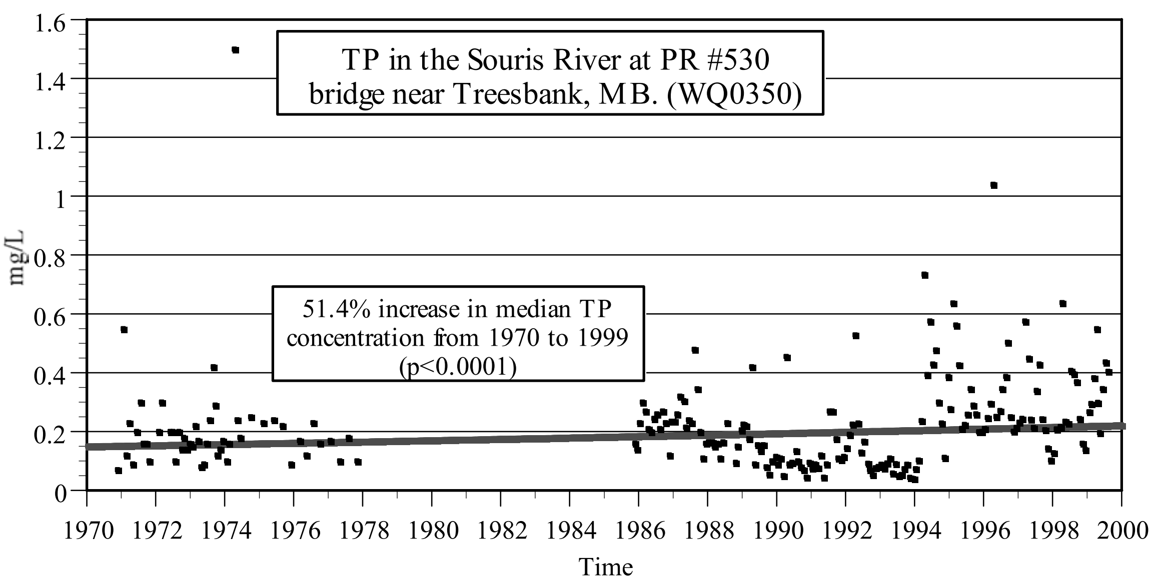

Figure 30. Trend in TP concentration in the Souris River at PR #530 near Treesbank, MB, 1970 to 1999 (inclusive). Dots represent measured concentrations, while the solid line represents the trend in flow-adjusted concentrations. The % change in median concentration refers to the median concentration of the flow-adjusted trend line.

A third water quality sampling station is located in the upstream portion of the watershed near the international border where the river crosses into Canada from the United States. Over the years the United States Geological Survey (USGS) and Environment Canada have collected water samples on their respective side of the border -- the USGS with a station near Westhope, North Dakota, and Environment Canada with a station near Coulter, Manitoba. However, since neither agency has a complete long-term record of data for this section of the river, the data sets from both locations were combined to provide a longer period of record for the trend analysis. The combined data set consisted of Environment Canada data collected from 1973 to 1992 at Coulter and USGS data collected from 1993 to 1999 (inclusive) at Westhope. Flow data were provided from the hydrometric station near Westhope (ND05NF012).

Flow-adjusted TP concentrations showed no significant trend between 1973 and 1999 ($p = 0.1147$) at the station near Coulter (Figure 31). Total nitrogen data could not be analysed because of problems with Environment Canada's nitrogen analysis.

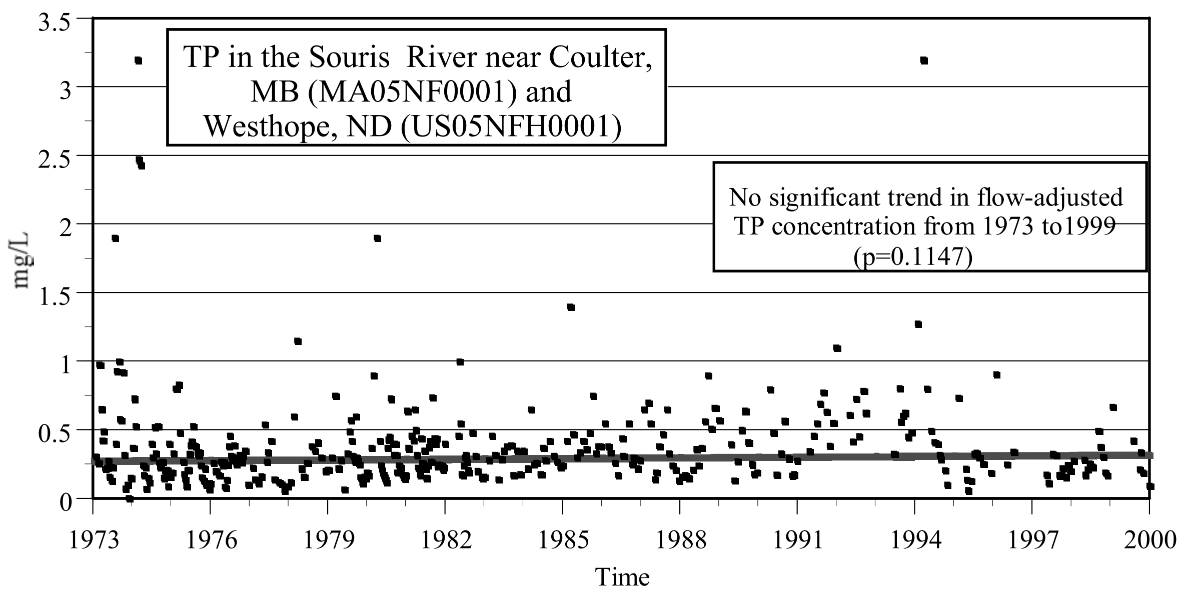

Figure 31. Trend in TP concentration in the Souris River near Coulter, MB, and Westhope, ND, 1973 to 1999 (inclusive). Dots represent measured concentrations, while the solid line represents the trend in flow-adjusted concentrations.

A positive trend at a water quality monitoring station could be attributed to an increase in nutrient additions to the waterway. However, the potential source of nutrient addition (*i.e.* point or non-point source, anthropogenic or natural) was not identified. Also assessment of the potential impact of an increase in nutrients on an aquatic system depends on the magnitude of the increase and the actual recorded concentrations present. In addition, monitoring stations where trends were not detected may still be subject to anthropogenic nutrient additions leading to eutrophication.

Lake Winnipeg Watershed
The Souris River is part of the Lake Winnipeg watershed which stretches across four provinces and four U.S. states (Figure 32). Excessive concentrations of nitrogen and phosphorus in Lake Winnipeg are causing gradual changes to occur in the lake's water quality and biological communities. Nitrogen and phosphorus are contributed from virtually all of our activities in Lake Winnipeg's large watershed and are directly associated with the production of nuisance growths of algae - affecting fish habitat, recreation, drinking water quality, and clogging fishing nets. Some nuisance growths of algae can also produce toxins.

Manitobans, including those in the Souris River watershed, contribute about 41 % of the phosphorus and 36 % of the nitrogen to Lake Winnipeg (Bourne *et al.* 2002). About 14 % of the phosphorus and 5 % of the nitrogen entering Lake Winnipeg is contributed by agricultural activities within Manitoba. In contrast, about 11 % of the phosphorus and 7 % of the nitrogen entering Lake Winnipeg from Manitoba is contributed by wastewater treatment facilities such as lagoons and sewage treatments plants. The Souris River watershed contributes about 2 % of the nitrogen and 5 % of the phosphorus to Lake Winnipeg.

In February of 2003, the provincial government announced the Lake Winnipeg Action Plan, a commitment to reduce nitrogen and phosphorus loads to Lake Winnipeg to pre-1970s levels. The Lake Winnipeg Action Plan recognizes that nutrients are contributed by most activities occurring within the drainage basin and that reductions will need to occur across all sectors. Reductions in nutrient loads across the Lake Winnipeg watershed will benefit not only Lake Winnipeg but also improve water quality in the many rivers and streams that are part of the watershed including the Souris River.

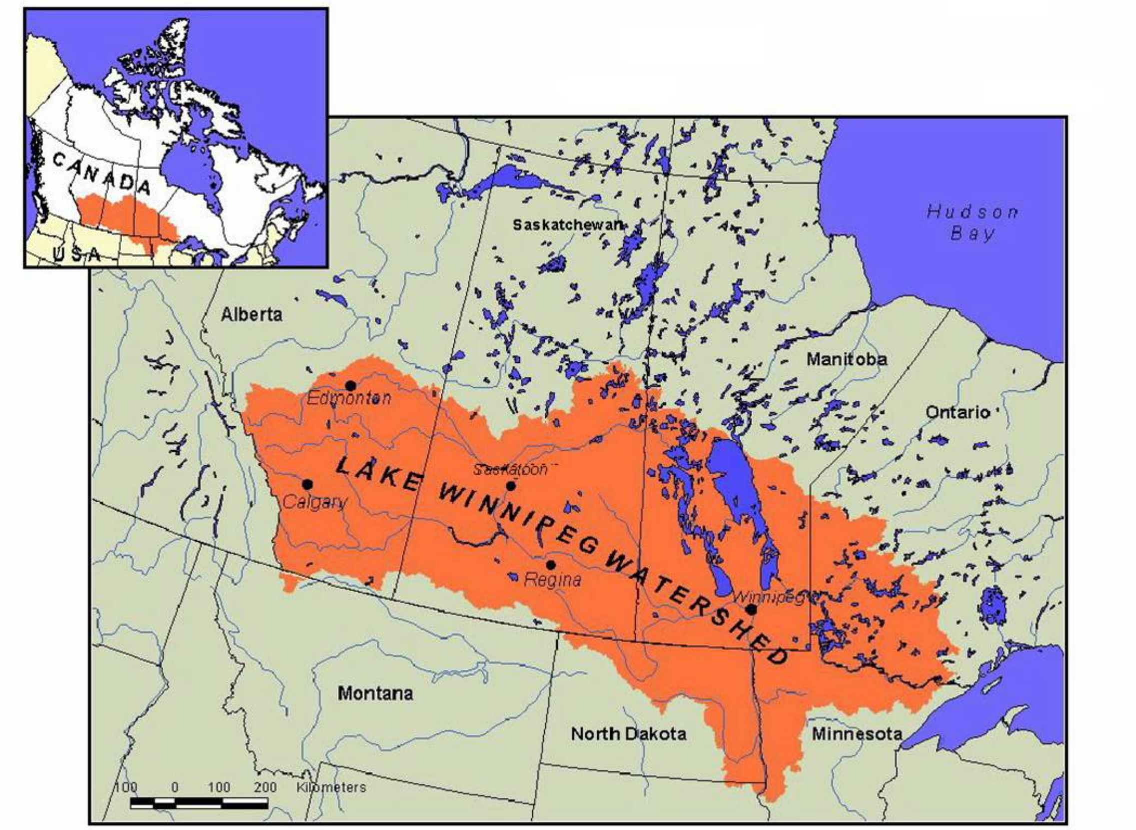

Figure 32. The Lake Winnipeg watershed, the second largest in Canada, stretches across four provinces and four U.S. States.

As part of the Lake Winnipeg Action Plan (www.manitoba.ca/lakewinnipeg), the Manitoba government has:

- Established a Lake Winnipeg Stewardship Board to help Manitobans identify further actions necessary to reduce nitrogen and phosphorous to pre-1970 levels in the lake by 13 percent or more;
- Provided a program to expand soil testing to ensure appropriate fertilizer application in both rural and urban settings;
- Introduced a new sewage and septic field regulation that outlines clear standards for the placement of systems, and;
- Commenced cross-border nutrient management discussions.

However, reducing nutrients across the Lake Winnipeg watershed is a challenge that will require the participation and co-operation of all Manitobans and will involve:

- Implementing expensive controls on nutrients in municipal and industrial wastewater treatment facilities.

- Developing scientifically-based measures to control the application of inorganic fertilizers, animal manure, and municipal sludge to agricultural lands.
- Reducing nutrient contributions from individual cottagers and homeowners.
- Working with our upstream neighbours.

You can help by taking the following steps:

- Maintain a natural, riparian buffer along waterways. Natural vegetation slows erosion and helps reduce the amount of nitrogen and phosphorus entering lakes, rivers and streams.
- Value and maintain wetlands. Similar to riparian buffers along waterways, wetlands slow erosion and help reduce nutrient inputs to lakes, rivers, and streams. Wetlands also provide flood protection by trapping and slowly releasing excess water while providing valuable habitat for animals and plants.
- Don't use fertilizer close to waterways. Heavy rains or over-watering your lawn can wash nutrients off the land and into the water.
- Use phosphate-free soaps and detergents. Phosphates have been prohibited from laundry detergents but many common household cleaners including dishwasher detergent, soaps, and other cleaning supplies still contain large amounts of phosphorus. Look for phosphate-free products when you are shopping.
- Ensure that your septic system is operating properly and is serviced on a regular basis. It's important that your septic system is pumped out regularly and that your disposal field is checked on a regular basis to ensure that it is not leaking or showing signs of saturation.

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Groundwater Resources

GROUNDWATER RESOURCES
Groundwater is an important source of water supply for rural, private domestic use as well as municipal, agricultural and industrial purposes within the ESR study area. Groundwater resource information for areas of the ESR study area is provided within the following reference material:

- Groundwater Resources in the Souris Basin in Manitoba. Department of Mines, Resources and Environmental Management, Water Resources Branch. Report No. 76/23. 1976.

- Groundwater Resources in the Turtle Mountain Conservation District. Manitoba Department of Mines, Resources and Environmental Management. Planning Branch. Report No. 78/27. 1978.

- Turtle Mountain Conservation District – Groundwater Availability Study. Prepared for Water Resources Branch, Manitoba Department of Natural Resources. Prepared by Western Ground-Water Consultants Ltd. 1982.

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- Groundwater Resources in the Town of Deloraine (A Synopsis). Manitoba Department of Natural Resources. Water Resources Branch. Report No. 83/15. 1983.

- Groundwater Resources in the Southwestern Region of Manitoba (A Synopsis). Manitoba Department of Natural Resources. Water Resources Branch. Report No. 85/3. 1985.

- Groundwater Resources in the Del-Win Planning District (A Synopsis). Manitoba Natural Resources. Water Resources Branch. Report No. 86/3. 1986.

- Groundwater Availability Map Series, Virden Area (62-F), Manitoba Natural Resources, Water Resources, 1983.

- Aquifer Maps of Southern Manitoba, Map 1 of 2, Bedrock Aquifers, M. Rutulis, Department of Natural Resources, Water Resources Branch, 1986.

- Aquifer Maps of Southern Manitoba, Map 2 of 2, Sand and Gravel Aquifers, M. Rutulis, Department of Natural Resources, Water Resources Branch, 1986.

Data is also available from GWDrill, a provincial data base containing geological, hydrogeological, geochemical and well construction information for test holes and water wells from well driller's reports. GWDrill is administered by the Groundwater Management Section of the Water Science and Management Branch, Manitoba Water Stewardship.

Aquifer Information
Groundwater is available from a number of aquifers located throughout the area of the ESR study area. The quantity and quality, however, varies considerably from location to location. Maps of the approximate boundaries of the sand and gravel and bedrock aquifers within the ESR study area are presented on Figures 33 and 34 respectively, and in general, are summarized below. GIS layers of the sand and gravel and bedrock aquifers are available from Manitoba Water Stewardship's geospatial data library.

Sand and Gravel Aquifers
Thin Unconfined Sand: These aquifers are formed by generally thin surface sand deposits, and often are minimal in saturated thickness and areal extent. Well yields are often low and the supply not reliable, and typically range from about 1 to 50 Igpm. The chemical quality of groundwater for domestic use ranges from fair to excellent.

Thick and Extensive Unconfined Sand and Gravel: A small portion of the study area intercepts the south-eastern edge of the Oak Lake Aquifer. The sand and gravel deposits in this area are generally thin and minimal in saturated thickness. Well yields are low to moderate, and typically range from about 1 to 50 Igpm. The chemical quality of groundwater for domestic use ranges from fair to excellent.

Lenses of Sand and Gravel: These aquifers occur in till and other surficial deposits, and vary considerably in thickness and areal extent. The depth of these aquifers range from a few metres to more than 100 metres. Well yields are low to moderate, and typically range from about 1 to 65 Igpm. The chemical quality of groundwater for domestic use ranges from very poor to excellent.

Minor Sand and Gravel: These are areas with very few scattered minor sand and gravel aquifers. Typically bedrock is at or near ground surface or surficial deposits consist of mainly low permeability materials (e.g., clay and till). Often these areas are underlain by bedrock aquifers. Well yields and the chemical quality of groundwater are variable.

Buried Channel: A buried channel aquifer (referred to as the Waskada-Medora channel aquifer) exists to the west of Waskada. There is evidence this buried channel begins in North Dakota and extends north to nearly Medora. The channel is approximately ½ to ¾ miles wide and extends to a depth of over 300 feet near Waskada. Previous test drilling carried out indicates the channel is not continuous and is only water bearing up to about 2 miles north of Waskada. Well yields in the Waskada area are moderate to high, and range from about 50 to over 200 Igpm. The chemical quality of groundwater for domestic use ranges from fair to good. While the channel exists near Medora, it does not yield quantities of water suitable for domestic or other uses.

Bedrock Aquifers
Sandstone and Sand: These aquifers consist of sandstone and, more commonly, sand layers interbedded with clay, silt, shale and coal beds. The depth of the sandstone is generally less than 40 metres. Well yields are typically less than 13 Igpm but can exceed 100 Igpm at a few locations. The chemical quality of groundwater for domestic use ranges from poor to good.

Shale: These aquifers are formed in fractured shale beds of the Odanah Shale member. The depth of these aquifers typically ranges from about 10 to 40 metres. Well yields are typically low and yield less than 13 Igpm. The chemical quality of groundwater for domestic use ranges from very poor to good. As shown on Figure 35, an extensive area of the shale contains slightly saline water with a total dissolved solids concentration typically in the range of 2,500 to 5,000 mg/L. The water is not potable, but may be acceptable for some livestock and other uses.

Provincial Observation Wells
The province currently maintains a network of 6 active observation wells within the ESR study area as shown on Figure 33 (two wells are located on SW32-3-24W). The observation wells are used to monitor groundwater levels and collect groundwater chemistry data from various sand and gravel aquifers located throughout the study area. A GIS layer of the provincial observation well locations is not yet available within Manitoba Water Stewardship's geospatial data library.

GROUND WATER AND WATER WELL ACT

The Ground Water and Water Well Act (Chapter G110) and Well Drilling Regulation (228/88R) is administered by the Water Science and Management Branch of Manitoba Water Stewardship. The Act applies to all sources of groundwater and to all wells whether drilled or developed before or after the Act was established in 1963. With the exception of controlling the flow from wells and the prevention of polluting groundwater and wells, the Act does not apply to a well that is drilled or developed by an owner on his land, using equipment owned by him, for the purpose of obtaining water solely for his domestic use.

Specifically, the Act:

- licenses all persons engaged in the business of drilling water wells;
- allows access and inspection of all wells or operations, and to all records, plants or equipment;
- allows undertaking of surveys of groundwater resources and studies of the conservation, development and utilization of groundwater;
- allows control of flow from wells;
- requires all reasonable precautions be taken to prevent contamination of groundwater via wells; and
- allows establishment of regulations related to the conservation, development and control of groundwater resources and the drilling and operation of wells and the production of groundwater there from.

The Well Drilling Regulation provides regulation for:

- the terms of licensing;
- collecting well drilling and testing information, maintaining well logs and submitting well reports;
- construction requirements;
- control of flow (artesian conditions);
- prevention of contamination of wells and aquifers; and
- sealing of abandoned wells.

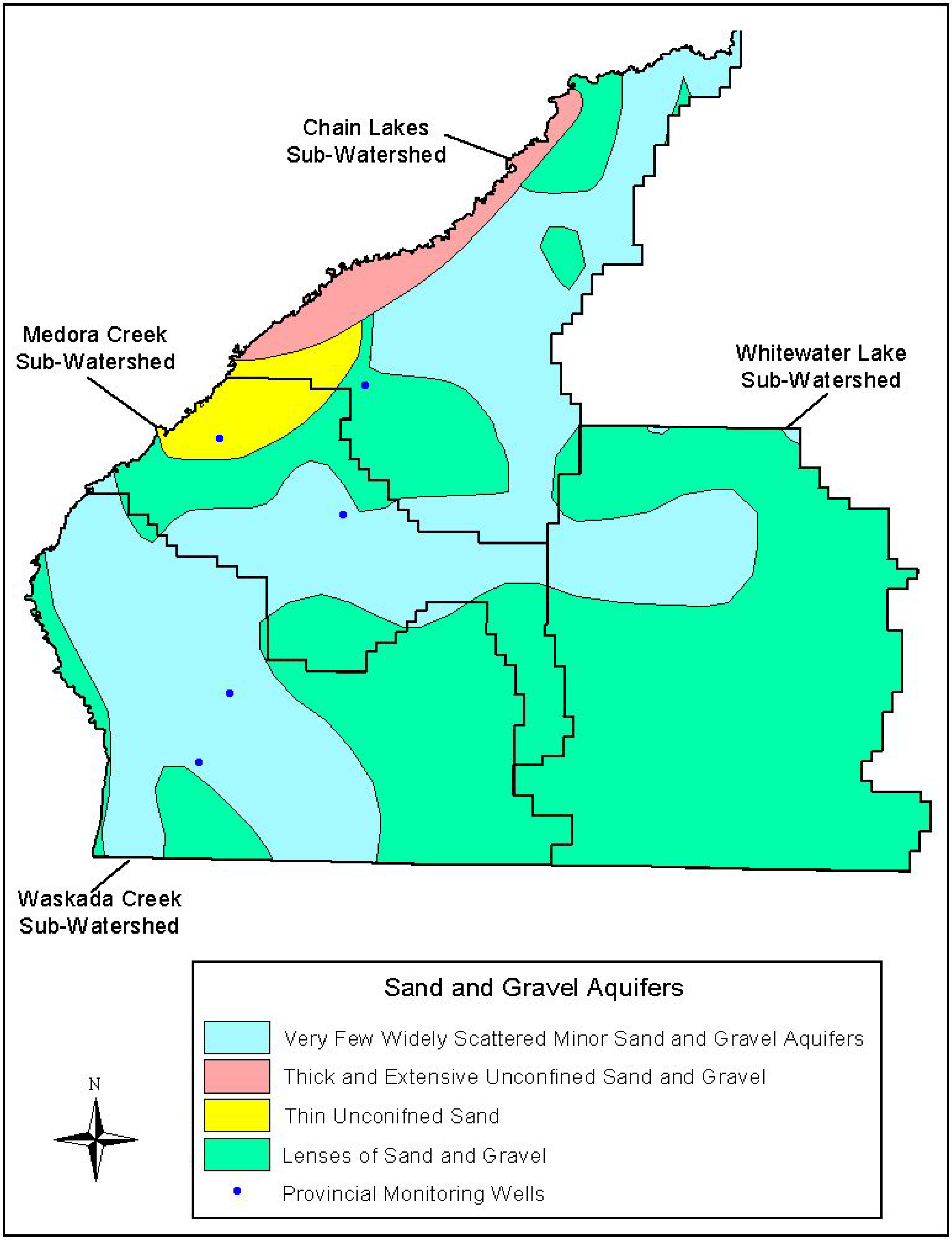

Figure 33. Sand and Gravel Aquifer map for the East Souris River IWMP study area.

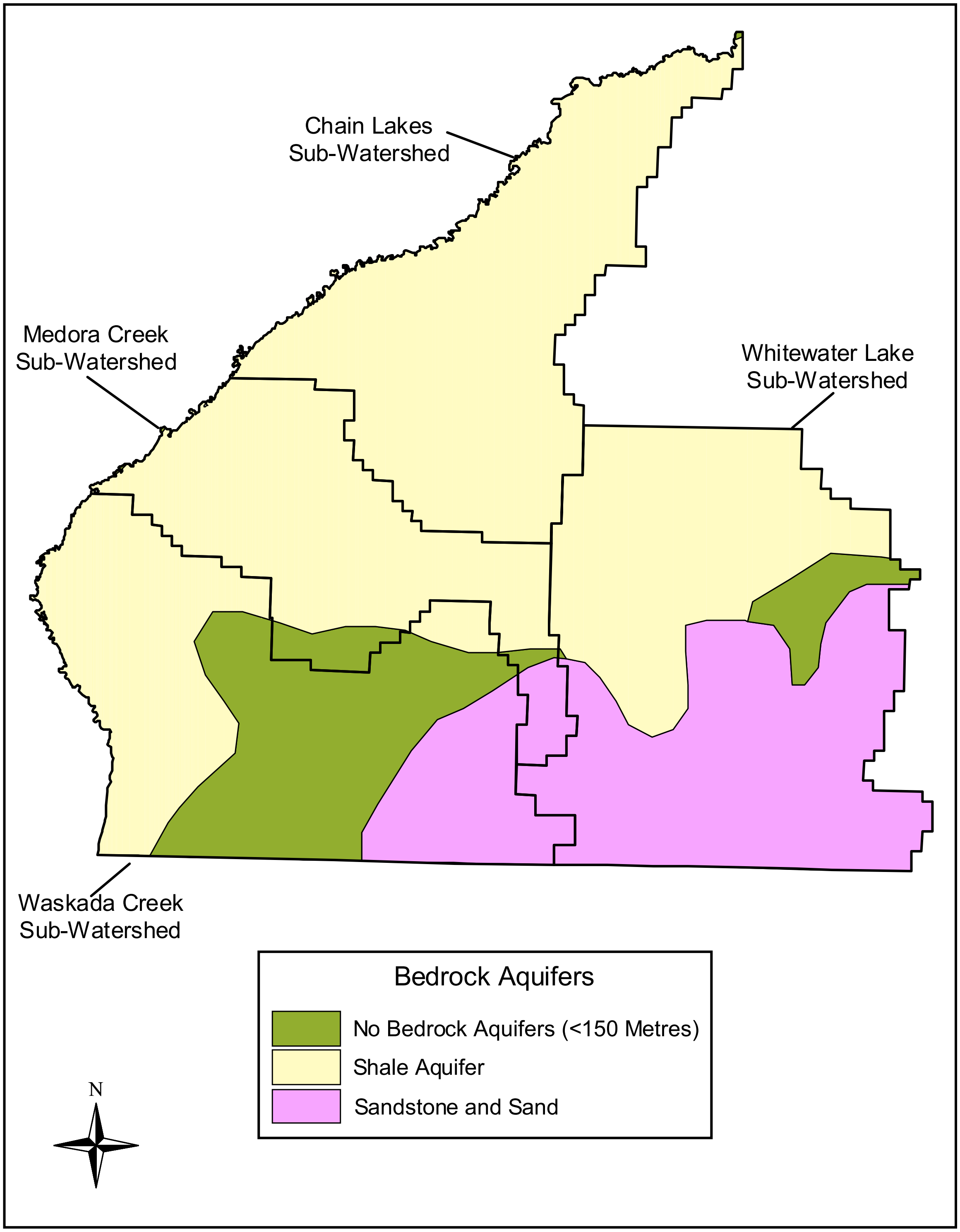

Figure 34. Bedrock Aquifer map for the East Souris River IWMP study area.

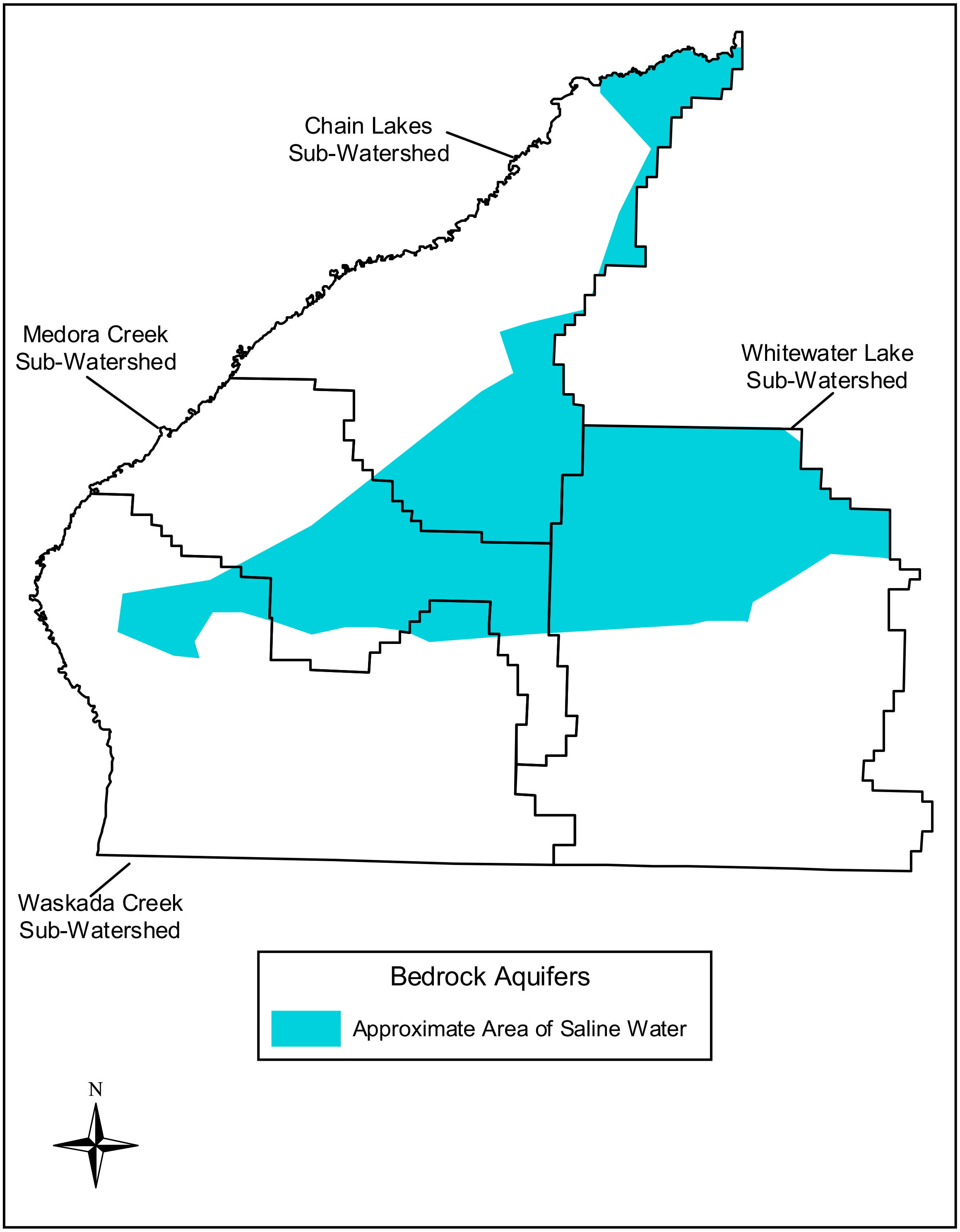

Figure 35. Approximate area of saline groundwater for the East Souris River IWMP study area.

GROUNDWATER CONTAMINATION ISSUES

With respect to contamination of water wells or aquifers, any well or aquifer has the potential to become contaminated if measures are not taken to protect from or reduce the risk of contamination. In considering development plans within the watershed, the following comments are offered:

Groundwater Sensitive Areas

Groundwater sensitive areas are defined as those areas with the greatest risk for contamination of groundwater from sources at or near the surface regardless of how local or extensive the aquifer may be. The degree to which shallow aquifers will be vulnerable to contamination from the surface will largely depend upon the thickness and properties of the material overlying the aquifer and the properties of the contaminant. Aquifers that are overlain by six metres or more of low permeability material (such as clay or till) are considered as having low potential for contamination from surface activities. Aquifers consisting of sand and/or gravel or bedrock that are exposed at the surface are vulnerable to water degradation from surface activities. The degree of protection of the groundwater will increase with increasing cover of low permeability material.

Within the ESR study area, existing map information and water well logs can be used as a reconnaissance siting tool in identifying groundwater sensitive areas. For any proposed site development in the watershed, site specific investigations should be considered. The degree of detail for the site specific investigations would depend on the proposed site use and potential for contamination of underlying soil and groundwater.

Water Well Construction

The responsibility lies with the owner of a water well to ensure that their well and water distribution system is properly constructed and maintained and that the well provides water that is safe for drinking. Unfortunately, past investigations conducted by Manitoba Conservation and Manitoba Water Stewardship throughout regions of the Province indicate that a common cause of water well contamination is improperly constructed, maintained or protected wells. Property owners installing new water wells should ensure:

- an experienced and licensed well drilling contractor is retained for the drilling and construction of the water well;
- water wells are located at a safe distance from potential sources of contamination and in an area away from surface runoff from potential sources;
- an experienced and licensed contractor completes the hook-up of the water well to the water distribution system (pitless well construction);
- after the water well has been completed but before it is put into operation, the well, pump and water distribution system are disinfected to kill any bacteria that may be present; and
- old wells are properly sealed to the standards recommended in Manitoba's Guide for Sealing Abandoned Water Wells.

The Turtle Mountain Conservation District has sealed 74 abandoned wells within the ESR study area since they commenced well sealing activities began in 1999. The locations of 69 of those wells are plotted on Figure 36. The exact legal location of the five wells not shown in Figure 36 is not available at this time.

Private Sewage Disposal Systems
Private sewage disposal systems are regulated by the Onsite Wastewater Management Systems Regulation under The Environment Act. Municipalities within the TMCD should ensure the design and construction of private sewage disposal systems are suitable for the soil conditions encountered and lot size proposed for any development.

Livestock Operations
Livestock operations and manure spreading are regulated under the Livestock Manure and Mortalities Management Regulation under The Environment Act. As well, the Province has prepared Farm Practice Guidelines for Hog / Beef / Dairy / Poultry Producers in Manitoba and provides a Technical Review process for new and expanded operations. These processes have been developed to reduce the potential risk of groundwater contamination.

Sand and Gravel Pits
There are a number of active and inactive sand and gravel pits located throughout the ESR study area (Figure 36). The establishment and operation of quarries are regulated by the Quarry Minerals Regulation under The Mines and Minerals Act. The regulation states that no operator shall contaminate groundwater, or permit the contamination of groundwater, through the establishment or operation of an aggregate quarry.

Other Considerations
Other potential sources of contamination that may be considered include: municipal sewage systems, waste disposal grounds, agricultural operations, industrial operations, pipelines, gas stations and transportation spills.

Well head protection programs, at the private, municipal or watershed level, should also be considered to reduce the risk of contaminating water supplies.

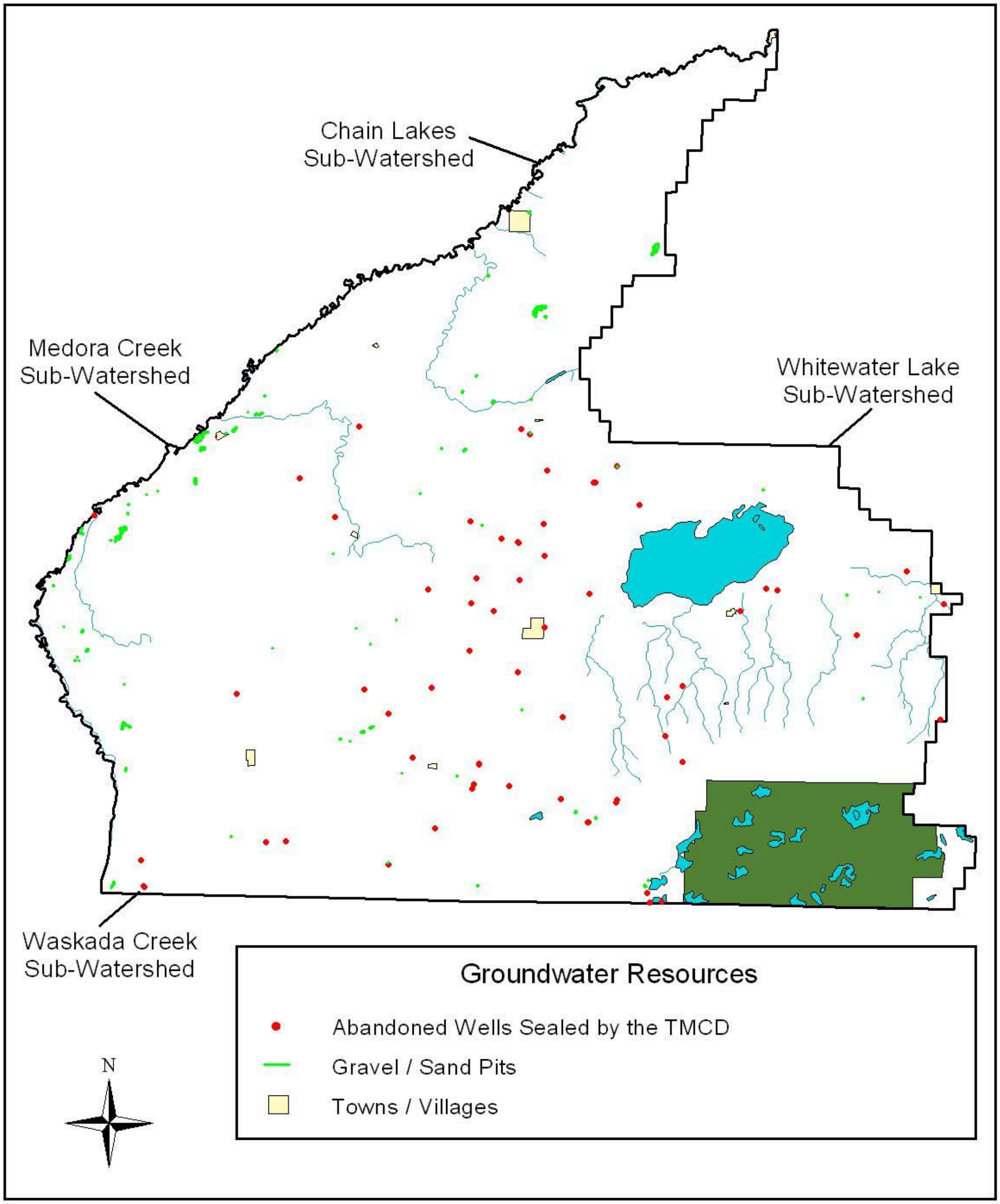

Figure 36. Location of sealed abandoned wells and gravel/sand pits in the East Souris River IWMP study area.

Water Systems
The classification of water systems falls under The Drinking Water Safety Act (S.M. 2002, c. 26) which is administered by The Office of Drinking Water, Manitoba Water Stewardship. Under the Act, a water system is defined as a well, or a device or structure or an assemblage of devices and structures, used or intended to be used for the production, treatment, storage or delivery of potable water for domestic purposes.

There are three types of systems supplying water, namely:

1) public water system – a water system that has 15 or more service connections, unless otherwise specified in the Act.

2) semi-public water system – a water system that is not a public water system or a private water system (e.g., community well tank loading stations, schools, hospitals and hotels).

3) private water system – a water system that supplies water only to one private residence, unless otherwise specified in the Act.

Well location, stratigraphic, well construction and well testing information for public, semi-public and private water wells are available from the provincial GWDrill data base, providing the information has been forwarded to the Water Science and Management Branch. In most cases, accurate UTM data is not available.

<u>Public Water Systems</u>

There are a total of 11 public water plants located within the East Souris River study area (Figure 37). Eight are classified as well source water systems, and service Napinka, Waskada, the Waskada Rural Water Coop (which services the rural area south and west of Waskada), Goodlands, Hartney, Souris, Lake Max and Lake Adam. At present, the Town of Waskada and Waskada Rural Water Coop pipeline are sourced from the Waskada-Medora channel aquifer. Of the remaining three public water systems, two are surface sources located in Deloraine and Medora and the other is a well/surface source located in the Town of Boissevain.

<u>Semi-Public Systems</u>

Water Plants

There are two semi-public water plants located within the study area. One is a well source located at the Turtle Mountain Bible Camp. The other is a surface water source located at Camp Koinonia.

Community Well Tank Loading Stations

Throughout the East Souris River watershed there are relatively few aquifers with sufficient groundwater capacity that can be used as community well tank loading facilities. One such aquifer is within the portion of the Waskada-Medora buried channel located to the west of Waskada. In addition to supplying the Waskada Town well and pipeline well the channel aquifer supports two tank loading facilities. One is located southwest of Waskada and the other is located just to the north of Waskada (Figure 38). Because of the volume of water withdrawn from this portion of the channel aquifer, and the resulting gradual lowering of the water levels in the

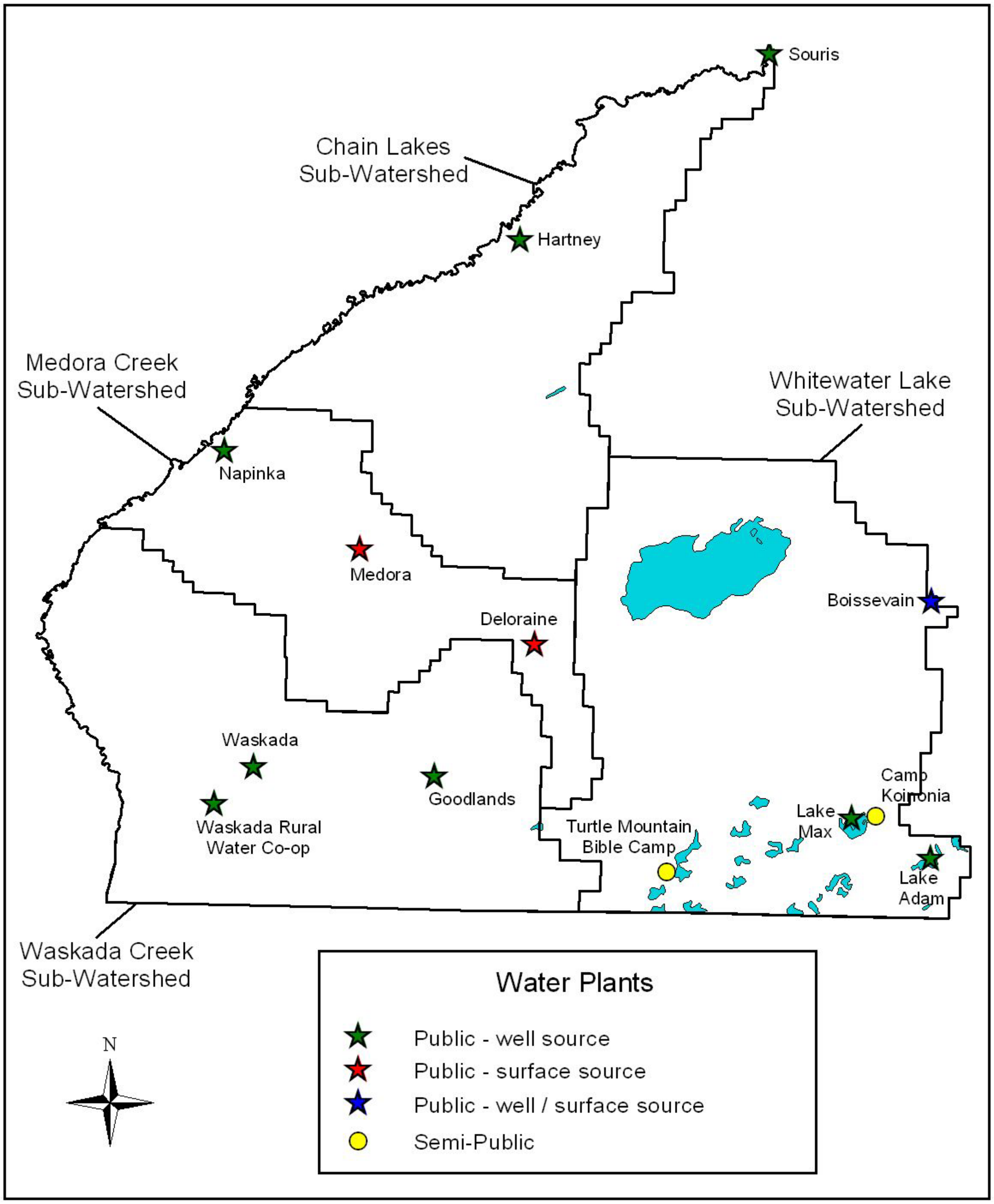

Figure 37. Location of public and semi-public water plants within the East Souris River IWMP study area.

aquifer, no further development of the channel aquifer is recommended until an evaluation of the sustainable yield of the aquifer is completed.

Other aquifers supplying groundwater for tank loading facilities are either sand and gravel deposits associated with creeks and rivers that cut through the area or are very localized pockets of sand and gravel. The community wells located directly south (7 miles) of Goodlands are developed within the sand and gravel deposits associated with the creek and have proven to be a reliable source of groundwater. These wells also provide piped water to the Village of Goodlands and surrounding area.

The two community wells located to the north of Goodlands have been developed within gravel pockets and are very limited in capacity. In general, by the time the spring spraying season is over, the wells are nearly dry.

There are tank loading facilities developed within sand and gravel aquifers northeast of Napinka and east of Hartney that have proven to be relatively reliable and tend not to be affected by drought conditions. The tank loading system located south of Hartney is developed within an old gravel pit and produces a large capacity of water during wet conditions but tends to produce less water during drought conditions.

While it is possible to develop a very high capacity loading station on the channel between the Chain Lakes, the very high iron content would drastically limit its usefulness for spraying applications.

The RM of Winchester has developed two tank loading systems off the Town of Deloraine surface water supply. One uses treated water from the town water plant while the other utilizes water from the main supply line from the lake. Both systems are lower in capacity due to possible interference with the water treatment plant operation. The RM has looked at increasing the flows from the treated water system but must wait until a larger reservoir at the treatment plant is completed.

All the other tank loading systems in this area utilize surface water as the source and are generally developed using a dugout or have been developed using an existing dam. The old dugout located at Goodlands is also connected to a dam located approximately 1 ½ miles to the southeast with a buried pipeline. During periods of drought, water can be let down from the dam to fill the dugout. During periods of extended drought, water can be further augmented by flowing water down the channels from two other dams located upstream to fill the first dam.

All the surface water tank loading facilities located throughout this area are equipped with screen filters to remove any algae or any suspended materials that may plug sprayer nozzles.

Generally, the heaviest usage on the tank loading facilities occurs during spraying season. It is not uncommon to have up to 60,000 gallons of water hauled from some facilities in one day during spraying season. Since most chemicals are very sensitive to hardness minerals, surface waters tend to be better for use in spraying of crops as they normally have lower hardness levels. Because of the potential for ground and surface water contamination of a tank loading station should a chemical spill occur, no sprayers or chemicals are allowed at the filling site.

Private Water Systems

The responsibility lies with the owner of a private water system to ensure it is properly constructed and provides water that is safe for drinking. Buyers of property containing an existing water system should retain a qualified professional to inspect the system to ensure it is properly constructed and in good working order.

It is recommended that all water system owners monitor the quality of their water supplies and conduct proper maintenance on a regular basis. The Province of Manitoba currently subsidizes 70 percent of the cost of drinking water bacterial tests for all drinking water systems.

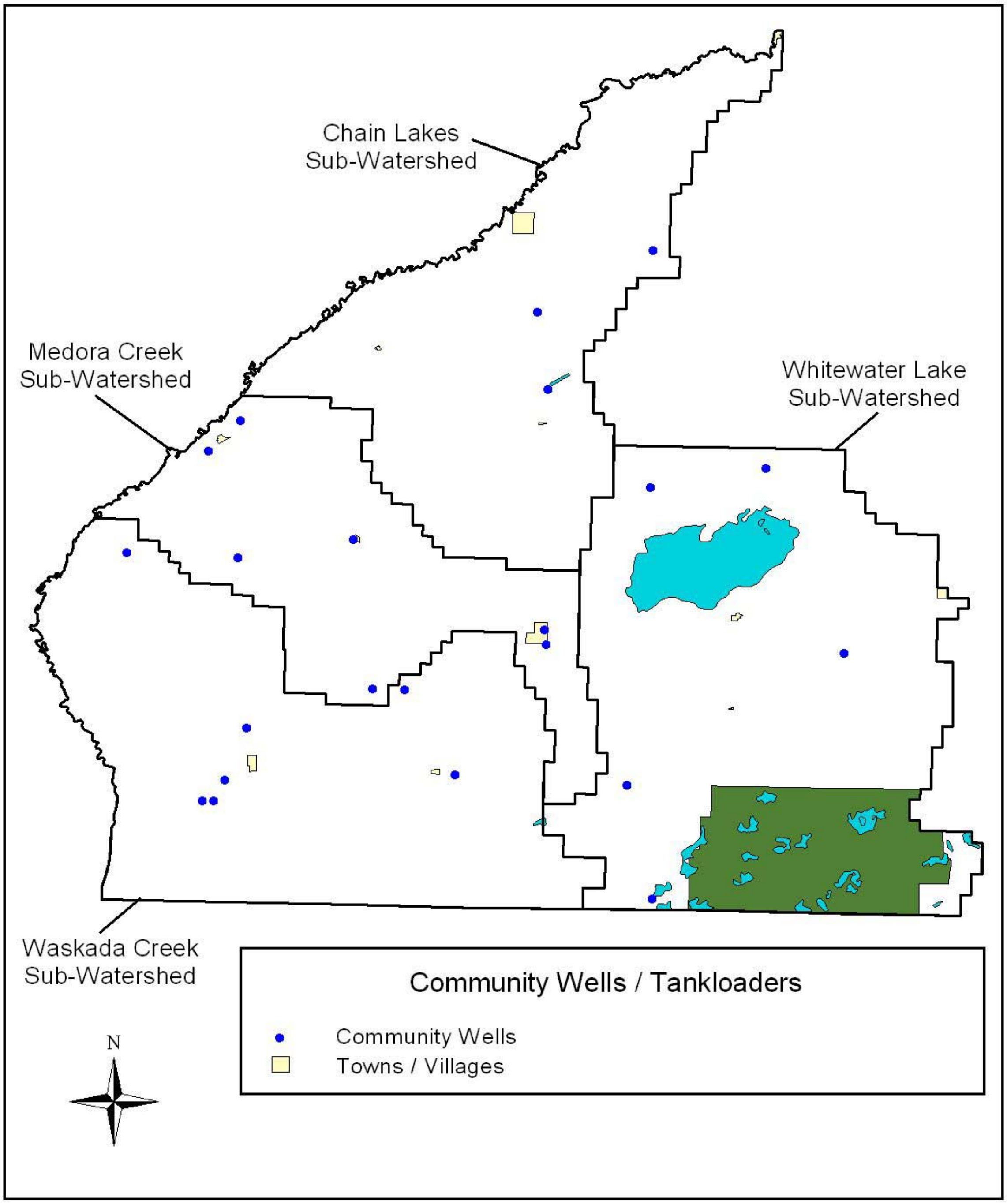

Figure 38. Location of community wells / tankloaders in the East Souris River IWMP study area.

Petroleum Resources

The following information is based on information included in the Manitoba Oil Activity Review document produced by Manitoba Industry, Economic Development and Mines which includes information up until the 2003 year. Within Manitoba there are a total of 13 oilfields and six of those oilfields exist within the boundaries of the East Souris River IWMP study area. The six oilfields are Lulu Lake, Mountainside, Regent, Souris Hartney, Waskada and Whitewater (Figure 39).

Drilling Activity by Area

As of 2003 total oil wells both inactive and active within Manitoba numbered close to 1,700. In 2003, four of the six oilfields in the ESR IWMP study had new wells drilled (Table 16). These wells totalled 48, with 40 being for development and eight for exploratory purposes. There are also a number of potential oil wells (POW) that were designated, 33 for development and seven for exploratory.

Table 16. Drilling activity in 2003 in oilfields within the East Souris River IWMP study area.

				Development		Exploratory				
Field	TWP	RGE WPM	Wells Drld.	Drld.	POW	Drld.	POW	Total POW	Dry / Abandonned	Other
Regent	4	21-22	2	2	2	0	0	2	0	0
Souris Hartney	6	22	1	1	1	0	0	1	0	0
Waskada	1-2	25-26	43	35	28	8	7	35	0	8
Whitewater	3	21	2	2	2	0	0	2	0	0
Total			**48**	**40**	**33**	**8**	**7**			
% of Total Drilled				**83**		**17**				

POW - Potential Oil Wells

Horizontal Wells

Of the 48 wells drilled in 2003, three were horizontal wells (Table 17). The one well in the Souris Hartney field has two legs with a horizontal length of 316 meters for one leg and the second of 648 meters. The two wells in the Whitewater field had only one leg 809 meters for one and 563 meters for the other.

Table 17. Horizontal wells drilled in 2003 within the East Souris River IWMP study area.

Field	Surface Location	Bottom Hole Location	Horizontal Length (m)	Licensee	Initial Production * (m^3/d)
Souris Hartney	9C-10-6-22	16D-10-6-22	316	Tundra Oil and Gas Ltd.	47.6
		1C-15-6-22	648**		
Whitewater	13D-34-2-21	A9A-33-2-21	809	Tundra Oil and Gas Ltd.	22.4
	4C-21-3-21	12D-21-3-21	563	EOG Rsources Inc.	3.1

* Average oil rate for first six months (or less) of production
** Second Leg

Areas of Activity
In 2003 the Waskada oilfield continued to be the most active area in the Province with a total of 43 wells being drilled. These wells were all drilled vertically with eight of the 43 being drilled as water injection wells.

As of 2003 in the six oilfield areas within the ESR IWMP study area there were a total of 475 active wells. Of these active wells 370 are active oil production wells while 105 are active wells (Table 18) for other purposes (water injection, salt water disposal, water supply, gas injection and various others).

Table 18. Non-abandoned wells in 2003 in the six oilfields within the East Souris River IWMP study area.

Field	Active (1) Oil Producers	Active (2) Other Wells
Lulu Lake	4	2
Mountainside	14	1
Regent	9	1
Souris Hartney	10	3
Waskada	297	95
Whitewater	36	3
Total	**370**	**105**

(1) Wells classified as capable of oil production at year end that produced oil in 2003. Dual completions or commingled wells count as one well.
(2) Includes Water Injection, Salt Water Disposal, Water Supply, Gas Injection and Other Wells.

Production and Markets
Total oil production in Manitoba for 2003 was 633,098 m^3 (4.0 million barrels) of which the Waskada field accounted for 113,957.64 m^3, 18 % of the year's oil production. This was third highest when compared to the Virden oilfield which produced 234,246.26 m^3, 37 % of the year's oil production; Daly oilfield produced 132,950.58 m^3, 21 % of the year's oil production and the Pierson oilfield produced 63,309.8 m^3, 10 % of the year's oil production.

In 2003 there were a number of fields that showed an increase in oil production over the 2002 year. Of these fields three were in the ESR study area; the Souris Hartney with a 123 % increase, Regent with a 20 % increase and Waskada with a 7 % increase.

Oil Production by Field Comparison between 2003 and 2002
As mentioned earlier, Manitoba's annual oil production was 633,098 m^3 (4.0 million barrels), down roughly 3 % from 2002 oil production. However, this was not the case for oil production from the six fields in the ESR study area. In 2002, the combined oil production from the six fields was 148,999 m^3, accounting for 22.9 % of Manitoba's total oil production (Table 19). Then in 2003, oil production in the ESR study area totalled 157,017 m^3, accounting for 24.8 % of

Manitoba's total oil production. This is an 8,018 m^3 or 2.6 %, increase in oil production for the ESR study area from 2002 to 2003.

General details about the six oilfields located in the ESR study area are listed in Table 20.

Table 19. Comparison of oil production in 2002 and 2003 by oilfields within the East Souris River IWMP study area.

	2003		2002		2003 / 2002 increase / (decrease)	
Field	**m^3**	**% of Total**	**m^3**	**% of Total**	**m^3**	**% of Change**
Lulu Lake	4,852.9	0.8	6,143.6	0.9	(1,290.7)	(21.0)
Mountainside	4,205.5	0.7	5,054.9	0.8	(849.4)	(16.8)
Regent	1,734.0	0.3	1,446.6	0.2	287.4	19.9
Souris Hartney	12,696.2	2.0	5,688.3	0.9	7,007.6	123.2
Waskada	113,621.5	17.9	105,786.7	16.3	7,834.8	7.4
Whitewater	19,907.3	3.1	24,879.5	3.8	(4,972.2)	(20.0)
Total	**157,017.4**	**24.8**	**148,999.6**	**22.9**	**8,017.5**	**92.7**

Table 20. Information from the six oilfields within the East Souris River IWMP study area up to 2003.

	OilField						
	Lulu Lake	Mountianside	Regent	Souris Hartney	Waskada	Whitewater	Total
Discovery Year	1953	1982	1955	1962	1952	1953	**--**
Avg. Depth to Producing Formation (m)	1,005	895	767	655	918	782	**--**
Producing Formation	L	L	L	L	MC/Lam	Lam/L	**--**
Well Spacing (m)	16	16	16	32/16	16/8/4	16	**--**
Active Oil Wells 2003*	4	14	9	10	297	36	**370**
2003 Oil Prod. ('000 m ^{3})	4.9	4.2	1.7	12.7	113.6	19.9	**157**
Cum. Oil Prod. (Dec 31, 2003) ('000 m ^{3})	113.7	105.3	49.6	221.9	3,585.10	396.4	**4472**
Remaining Established Reserves (Dec 31, 2002) ('000 m ^{3}) **	19.1	48.8	6.8	18.1	950.5	82.6	**1125.9** ***

L = Lodgepole
LAm = Lower Amaranth
MC = Mission Canyon

* Wells classified as capable of oil production at year-end that produced oil in 2003. Dual completions or commingled wells count as one well. Confidential wells not included.
** Does not include 2003 reserves
*** Total includes confidential remaining reserves

A summary of the status of all wells drilled for petroleum production within the six oilfields of the ESR watershed are displayed in Table 21, while those wells are mapped by active wells in Figure 39 and the abandoned wells are displayed in Figure 40.

Table 21. Summary of the well status and number of wells for each classification for all wells drilled within the East Souris River IWMP study area (source MB Industry, Economic Development and Mines GIS oil well layer)

Well Status	Number
Abandoned Dual Completion	1
Abandoned Producer	297
Abandoned Salt Water Disposal (former producer)	7
Abandoned Structure Test Hole	2
Abandoned Water Injection Well	2
Abandoned Water Injection Well (former producer)	39
Abandoned Water Supply Well	7
Dry and Abandoned	238
Horizontal or Directional Surface Location	41
Location	9
Producer	432
Salt Water Disposal	3
Salt Water Disposal (former producer)	10
Standing	14
Water Injection Well	35
Water Injection Well (former producer)	77
Water Supply Well	2

The following report was used in preparing the Oil Resource Inventory Section

References

Manitoba Industry, Economic Development and Mines, January 2005, Manitoba Oil Activity Review 2003, http://www.gov.mb.ca/iedm/petroleum/oar/

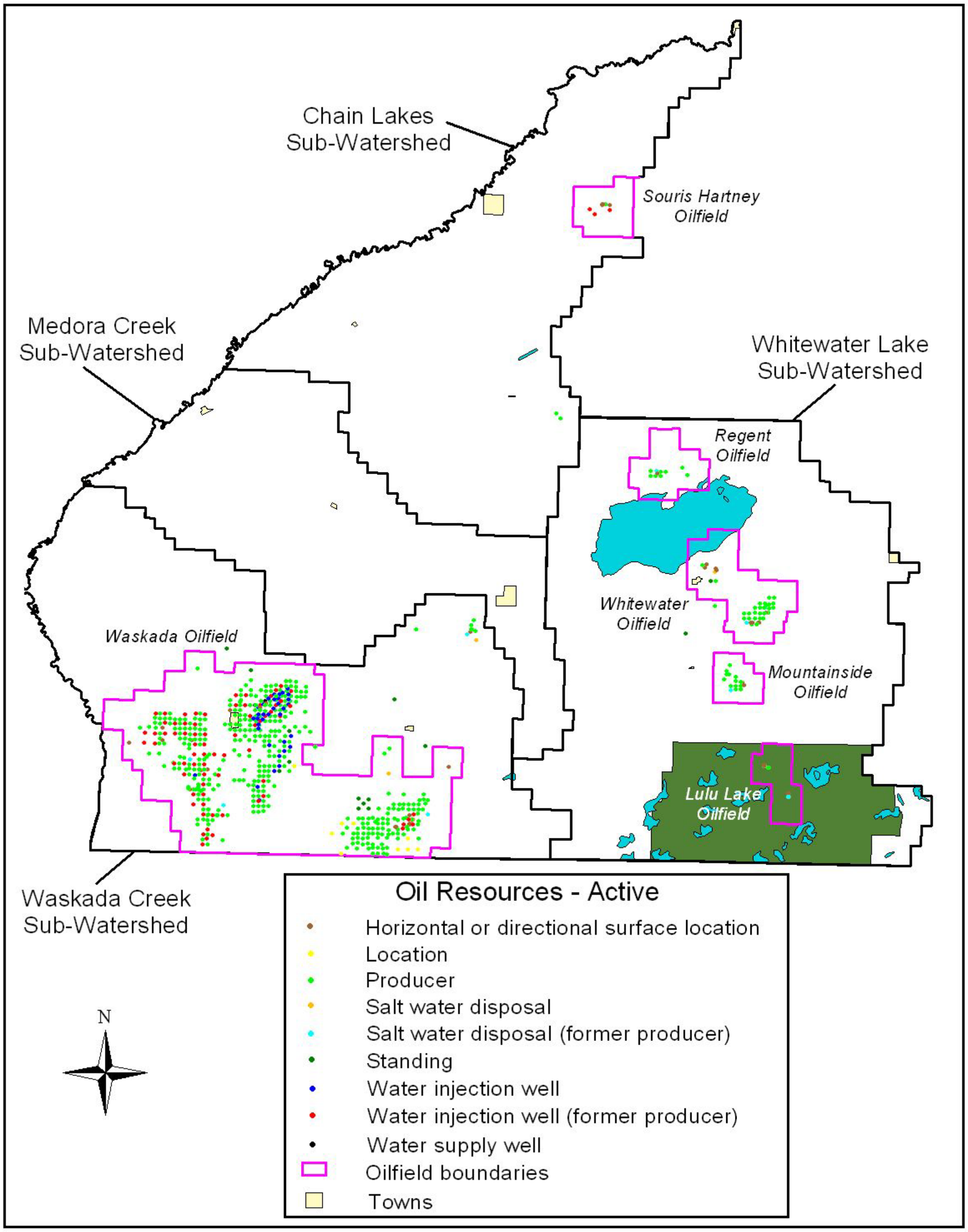

Figure 39. Location of active oil wells within the East Souris River IWMP study area.

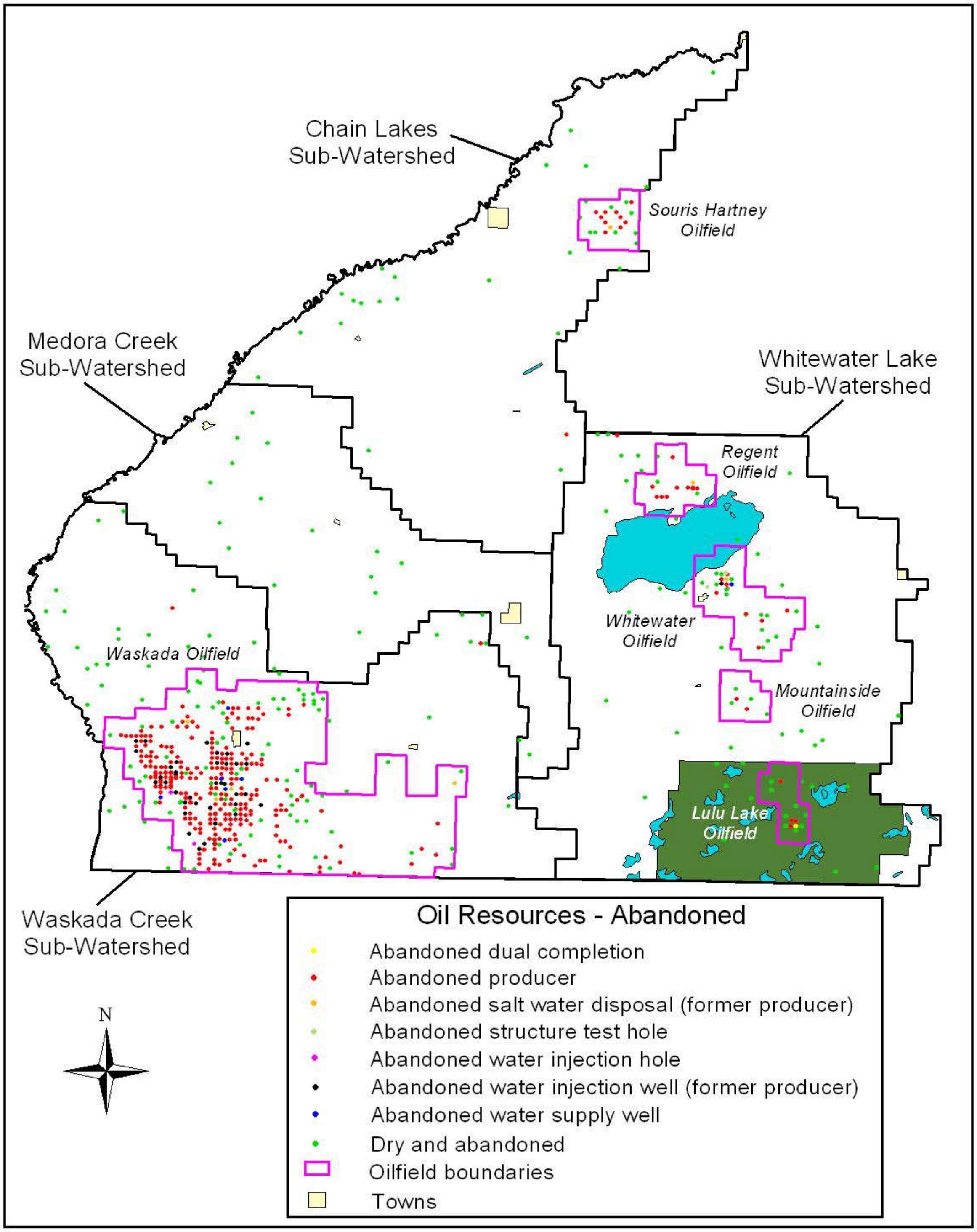

Figure 40. Location of abandoned oil wells within the East Souris River IWMP study area.

Geology

The geology of the East Souris River watershed consists of a bedrock formed by Cretaceous and Tertiary aged sediments (approximately 55-80 million years before present) overlain by unconsolidated deposits laid down prior to, during, and following Pleistocene glaciation.

The oldest bedrock sediments consist of Cretaceous shales and siltstones of the Riding Mountain Formation. These include the soft bentonitic shales of the Millwood Member (forming the lower part of the Riding Mountain Formation), the siliceous shales and minor bentonites of the Odanah Member which overlies the Millwood, and the soft bentonitic shales and siltstones of the Coulter Member which overlies the Odanah Member near Turtle Mountain (see Figure 41). In the southern and eastern parts of the watershed, sediments comprising the Riding Mountain Formation are overlain by younger bedrock deposits which form the Turtle Mountain upland. The oldest of these is the Boissevain Formation of Cretaceous age, consisting of greenish-grey sandstones and shales. The Boissevain Formation is overlain by the Turtle Mountain Formation formed by sandstones, siltstones and shales with minor coal. The distribution of these bedrock units is shown on Figure 41.

The bedrock is overlain by much younger unconsolidated sediments which, with some exceptions, were laid down during a series of glacial advances and retreats over the past 2 million years. Throughout most of the area surficial deposits consist of glacial till of varying thickness. Tills are poorly sorted mixtures of clay, silt, sand and gravel derived from materials that the glaciers moved over then deposited as the ice melted and retreated. Sand and gravel deposits are locally associated with the tills, either as sand and gravel lenses found at depth within the tills or as sand and gravel deposits found at ground surface. These deposits often represent stagnation areas where the advance or retreat of the glaciers stalled for a period of time and deposited water sorted sediments. South of the Souris River, the tills are overlain by clays, silts and sands which were deposited into a large ice-marginal lake formed near the end of the last glaciation, named Lake Hind. A map showing the surficial deposits for the watershed area is given as Figure 42.

There are at least two buried valleys mapped within the watershed area. These features are formed by river erosion cutting incised valleys into the underlying bedrock deposits followed by the infilling of these valleys by sediments, generally tills and sand/gravel of Pleistocene age but in some areas the basal sediments in the valleys may be Tertiary in age. The largest of these features is the Medora-Waskada buried valley shown on Figure 43. Sand and gravel deposits in the infill materials in this valley form an important local aquifer. A second buried valley has been identified in the Turtle Mountain area, traversing to the north before disappearing near Whitewater Lake. Sand and gravel aquifers have not been identified in this feature.

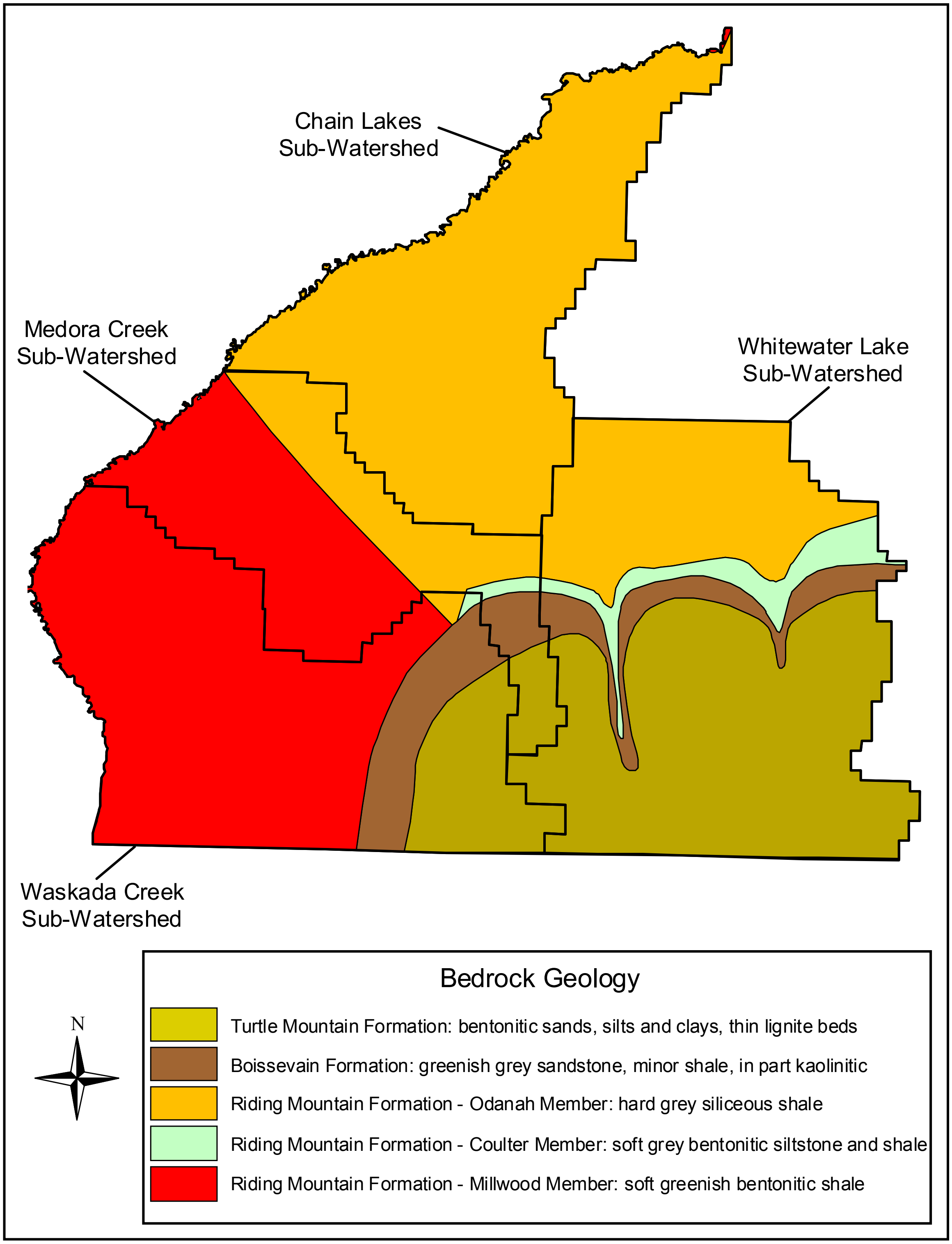

Figure 41. Bedrock geology map for the East Souris River IWMP study area.

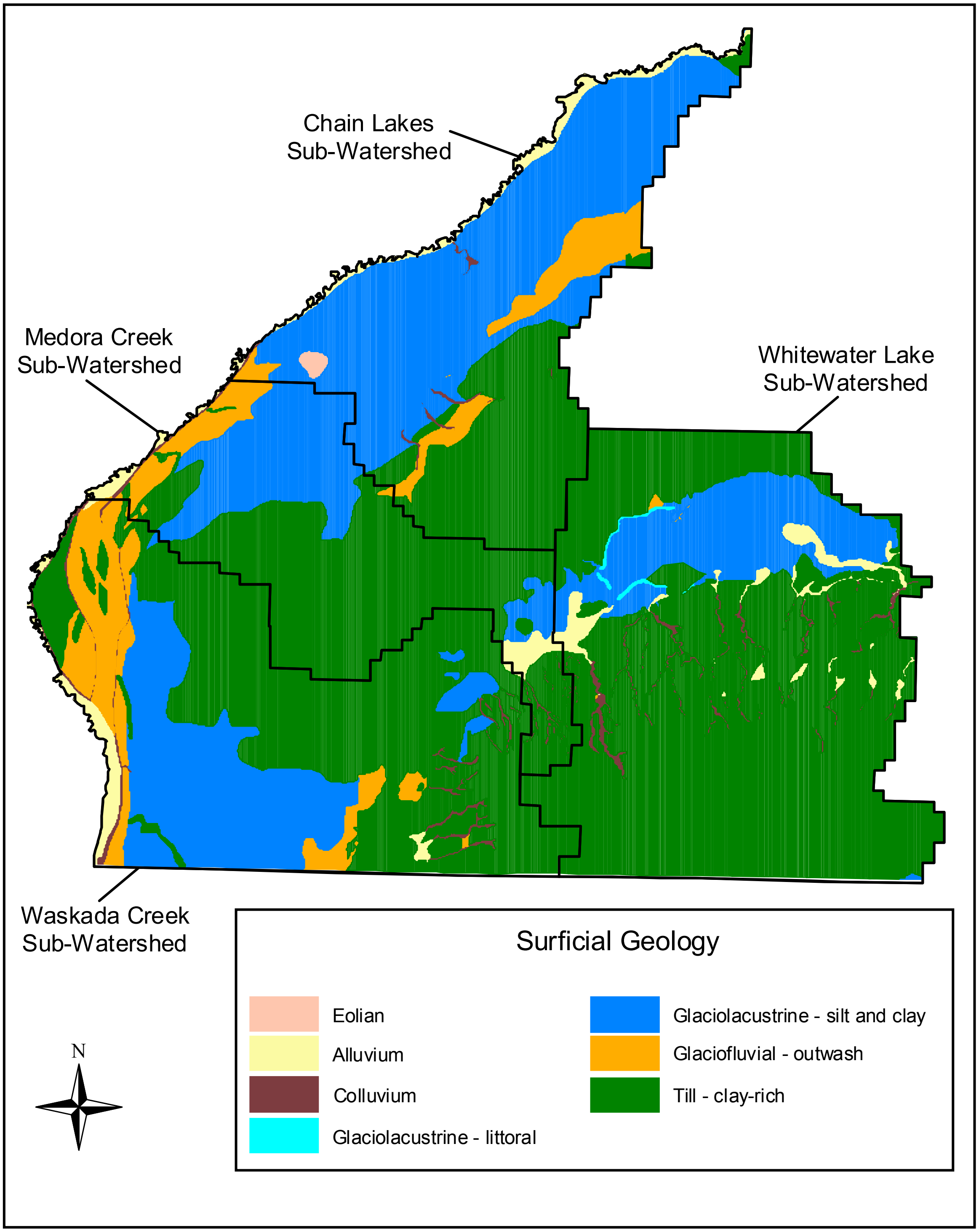

Figure 42. Surficial geology map for the East Souris River IWMP study area.

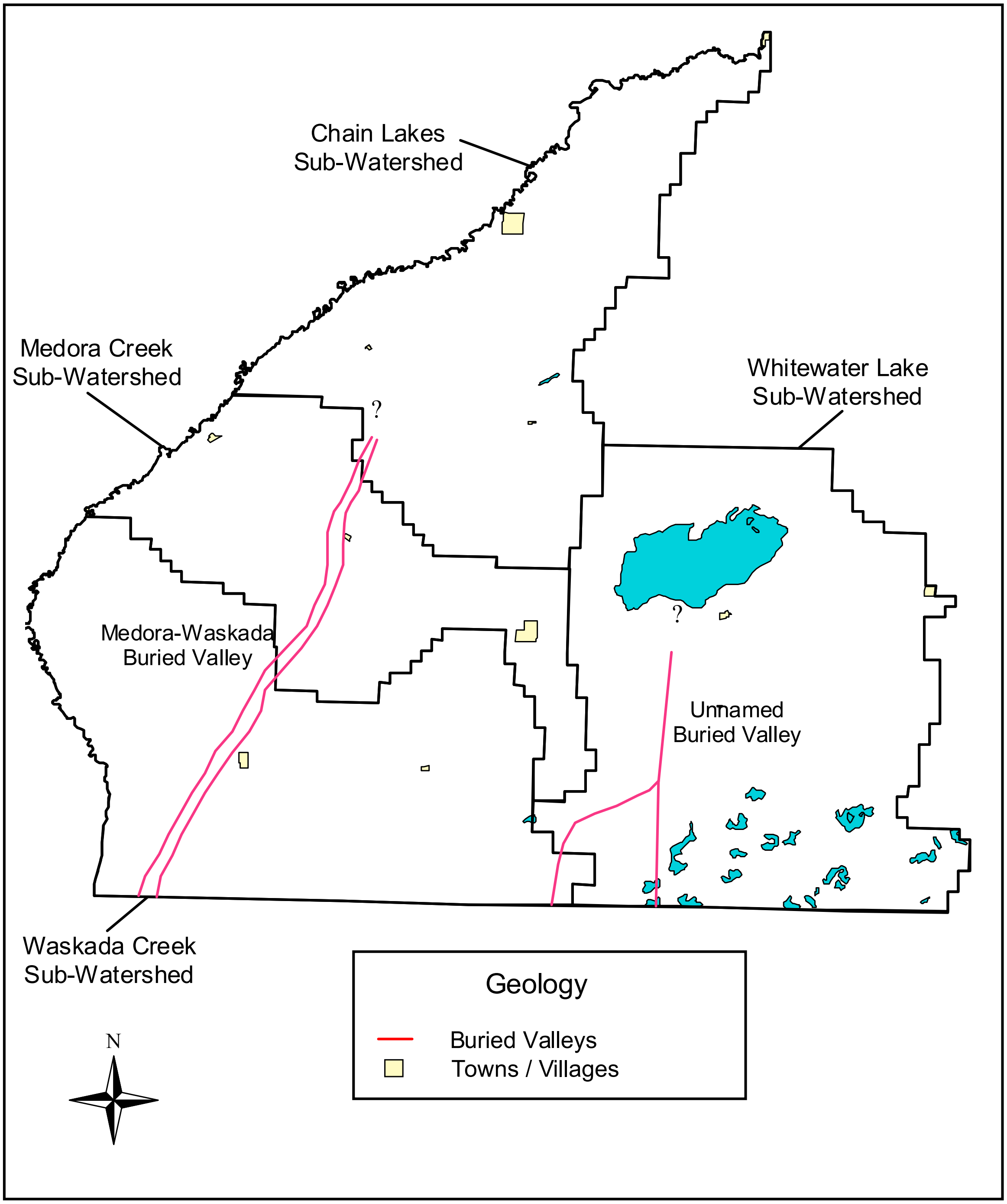

Figure 43. Locations of Buried Valleys within the East Souris River IWMP study area (Source: Virden Groundwater Availability Study). ? denotes the uncertainty on where the buried valley extends to from the known location identified in Figure 43.

Slope and Topography

Slope and topography can be used to illustrate the same relative features as they are related to each other based on elevation. Slope is the measure of steepness on the landscape surface, while topography is the illustration of relief and positions of natural and manmade features on the landscape. Slope is measured based on a percentage of steepness on the landscape and has six classes; 0–2 %, 2-5 %, 5-9 %, 9-15 %, 15-30 % and > 30 **%**. Topography is measured in meters (m) above sea level (asl).

Within the East Souris River study area there are four main areas characterizing the slope and topography of the landscape. The first are the Turtle Mountains located in the south easterly portion of the study area along the Canada – United States border. This area is the highest elevation in the study area reaching elevations ranging from 751 – 775 m asl (Figure 44). This hummocky upland slopes north and east and descends at rates of nearly 23 meters per km to elevations ranging from 526 – 550 m asl. The greatest elevation variation is within the gullies and channels which cut the escarpment with a slope in excess of 30 percent. The Boissevain Plain, surrounding the Turtle Mountains, slopes at a rate of 10 meters per km and then slows to a more gradual decline with elevations of approximately 555 m asl to 450 m asl from the foot of the Turtle Mountains. Generally, the Boissevain Plain has a slow relief with level terrain slopes of less than two percent around Whitewater Lake and undulating terrain and slopes of two to nine percent below the mountainside escarpment and into the central portion of the watershed. Along the western border of the study area going north is another influential landscape feature, the Souris River. This feature has an entrenched channel that is 20 to 30 meters below land surface. The river's valley sidewalls, tributary gullies and associated channels have a slope in excess of 30 percent. Another influence, although on a smaller scale, is the Antler River – Lake Souris Plain in the north western portion of the study area. This region is found to be relatively level land with low relief ranging from 428 to 457 m asl. The landscape slope is very moderate with less than two percent.

The highest elevation within the ESR watershed is located within the Whitewater Lake sub-watershed, which is 762 metres asl, while the lowest point is located within the Chain Lakes sub-watershed and it is 406 metres asl (Table 22).

Table 22. Highest and lowest elevations within each sub-watershed within the East Souris River IWMP study area.

Sub-Watershed	Highest Elevation		Lowest Elevation	
	Metres (asl)	Feet (asl)	Metres (asl)	Feet (asl)
Chain Lakes	506	1670	406	1340
Medora Creek	684	2257	422	1393
Waskada Creek	738	2435	418	1379
Whitewater Lake	762	2515	494	1630

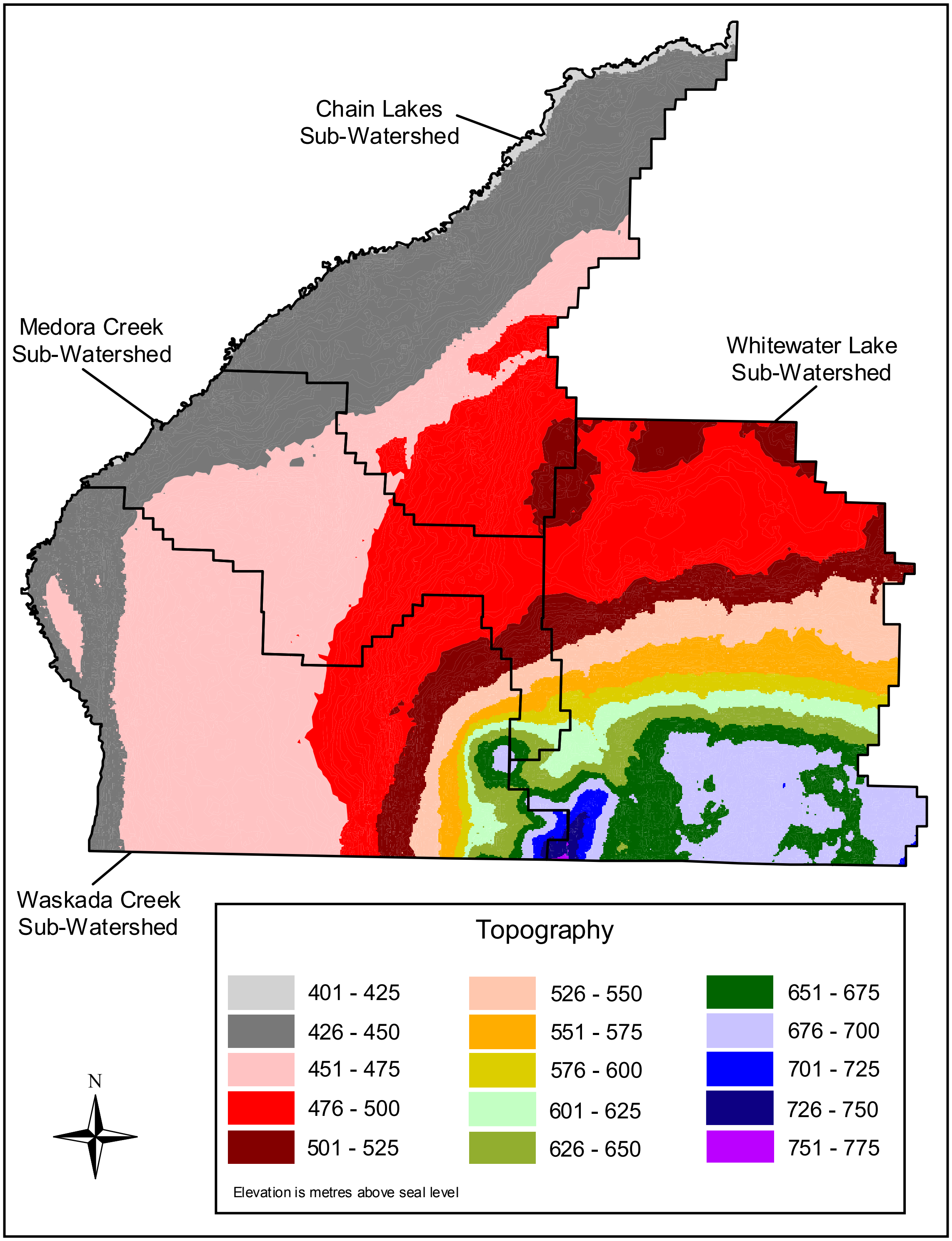

Figure 44. Topography within the East Souris River IWMP study area.

The majority of the land within the Chain Lakes, Medora Creek and Waskada Creek sub-watersheds falls within the 0-2% and 2-5% slope classes (Table 23) and is displayed on Figure 45. The Whitewater Lake sub-watershed is comprised of 14.3% water due mainly to Whitewater Lake and the numerous wetlands and lakes in the Turtle Mountains.

Table 23. Area (ha) and percent (%) of land in each slope classification for the four sub-watersheds within the East Souris River IWMP study area (source 1:40,000 / 1:127,000 GIS soils layer).

	Chain Lakes Sub-Watershed		**Medora Creek Sub-Watershed**		**Waskada Creek Sub-Watershed**		**Whitewater Lake Sub-Watershed**	
Slope Classes	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)
0 - 2 %	42,361	64.4	32,419	67.3	58,050	71.8	33,200	34.2
2 - 5 %	15,496	23.6	12,010	24.9	13,882	17.2	24,865	25.6
5 - 9 %	6,140	9.3	2,736	5.7	2,995	3.7	8,272	8.5
9 - 15 %	1	0	0	0	3,378	4.2	11,710	12.1
15 - 30 %	630	1	0	0	0	0	667	0.7
> 30 %	609	0.9	689	1.4	2,042	2.5	4,350	4.5
Unclassified	52	0.1	165	0.3	0	0	32	0
Water	461	0.7	144	0.3	489	0.6	13,850	14.3
Total	**65,750**	**100**	**48,163**	**100**	**80,836**	**100**	**96,946**	**100**

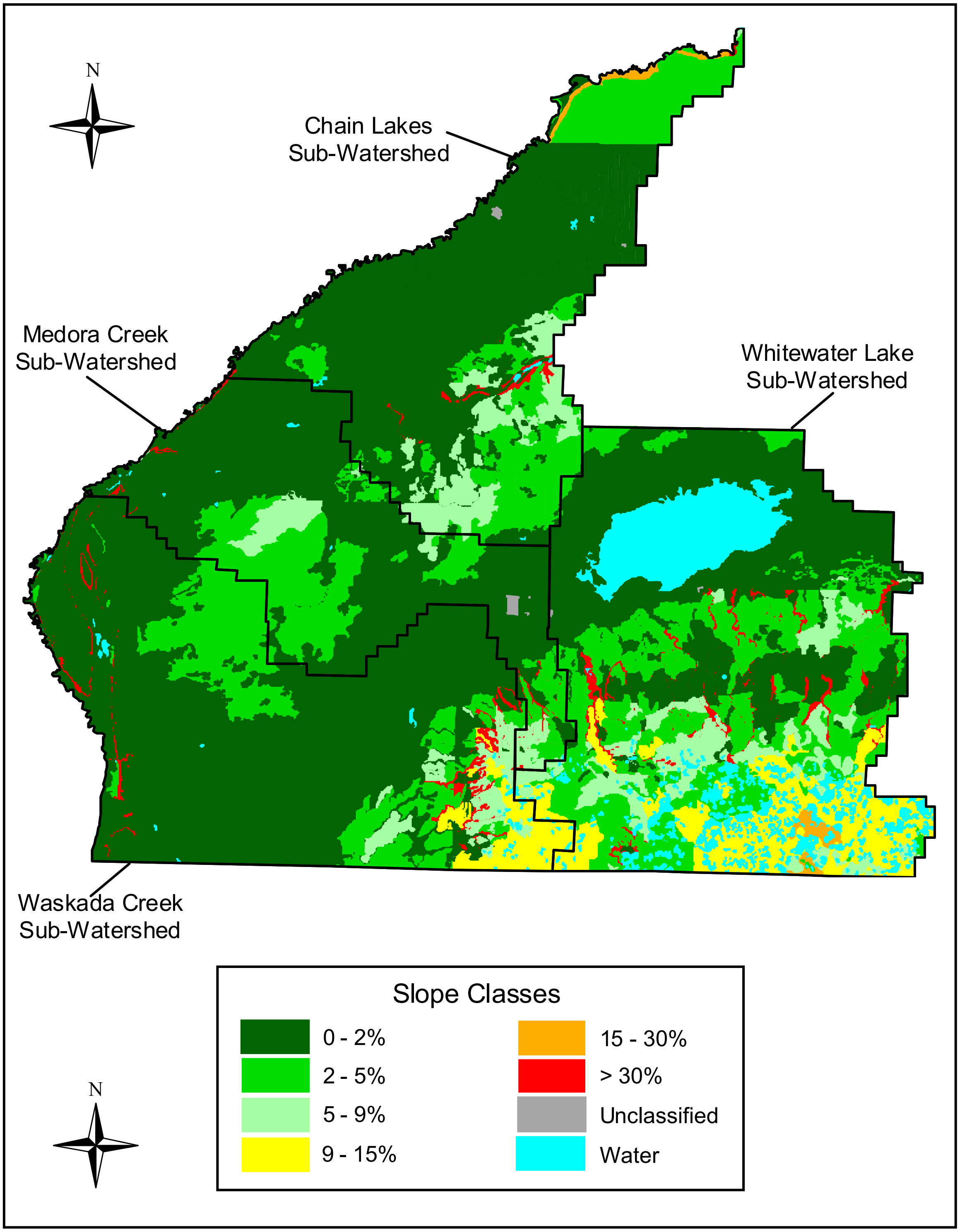

Figure 45. Surface Slope map for the East Souris River IWMP study area.
The following reports were used in preparing the Slope and Topography Sections

References

Manitoba Land Resource Unit (MLRU) 96-6. 1998. Rural Municipality of Glenwood, Information Bulletin 96-6; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 24pp.

Manitoba Land Resource Unit (MLRU) 97-3. 1998. Rural Municipality of Brenda, Information Bulletin 97-3; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

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Manitoba Land Resource Unit (MLRU) 97-5. 1998. Rural Municipality of Morton, Information Bulletin 97-5; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

Manitoba Land Resource Unit (MLRU) 97-2. 1998. Rural Municipality of Arthur, Information Bulletin 97-2; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

Manitoba Land Resource Unit (MLRU) 97-7. 1998. Rural Municipality of Cameron, Information Bulletin 97-7; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

Landcover

Land use in for the East Souris River study area can be classified as follows annual cropping, forest (deciduous, open deciduous, conifer and forest cut blocks), water areas (including bodies of water, marshes, fens and bogs), grassland, forage crops, cultural, bare rock/sand/gravel and roads/trails (Table 24). The landcover data in this report are from landsat imagery collected in 1994 (Figure 46).

The annual cropping classification was found to have the greatest difference in percentage of landcover when comparing data from the four sub-watersheds. In the Waskada Creek, Medora Creek and Chain Lakes sub-watersheds annual cropping accounted for 74.0% (60,113 ha), 78.0% (37,571 ha) and 75.5% (49,680 ha) of the total area respectively (Table 24). However, in the Whitewater Lake sub-watershed annual cropping only amounted to 36.2% (35,159 ha) of the area (Table 24). A few reasons for this large discrepancy are that the Turtle Mountain Provincial Park and Whitewater Lake account for a considerable portion of land and water in the Whitewater Lake sub-watershed.

The forested landcover classification as varies greatly amongst for the four sub-watersheds. In the sub-watersheds of Waskada Creek, Medora Creek and Chain Lakes the forest cover was 4.1% (3,305 ha), 1.4% (657 ha) and 2.0 % (1,325 ha) of the total area respectively (Table 24). Within the Whitewater Lake sub-watershed the forest area accounted for 22.7% (22,068 ha) of the landmass due mainly to the forested areas within the Turtle Mountain Provincial Park and forest habitat on private land adjacent to the TMPP.

The water classification also displayed similar trends as the annual cropping and forest landcover classes. In the sub-watersheds of Waskada Creek, Medora Creek and Chain Lakes water covered 1.6 % (1,281 ha), 1.2 % (551 ha) and 2.1% (1,378 ha) of the total area respectively (Table 24). In the Whitewater Lake sub-watershed 14.7% (14,301 ha) of the sub-watershed was covered with water (Table 24). The two factors influencing these figures in the Whitewater Lake sub-watershed are the large area of Whitewater Lake and the other is the large number of wetlands within the Turtle Mountain uplands.

Table 24. Area (ha) and percent (%) of landcover classes for the four sub-watersheds within the East Souris River IWMP study area based on landsat data from 1994.

	Chain Lakes Sub-Watershed		**Medora Creek Sub-Watershed**		**Waskada Creek Sub-Watershed**		**Whitewater Lake Sub-Watershed**	
1994 Landcover Class	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Annual Cropping	49,680	75.5	37,571	78.0	60,113	74.0	35,159	36.2
Forest	1,325	2.0	657	1.4	3,305	4.1	22,077	22.7
Water	1,378	2.1	551	1.2	1,281	1.6	14,301	14.7
Grassland	9,927	15.1	7,264	15.1	13,136	16.2	20,082	20.7
Forage Crops	1,362	2.1	541	1.1	1,119	1.4	3,422	3.5
Cultural	115	0.2	157	0.3	87	0.1	71	0.1
Bare rock/sand/gravel	62	0.1	24	0.1	30	0.0	46	0.1
Roads/Trails	1,940	3.0	1,384	2.9	2,124	2.6	1,958	2.0
Total	**65,789**	**100**	**48,149**	**100**	**81,195**	**100**	**97,116**	**100**

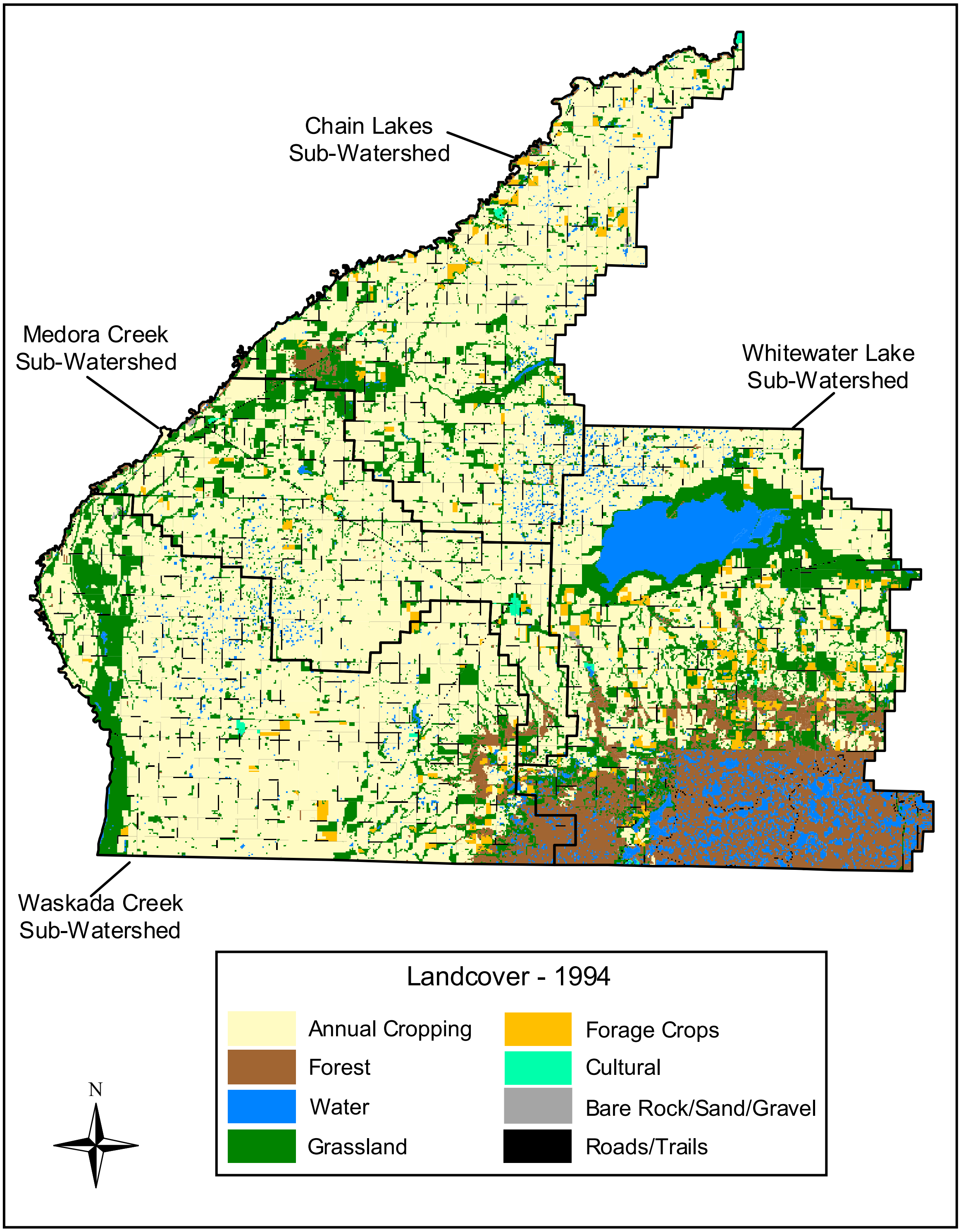

Figure 46. 1994 Landcover information within the East Souris River IWMP study area.

Soils

The type of soil in the ESR watershed and other watersheds across North America was dictated long before humans came to develop and work the land. However, proper management and techniques used on the land today will dictate how healthy it will be for future generations. In order to build proper management techniques for healthy soil we have to know what we are working with. The following information will provide an outlook on the type of soils and some of its characteristics to assist in building an effective watershed management plan for the East Souris River watershed.

The following reports were used in preparing the Soils and Agricultural Capability Sections

References

Manitoba Land Resource Unit (MLRU) 96-6. 1998. Rural Municipality of Glenwood, Information Bulletin 96-6; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 24pp.

Manitoba Land Resource Unit (MLRU) 97-3. 1998. Rural Municipality of Brenda, Information Bulletin 97-3; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

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Manitoba Land Resource Unit (MLRU) 97-5. 1998. Rural Municipality of Morton, Information Bulletin 97-5; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

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Surface Texture

Much of the soil in the ESR watershed has been classified as a type of loam with some small pocket areas of sand (Figure 47). The loam soil texture is an even composition of sand, silt, clay and organic matter of varying sizes. This soil is more fertile than other soil textures as it allows for high moisture retention while still allowing for air circulation due to the porosity formation. Within the ESR watershed the total area of soil in the loam category (coarse loamy, loamy and clayey) is approximately 234,725 ha, which represents the majority of the soil within the watershed (Table 25).

Sandy soil texture is the other significant surface texture found in the watershed. These pockets of sandy soils are found around areas with higher concentration of water such as along the Souris River and in the Whitewater Lake region. Sandy soil textures allow a higher rate of air and water movement enhancing drainage and facilitating cultivation as there is less resistance than with clay soil textures. The amount of soil within the watershed accounting for sandy soil textures (sands and coarse sands) is roughly 18,039 ha.

Another area of interest is the amount of land that is classified as eroded slopes. These could be considered areas of high interest as when there is an increase in eroded slopes there is an increase in water and soil erosion which in turn leads to deterioration with water and soil quality. Within the ESR there is roughly 7,527 ha classified as eroded slopes.

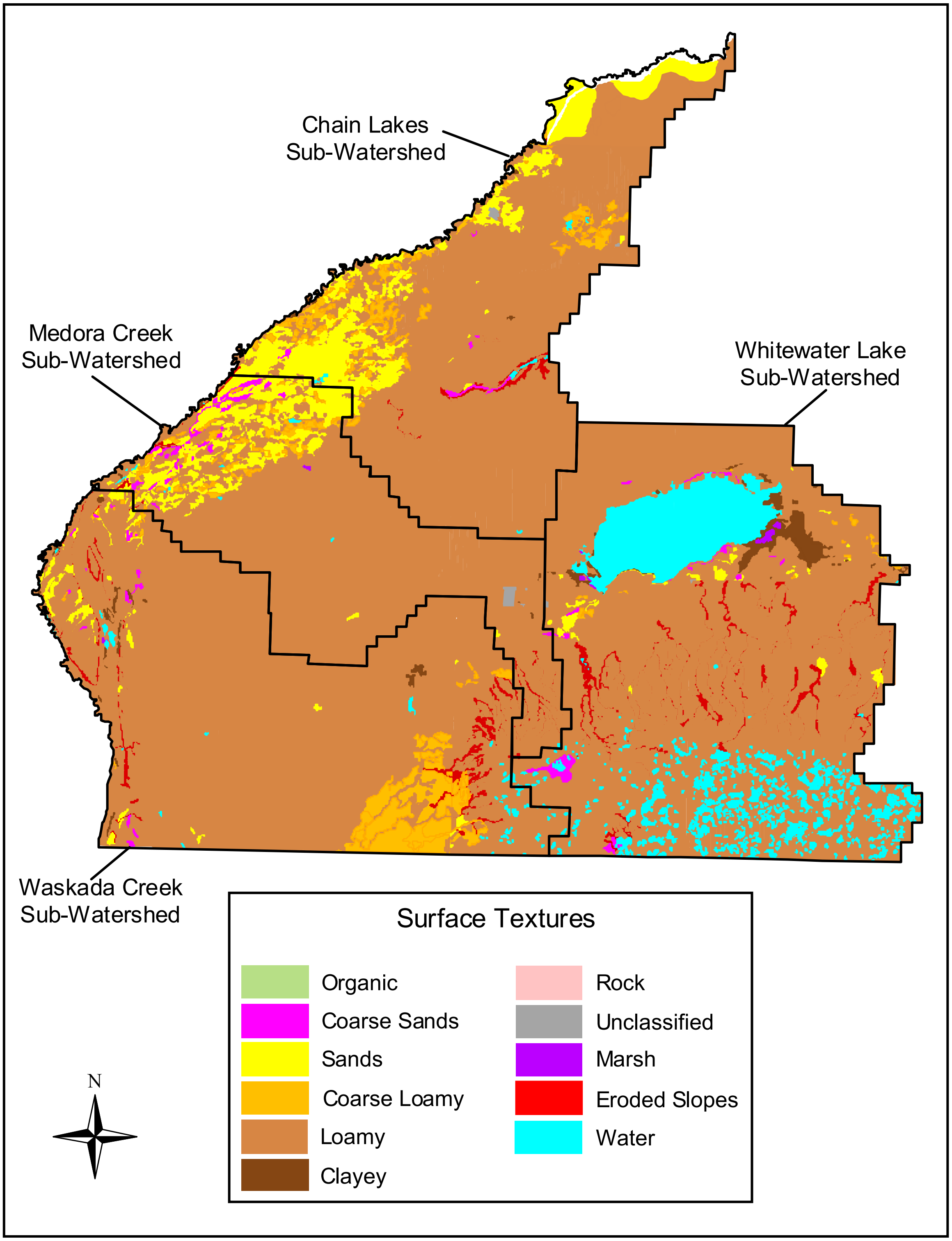


Figure 47. Surface Texture map for the East Souris River IWMP study area.

Table 25. Area (ha) and percent (%) of land in each surface texture classification for the four sub-watersheds within the East Souris River IWMP study area (source 1:40,000 / 1:127,000 GIS soils layer).

Surface Textures		Chain Lakes Sub-Watershed	Medora Creek Sub-Watershed	Waskada Creek Sub-Watershed	Whitewater Lake Sub-Watershed
Organics	Area (ha)	0	0	0	0
	Percent (%)	0.0	0.0	0.0	0.0
Coarse Sands	Area (ha)	141	762	128	534
	Percent (%)	0.2	1.6	0.2	0.6
Sands	Area (ha)	8,867	5,868	1,064	675
	Percent (%)	13.5	12.2	1.5	0.8
Coarse Loamy	Area (ha)	3,276	1,622	3,455	250
	Percent (%)	5.0	3.4	4.8	0.3
Loamy	Area (ha)	51,311	38,881	65,168	68,469
	Percent (%)	78.2	80.8	89.8	77.2
Clayey	Area (ha)	100	32	341	1,820
	Percent (%)	0.2	0.1	0.5	2.1
Eroded Slopes	Area (ha)	599	680	1,991	4,257
	Percent (%)	0.9	1.4	2.7	4.8
Marsh	Area (ha)	0	7	7	106
	Percent (%)	0.0	0.01	0.01	0.1
Unclassified	Area (ha)	937	166	0	33
	Percent (%)	1.4	0.3	0.0	0.0
Water	Area (ha)	388	122	433	12,576
	Percent (%)	0.6	0.3	0.6	14.2
Rock	Area (ha)	0	0	0	0
	Percent (%)	0.0	0.0	0.0	0.0
Total Area (ha)		65,619	48,140	72,587	88,720

Drainage

Drainage can best be described as the removal of excess surface or groundwater from an area by means of surface or subsurface drains. In order to accomplish drainage of surface and subsurface water the movement of soil and other materials are necessary. This means altering the natural flow of water which in turn alters the natural placement of water creating a need for effective management practices. These management practices must also incorporate appropriate agriculture techniques to assist with the increasing need of draining water from land in a timely manner for productive crops. However, there are some pieces of land that are easier to drain than others and require extensive work to achieve productive agriculture land. Based on this information drainage classifications were established to illustrate and evaluate the type of drainage associated with the land. There are five main drainage classes; Very Poor, Poor, Imperfect, Well and Rapid. A Very Poor drainage class is when water is removed from the soil at such a slow rate that the water table remains at or on the soil surface for the better part of time when the soil is not frozen. During most of the year excess water will be found in the soil. A drainage class of Poor is when water is removed from the soil so slowly in relation to the supply that the soil remains wet for most of the time it is not frozen. Any excess water can be found in the soil during most of the year. An Imperfect drainage class is when water is removed from the soil adequately enough for seeding access however; the soil remains wet for a considerable part of the growing season. Any excess water will relocate fast enough if the main source is only precipitation. A Well drainage class is when water is removed from the soil in a timely manner but not rapidly and excess water flows downward effortlessly into underlying soil materials or laterally as subsurface flows. A Rapid drainage class is when water moves from the soil without delay and excess water flows into the underlying soil materials if still permeable.

The majority of the ESR watershed is mainly well and imperfectly drained soils (Table 26). A good portion of the well drained soils are found in the Whitewater Lake sub-watershed in the area of the Turtle Mountains (Figure 48). There is also a large portion of imperfectly drained and poorly drained soils in this sub-watershed around Whitewater Lake. Throughout the other three sub-watersheds there is a variety of imperfectly drained and poorly drained soils. Surface runoff from snowmelt and rainfall will accumulate in poorly drained depressions and in unlikely areas when the water table is high. Much of the water movement and areas of standing water depends on soil type, topography of the land and drainage ditches that have been constructed.

Table 26. Area (ha) and percent (%) of land in drainage class for the four sub-watersheds within the East Souris River IWMP study area (source 1:40,000 GIS soils layer). *Data unavailable for area within sub-watershed in R.M. of Glenwood.

	Chain Lakes Sub-Watershed*		Medora Creek Sub-Watershed		Waskada Creek Sub-Watershed		Whitewater Lake Sub-Watershed	
Drainage Classes	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Rapid	884	1.5	2,319	4.8	2,708	3.6	4,906	5.5
Well	30,601	52.8	31,204	64.8	50,819	68.4	58,762	65.3
Imperfect	23,639	40.8	12,722	26.4	17,051	23.0	10,535	11.7
Poor (Improved)	0	0.0	0	0.0	0	0.0	0	0.0
Poor	2,355	4.1	1,599	3.3	3,227	4.3	2,852	3.2
Very Poor	0	0.0	0	0.0	0	0.0	0	0.0
Rock	0	0.0	0	0.0	0	0.0	0	0.0
Unclassified	55	0.1	168	0.3	0	0.0	40	0.0
Marsh	0	0.0	11	0.0	5	0.0	106	0.1
Water	378	0.7	134	0.3	450	0.6	12,780	14.2
Total	**57,912**	**100.0**	**48,157**	**100.0**	**74,260**	**100.0**	**89,981**	**100.0**

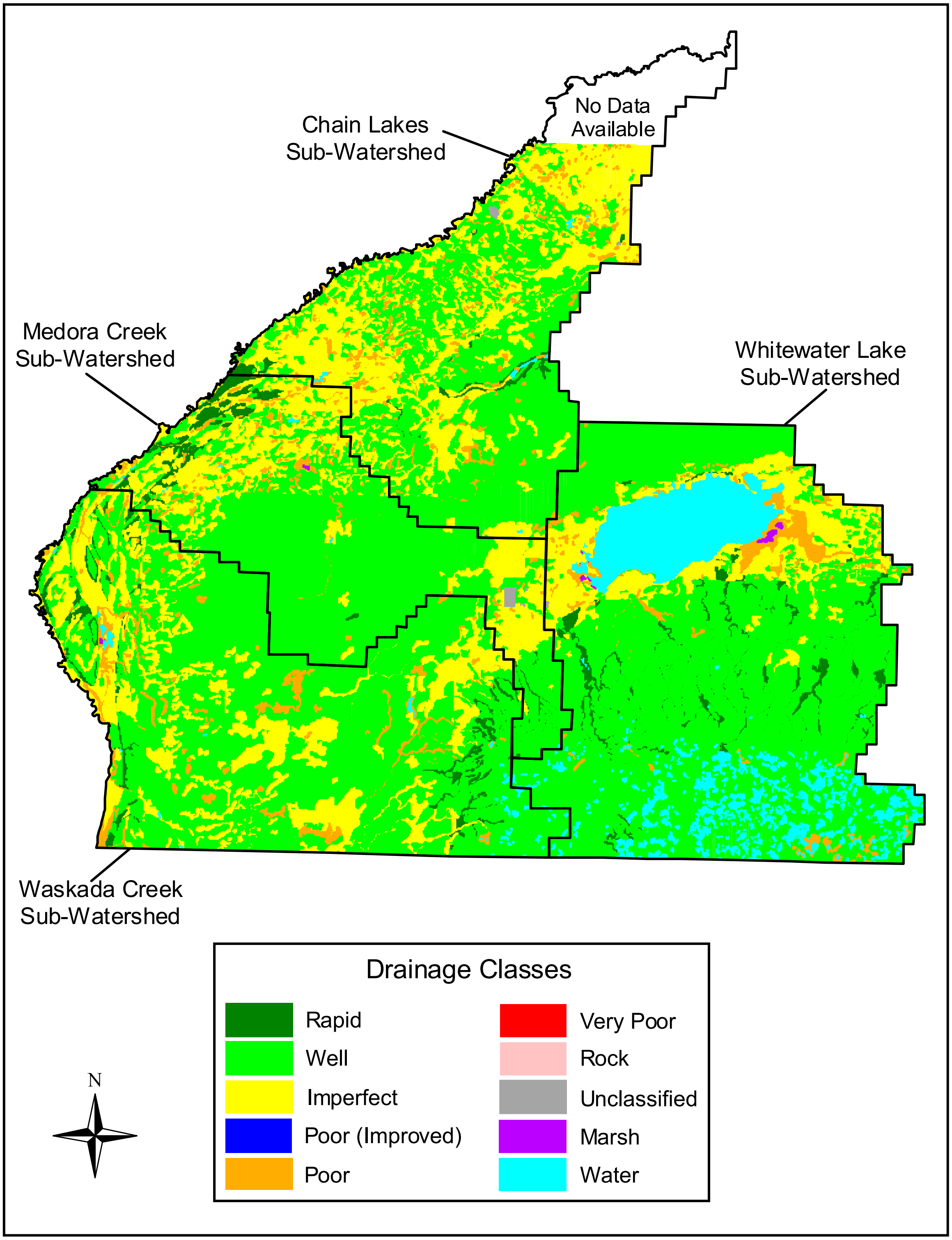


Figure 48. Drainage Classes map for the East Souris River IWMP study area.

Salinity

Soil salinity is simply defined as soils with high concentrations of soluble salts. It is another important issue in the ESR watershed requiring the use of appropriate agriculture management techniques on soils with special necessities. As a means to distinguish soils with different saline concentrations four classes were established and a map created to illustrate the location of these soils. These classes were determined by measuring the electrical conductivity of the saturation extracted in decisiemens per meter (dS/m). These classes include Non-saline (< 4 dS/m), Weakly saline (4 to 8 dS/m), Moderately saline (8 to 15 dS/m) and Strongly saline (> 15 dS/m).

Most of the area within the ESR watershed has been classified as Non-saline (Table 27). There is also a fair amount of soil with Weakly saline soils which seems to be located surrounding Whitewater Lake and in the northern portion of the watershed area (Figure 49). The presence of Moderately saline soils tends to be located along the Souris River banks, in the old Souris River Channel and in areas stretching from Deloraine towards Goodlands. As for Strongly saline soils there is a minimal amount present.

Salinity seems to be an increasing problem within the ESR watershed in recent years. Saline soils are a product of a high water table that brings salts to or near the surface. Salinity problems are also influenced by the weather; however the problems can be more evident in both dry and wet years. Saline problems seem to be more common along roadways and one unproven theory is that the compaction that occurs when roads are built creates an impermeable barrier that restricts the horizontal movement of water. The water and associated salts from the parent material are forced to the surface due to the barrier resulting in increased salinity problems along roads. Due to the relatively slow movement of water (movement can be centimetres-metres per year); the impact of roads built 40-50 years ago may now be contributing to salinity problems. The only economically feasible option to address salinity is to seed areas to forage to lower the water table. Tile drainage is another option that may work however it is very expensive, requires a lot of water to wash away the salt and it also transports the saline water downstream which may cause problems for other.

Table 27. Area (ha) and percent (%) of land in salinity class for the four sub-watersheds within the East Souris River IWMP study area (source 1:40,000 GIS soils layer). *Data unavailable for area within sub-watershed in R.M. of Glenwood.

	Chain Lakes Sub-Watershed*		**Medora Creek Sub-Watershed**		**Waskada Creek Sub-Watershed**		**Whitewater Lake Sub-Watershed**	
Salinity Classes	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Non Saline	48,095	83.0	45,190	93.8	67,241	90.5	64,954	72.2
Weakly Saline	8,778	15.2	1,617	3.4	1,413	1.9	7,669	8.5
Moderately Saline	26	0.0	351	0.7	3,155	4.2	135	0.2
Strongly Saline	0	0.0	0	0.0	0	0.0	0	0.0
Unclassified	55	0.1	168	0.3	0	0.0	40	0.0
Marsh	0	0.0	11	0.0	5	0.0	106	0.1
Eroded Slopes	580	1.0	686	1.4	1,996	2.7	4,297	4.8
Water	378	0.7	134	0.3	450	0.6	12,780	14.2
Total	**57,912**	**100.0**	**48,157**	**100.0**	**74,260**	**100.0**	**89,981**	**100.0**

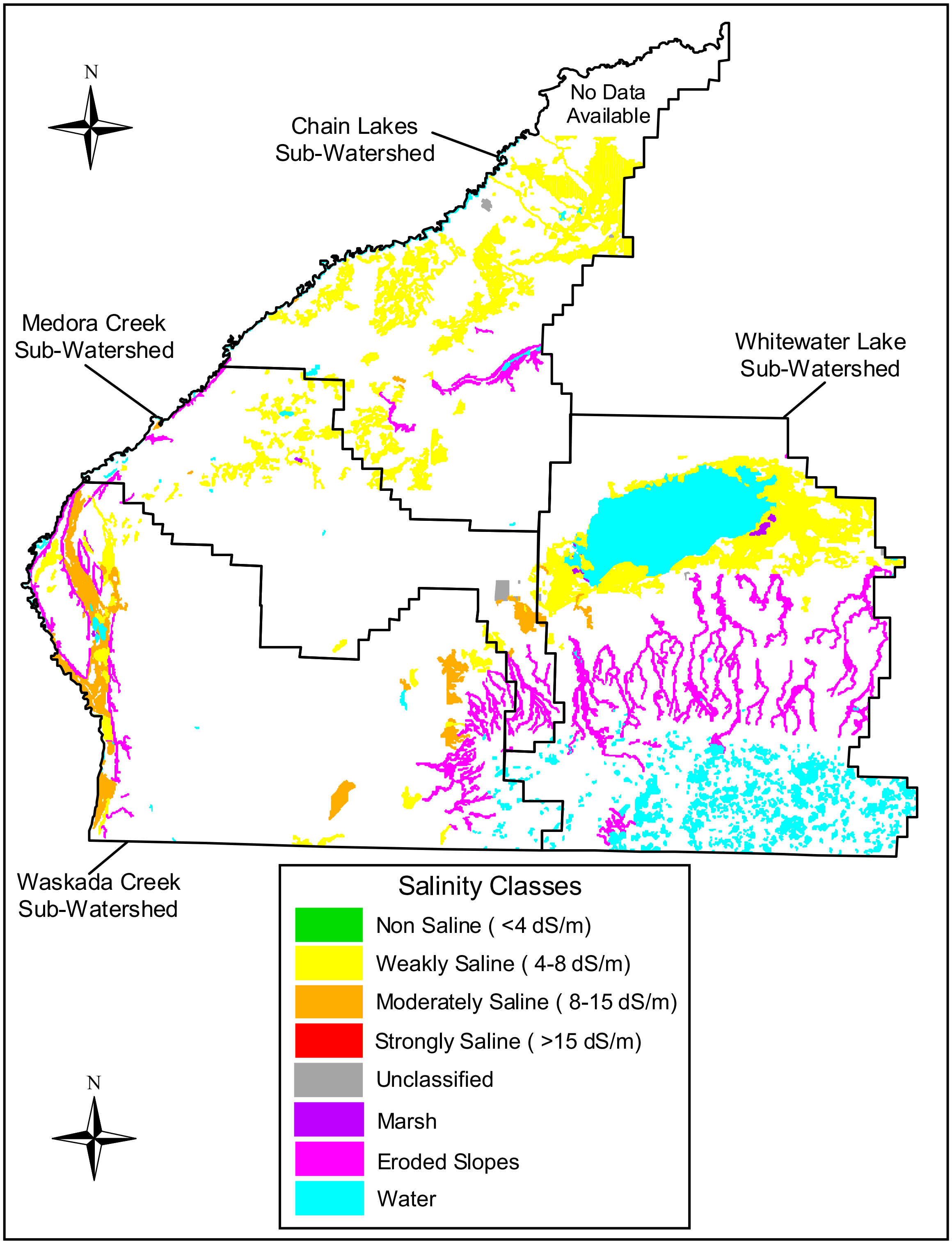


Figure 49. Soil Salinity Classes map for the East Souris River IWMP study area.

Land Resource Characteristics

Management considerations for the ESR watershed go beyond land resource issues of drainage and salinity. Other issues to be contemplated within the watershed include topography, texture and wetness. These land resource characteristics are further broken down and illustrated on a map as to their most common and prevalent trait on the land. Fine texture is soil with clays and silty clays which have low infiltration and internal permeability rates. These soils require special concern to alleviate surface ponding and runoff. As for agriculture tillage practices the style and timing may be restricted for this characteristic. Medium texture is soil ranging from loamy to clay loams that have beneficial water and nutrient retention properties. First-rate agriculture management and cropping practices are necessary to reduce erosion risk and leaching. Coarse texture is soil composed of loamy sands, sands and gravel which have a high rate of water and air movement between soil particles. Special considerations and practices are required when applying chemicals and other substances to the soil to ensure contaminants are not added to the soil and to maintain healthy soil and water quality. Topography is considered to be slopes greater than 5 % which require special management practices to minimize the risk of erosion. Wetness is considered as poorly drained soils and /or > 50 % wetlands. These soils have high water levels which may be due to flooding, ponding, permanent water bodies and even high water tables. This type of landscape demands special needs as a means to alleviate negative impacts to water quality, aquifers, crop production and erosion. Organic is soils with a high content of organic matter. These soils require special consideration of management practices in the areas of tillage, drainage and cropping. Bedrock is soils which have shallow or no soil deposits and may have exposed bedrock. This type of landscape is restricted in its use due to the depth of soil and exposure of bedrock. If possible to achieve some agriculture production on this landscape special management considerations are necessary.

The land within the ESR watershed consists mainly of medium texture soils (Table 28) and the distribution is displayed in Figure 50. Topography is a management consideration that exists in the Turtle Mountain area, in the headwaters of the Chain Lakes sub-watershed and a small area west of Medora. Fine Texture and Fine Texture and Wetness are also management concerns on the land bordering Whitewater Lake and along the Souris River and Blind Souris in the Waskada Creek sub-watershed.

Table 28. Area (ha) and percent (%) of land in each land resource characteristic class for the four sub-watersheds within the East Souris River IWMP study area (source 1:40,000 GIS soils layer). *Data unavailable for area within sub-watershed in R.M. of Glenwood.

	Chain Lakes Sub-Watershed*		Medora Creek Sub-Watershed		Waskada Creek Sub-Watershed		Whitewater Lake Sub Watershed	
Land Resource Characteristic Classes	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Medium Texture	41,688	72.0	36,274	75.3	59,545	80.2	49,468	55.0
Coarse Texture	6,546	11.3	6,530	13.6	1,169	1.6	1,183	1.3
Coarse Texture & Topography	10	0.0	0	0.0	0	0.0	0	0.0
Coarse Texture & Wetness	133	0.2	244	0.5	22	0.0	36	0.0
Bedrock	105	0.2	0	0.0	1,250	1.7	0	0.0
Topography	6,672	11.5	3,408	7.1	6,814	9.2	20,597	22.9
Fine Texture	103	0.2	33	0.1	2,609	3.5	2,955	3.3
Fine Texture & Wetness	2	0.0	22	0.0	97	0.1	1,643	1.8
Fine Texture & Topography	0	0.0	0	0.0	0	0.0	0	0.0
Organic	0	0.0	0	0.0	0	0.0	0	0.0
Marsh	0	0.0	11	0.0	5	0.0	106	0.1
Wetness	2,208	3.8	1,333	2.8	2,299	3.1	1,173	1.3
Unclassified	55	0.1	168	0.3	0	0.0	40	0.0
Water	378	0.7	134	0.3	450	0.6	12,780	14.2
Total	**57,900**	**100.0**	**48,157**	**100.0**	**74,260**	**100.0**	**89,981**	**100.0**

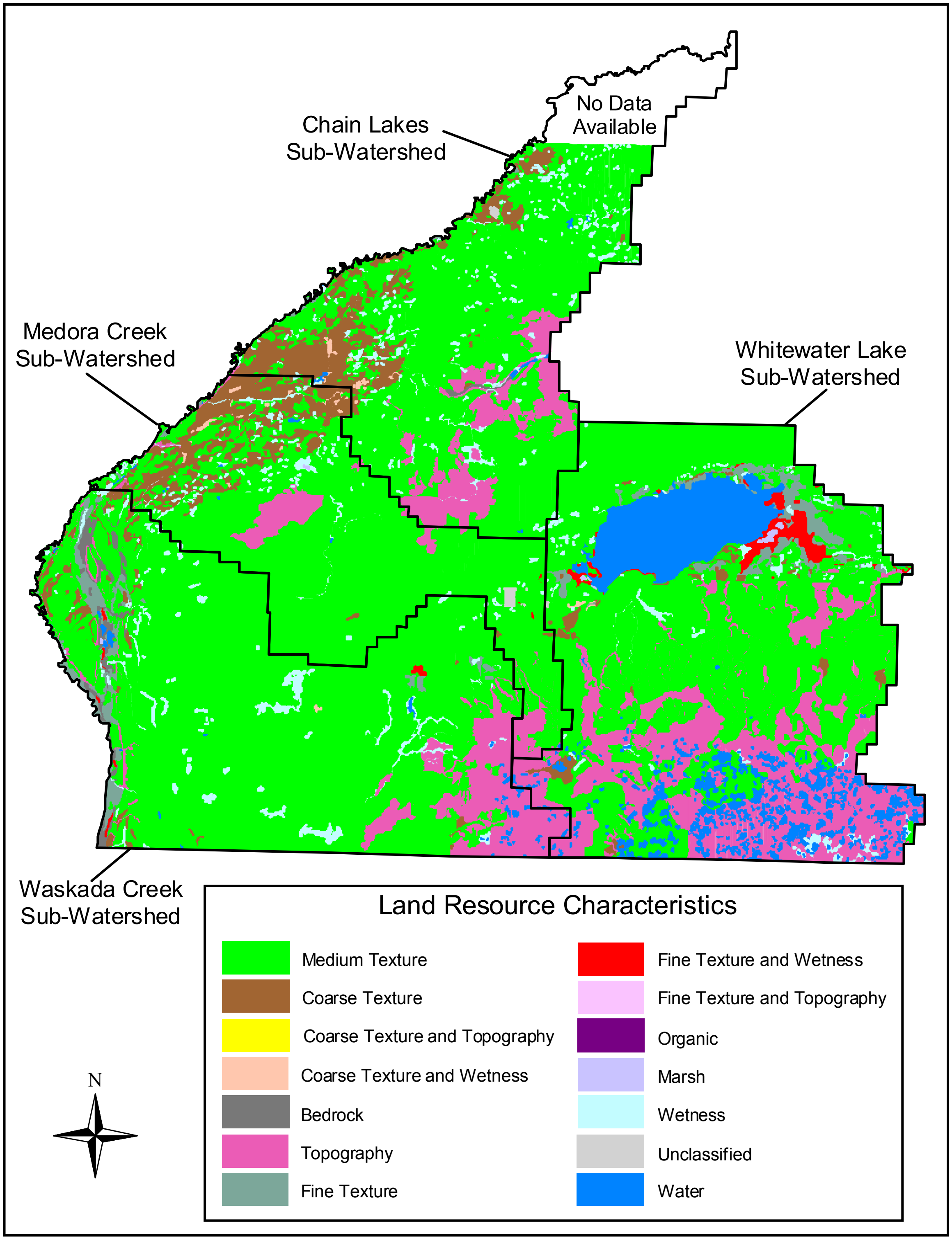


Figure 50. Land Resource Characteristics map for the East Souris River IWMP study area.

Agricultural Capability

The following reports were used in preparing the Soils and Agricultural Capability Sections

References

Manitoba Land Resource Unit (MLRU) 96-6. 1998. Rural Municipality of Glenwood, Information Bulletin 96-6; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 24pp.

Manitoba Land Resource Unit (MLRU) 97-3. 1998. Rural Municipality of Brenda, Information Bulletin 97-3; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

Manitoba Land Resource Unit (MLRU) 97-4. 1998. Rural Municipality of Winchester, Information Bulletin 97-4; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

Manitoba Land Resource Unit (MLRU) 97-5. 1998. Rural Municipality of Morton, Information Bulletin 97-5; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

Manitoba Land Resource Unit (MLRU) 97-2. 1998. Rural Municipality of Arthur, Information Bulletin 97-2; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

Manitoba Land Resource Unit (MLRU) 97-7. 1998. Rural Municipality of Cameron, Information Bulletin 97-7; Manitoba Land Resource Unit, Brandon Research Centre, Research Branch, Agriculture and Agri-Food Canada; Department of Soil Science, University of Manitoba; Manitoba Soil Resource Section, Soils and Crop Branch, Manitoba Agriculture, 28pp.

Canada Land Inventory

Agriculture capability can best be described as the ability of the land to support the appropriate type of crops and agriculture management techniques. Not all land can be used in the same manner and it varies according to soil type, topography, stoniness, soil moisture deficiency and low fertility, to name only a few of the limitations. Classes have been established and range from 1 to 7 with each class having its own characteristics. Class 1 land is capable of producing the most expansive variety of crops with soil and climate conditions being favourable. Class 2 land is capable of producing a wide variety of crops, however there may be some minor limitations due to restrictions with soil and climate. Class 3 land is capable of producing a variety of crops under proper management techniques with soil and climate causing a higher rate of limitation. Class 4 land is capable of producing a limited variety of crops and must take into consideration special management techniques for the land. Class 5 land has limited capabilities and is recommended only for the production of perennial forages. Soil and climate causes severe restrictions to the agriculture capacity of the land. Improvements to the land are considered feasible, depending on location. Class 6 land should only produce native vegetation and pasture, with a heavy emphasis on no cultivation due to high soil and climate limitations. Improvements to the land are not considered feasible for agriculture capabilities. Class 7 is considered unsuitable for dry-land/soil bound agriculture.

Within the ESR watershed the majority of the land is classified as CLI class 2, 3 and 4 with 166,120 ha, 52,288 ha and 31,668 ha, respectively. The amount of land within each CLI class for each sub-watershed is displayed in Table 29 and is shown geographically in Figure 51.

Table 29. Area (ha) and percent (%) of land in each class for CLI agriculture land capability the four sub-watersheds within the East Souris River IWMP study area (source 1:40,000 / 1:127,000 GIS soils layer).

	Chain Lakes Sub-Watershed		Medora Creek Sub-Watershed		Waskada Creek Sub-Watershed		Whitewater Lake Sub-Watershed	
Canada Land Inventory Class	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)
1	257	0.4	249	0.5	234	0.3	1	0.0
2	35,648	54.3	30,344	63.1	53,710	66.4	46,418	47.9
3	19,143	29.2	10,400	21.6	8,099	10.0	14,646	15.1
4	5,913	9.0	2,721	5.7	10,456	12.9	12,578	13.0
5	2,705	4.1	3,423	7.1	5,770	7.1	4,966	5.1
6	1,451	2.2	672	1.4	2,057	2.5	4,363	4.5
7	489	0.7	12	0.0	8	0.0	106	0.1
Organic	0	0.0	0	0.0	0	0.0	0	0.0
Unclassified	0	0.0	173	0.4	0	0.0	35	0.0
Water	0	0.0	127	0.3	502	0.6	13,837	14.3
Total	**65,606**	**100.0**	**48,121**	**100.0**	**80,836**	**100.0**	**96,950**	**100.0**

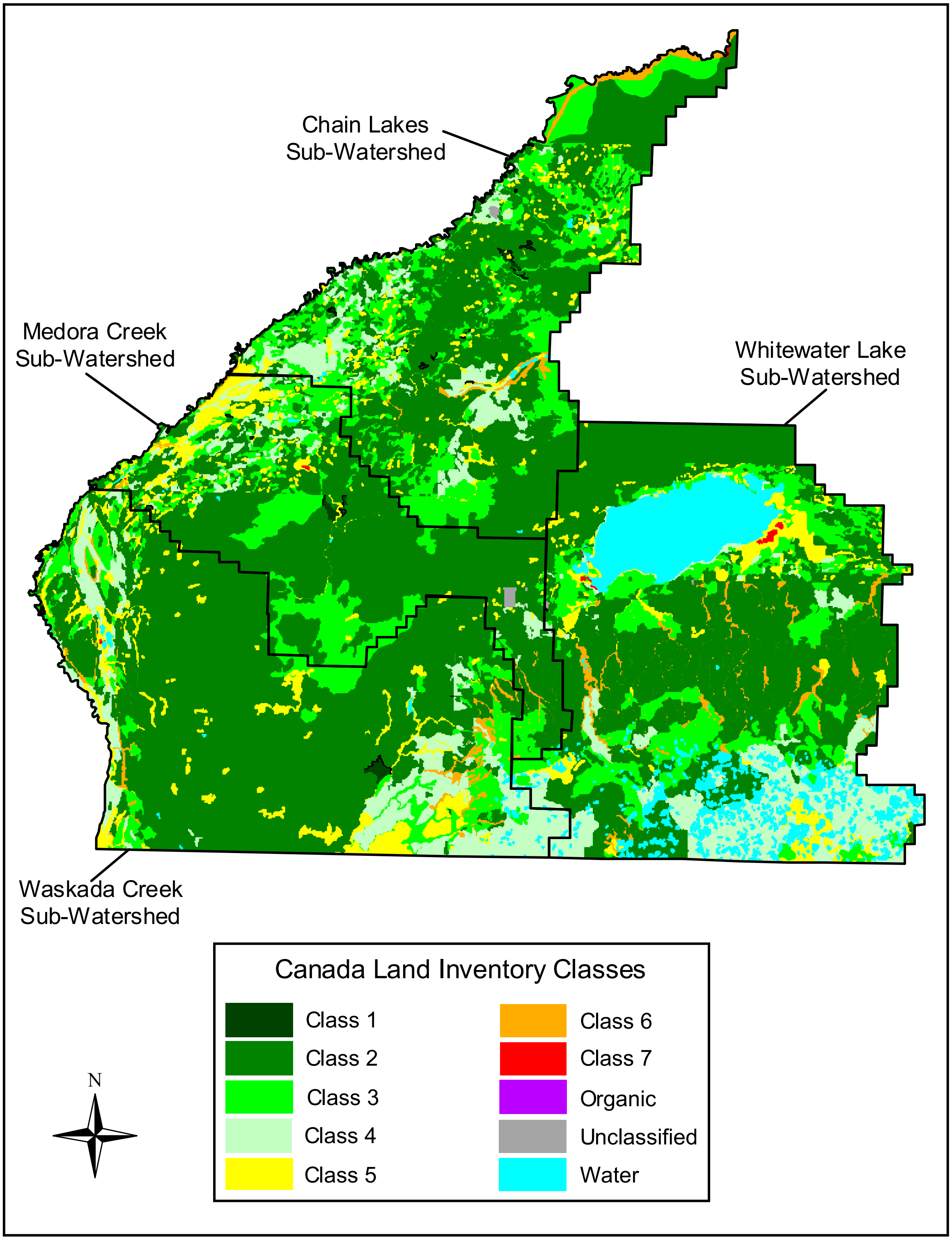


Figure 51. Canada Land Inventory – Agricultural Capability map for the East Souris River IWMP study area.

Manitoba Crop Insurance Corporation Soil Classes

The following information was submitted by Ken Pascal of Manitoba Crop Insurance Corporation

Summary of MCIC Productivity Indices

Beginning in the late 1930's the Manitoba Soil Survey started to group and classify soils based on morphological features. To date, most of Manitoba's agricultural land has been mapped and classified in the form of soil survey reports, which provides the basis for MCIC's Productivity Indices.

In order to assess the productivity of these lands, a joint project was undertaken by the Manitoba Department of Agriculture, the Department of Soil Science at the University of Manitoba and the Manitoba Soil Survey.

Major soil types in the province (benchmark soils) were selected and the long term (35 years) average wheat, oats, and barley yields were obtained for each soil from the Dominion Bureau of Statistics, the Sandford-Evans Statistical Service, and the Veterans' Land Act Administration.

The benchmark soils were then placed in one of 10 classes (A – J) with the soils having the highest yields being classes as "A" and the lowest yielding soils being rated as "J". The characteristics of all other soils mapped by the Soil Survey were then studied and compared to these benchmark soils and were placed in appropriate productivity classes.

Factors in Rating Productivity

Soil productivity is dependent upon the interaction of certain soil factors with one another and with climate.

Climate Factors – These include temperature (length of growing season, frost hazards, and heat units) and moisture (precipitation totals and distribution as well as evaporation rates).

Soil Factors

Soil Texture – This is important because of the effect on moisture retention. Higher ratings were given to medium textured soils such as loams and clay loams. Higher ratings were given to medium textured soils such as loams and clay loams. Lower ratings are given to heavy clays (poor internal drainage) and sandy soils (prone to erosion, lower water holding capacity and lower fertility due to leaching).

Organic Matter – This is important die to its relationship with fertility, tilth and water retention.

Drainage Characteristics – Natural internal soil drainage is of more importance than surface drainage.

Depth of Topsoil – This is important because it determines the rooting zone and is related to the total amount of organic matter and available plant nutrients in the soils.

Salinity – When the soluble salt concentration is high, soil productivity is greatly reduced.

Soil Erosion – The amount of topsoil removed is considered when rating a soil. Usually the potential for soil erosion is related to texture and topography of the land.

Topography – This contributes to the degree of erosion and localized drainage problems.

Stoniness – This is of minor importance unless it is severe enough to limit cultivation and land use.

Plus Soils

After several years of collecting yield and loss data, it was obvious that the fine textured, heavy clay soils with poor or restricted internal drainage responded differently than soils with good internal drainage.

These heavy clay soils (located in Risk Areas 12, 14, and 15) have been designated as plus soils and may be considered as a grouping of soils with a common limitation or risk.

Risk Areas

A Risk Area is defined as an area of common production risk. The criteria used for delineating risk areas were to place areas with similar soils and/or climate into a common group. It should be noted that a "C" soil in Risk Area 12 may not have the same productivity as "C" soil in Risk Area 6 due to climatic differences.

Soil Productivity Rating

The ratings are essentially based on five factors which are influenced by specific characteristics.
Climate: This is influenced by insolation, precipitation and circulation.
Hydrology: This is influenced by internal drainage, surface runoff and proximity to bodies of water.
Sensitivity: This is influenced by flooding, drought and erosion.
Soil: This is influenced by texture, organic matter, topsoil depth, salinity and stoniness.
Terrain: This is influenced by landforms, slope and bedrock.

Within the ESR watershed MCIC soil class E is the most common land class (see Table 30). Land with a soil class of H, I and J and potentially some class F and G land (if red spring wheat yields are less than 35 bushels per acre) can qualify for the Greencover Canada Land Conversion Program. The distribution of MCIC soil classes is displayed in Figure 52.

Table 30. Area (ha) and percent (%) of land in each soil class based on Manitoba Crop Insurance soil classifications for the four sub-watersheds within the East Souris River IWMP study area.

	Chain Lakes Sub-Watershed		**Medora Creek Sub-Watershed**		**Waskada Creek Sub-Watershed**		**Whitewater Lake Sub-Watershed**	
MCIC Soil Class	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)
C	3,506	5.6	0	0.0	0	0.0	0	0.0
D	8,256	13.2	1,046	2.3	3,351	4.7	0	0.0
E	25,433	40.7	29,313	63.2	45,569	63.6	43,323	50.0
F	10,852	17.3	2,989	6.4	12,729	17.8	13,624	15.7
G	9,698	15.5	7,131	15.4	5,028	7.0	3,248	3.7
H	3,484	5.6	2,760	5.9	3,030	4.2	2,796	3.2
I	1,284	2.1	2,767	6.0	801	1.1	718	0.8
J	46	0.1	404	0.9	1,126	1.6	9,414	10.9
U	0	0.0	0	0.0	0	0.0	13,524	15.6
Total	**62,559**	**100.0**	**46,410**	**100.0**	**71,634**	**100.0**	**86,647**	**100.0**

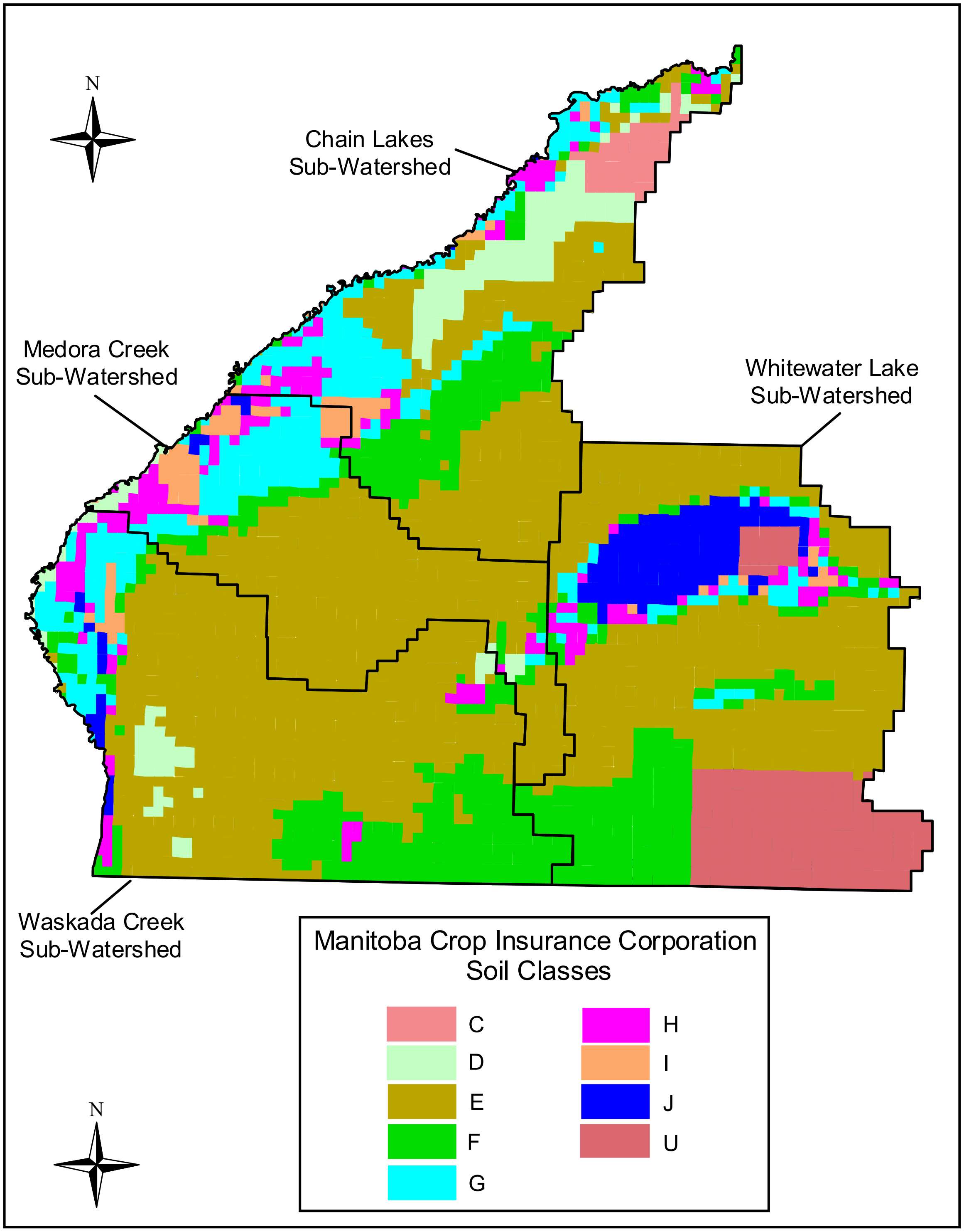


Figure 52. Manitoba Crop Insurance Soil Class map for the East Souris River IWMP study area.

Erosion Risk

Another important issue which needs to be considered with agricultural practices is the risk of water erosion. The risk of water erosion was calculated by using the universal soil loss equation (USLE) developed by Wischmeier and Smith. For each soil component in each soil map polygon, the USLE predicted soil loss (tons/hectare/year) is calculated and the erosion risk classes are determined based on the weighted average soil loss for each map polygon. As a means of determining areas with potential erosion risks a grading system was established and a map created to illustrate where the varying erosion risk areas are within the ESR watershed (Figure 53). The grading system includes five classes, which have been based on bare unprotected soil; Negligible, Low, Moderate, High and Severe. Negligible erosion risk is evaluated as having such modest consequence to the land that it does not warrant any or little attention to specific management techniques. Low to Moderate erosion risk is evaluated as having an increased awareness to agriculture management techniques practiced on the land as the erosion factor is of more concern due to varying features. High erosion risk is evaluated as having loamy soils with knolls and ridges which are more susceptible to erosion. This rating requires specific management practices as a means to maintain optimum soil quality and quantity. Severe erosion risk is evaluated as having steeply sloping soils predominantly bordering rivers and creeks. This rating requires a variation in land use from regular land cultivation and crops to perennial forages and pastures.

The majority of the ESR watershed falls in the low to moderate erosion risk category (Table 31) Areas with severe erosion risk are located in the Turtle Mountains and in the headwaters of the Chain Lakes sub-watershed. Agricultural practices like zero-tillage and permanent cover can reduce the risk of erosion in these areas and protect the soil resource.

The landcover data for the land in the high and severe erosion risk classes are displayed in Figure 54 and in Table 32. This information could be used to target programs to address land that may be susceptible to water erosion.

Table 31. Area (ha) and percent (%) of land in each erosion risk class for the four sub-watersheds within the East Souris River IWMP study area (source 1:40,000 GIS soils layer). *Data unavailable for area within sub-watershed in R.M. of Glenwood.

	Chain Lakes Sub-Watershed*		**Medora Creek Sub-Watershed**		**Waskada Creek Sub-Watershed**		**Whitewater Lake Sub-Watershed**	
Erosion Risk Classes	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Negligible	15,682	27.1	14,474	30.1	15,218	20.5	12,738	14.2
Low	22,380	38.6	16,696	34.7	24,069	32.4	20,086	22.3
Moderate	12,470	21.5	13,042	27.1	25,506	34.3	23,508	26.1
High	3,190	5.5	2,355	4.9	3,520	4.7	5,550	6.2
Severe	3,757	6.5	1,288	2.7	5,497	7.4	15,279	17.0
Unclassified	55	0.1	168	0.3	0	0.0	40	0.0
Water	378	0.7	134	0.3	450	0.6	12,780	14.2
Total	**57,912**	**100.0**	**48,157**	**100.0**	**74,260**	**100.0**	**89,981**	**100.0**

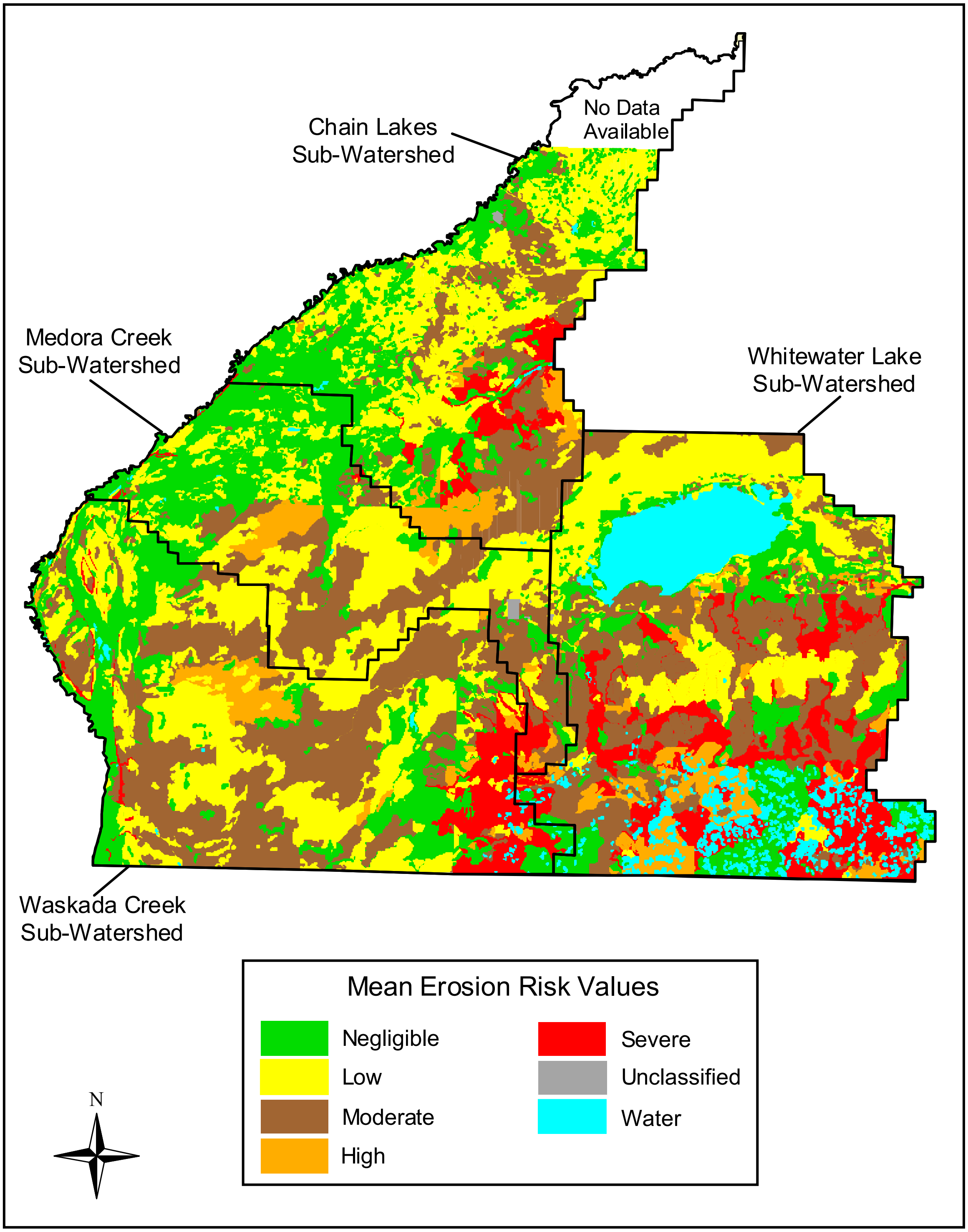


Figure 53. Erosion risk map (water) for the East Souris River IWMP study area.

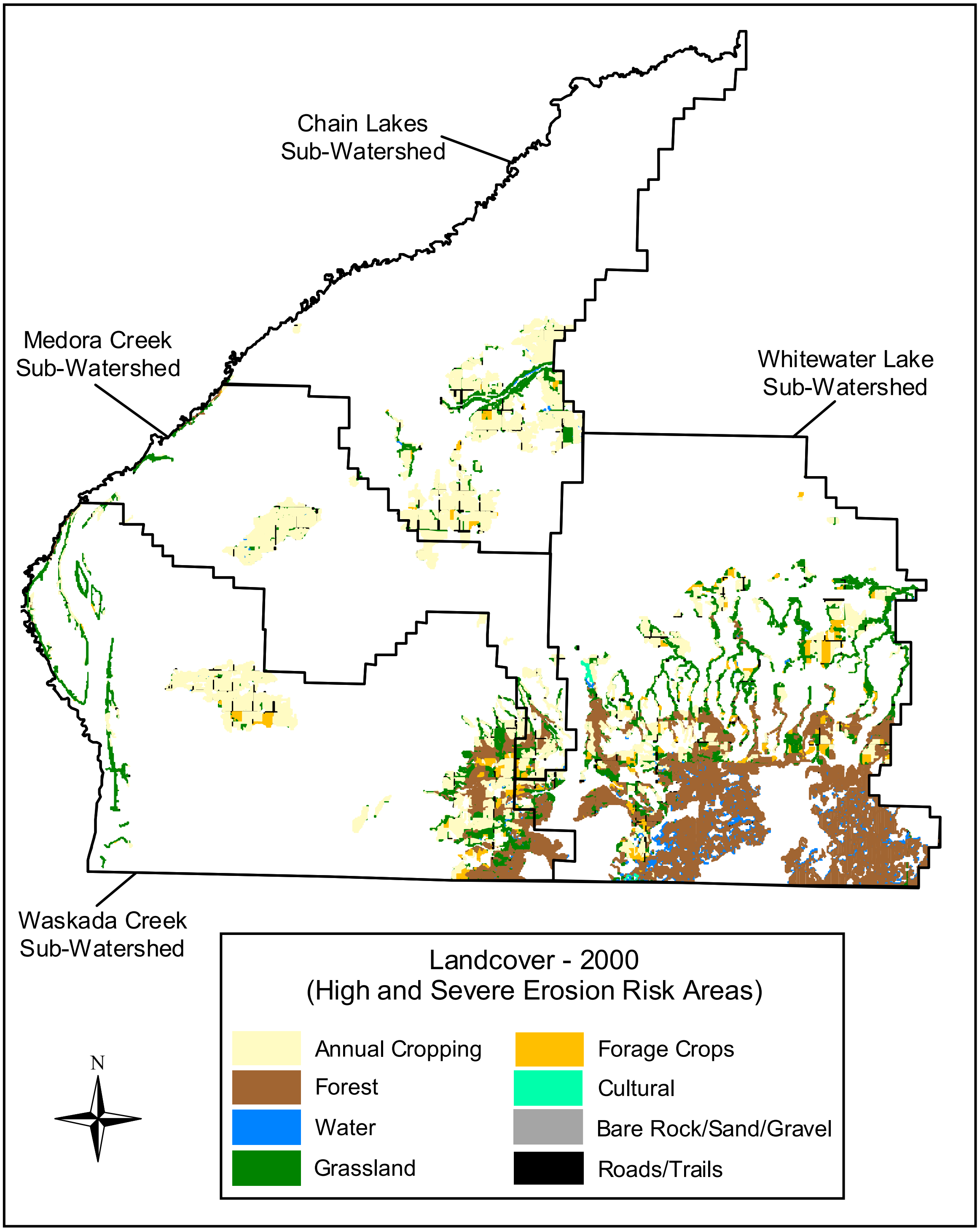


Figure 54. 2000 landcover within high and severe erosion risk areas (water) within the East Souris River IWMP study area.

Table 32. Area (ha) and percent (%) of landcover classes for land classified as having a high or severe risk of erosion under bare soil within the East Souris River IWMP study area based on landsat data from 2000.

	High Erosion Risk Land		**Severe Erosion Risk Land**	
2000 Landcover Class	Area (ha)	Percent (%)	Area (ha)	Percent (%)
Annual Cropping	8,452	58.7	8,114	32.2
Forest	2,870	19.9	8,109	32.2
Water	579	4.0	950	3.8
Grassland	1,672	11.6	5,947	23.6
Forage Crops	492	3.4	1,550	6.2
Cultural	0	0.0	54	0.2
Bare rock/sand/gravel	0	0.0	1	0.0
Roads/Trails	324	2.3	468	1.9
Total	**14,389**	**100**	**25,193**	**100**

Soil Association

Soil association is a more accurate means of classifying soil type. It breaks down the general classification of soils into detailed soil analysis. This classification illustrates the location of the soils in the ESR watershed in much finer detail (Figure 55). Unfortunately, no GIS data was available for the R.M. of Glenwood.

The majority of the soil in the ESR watershed is found to be a type of Loamy Lacustrine which stretches from the Whitewater Lake area towards Waskada and along the Souris River towards Hartney. A significant portion of Loamy Till soil can be found in the Turtle Mountains and central part of the study area. There is also Sandy Lacustrine soils along the Souris River, which are more common in the Medora Creek and Chain Lakes sub-watershed. A couple of interesting illustrations is that on the western portion of the watershed the old Souris River Channel (Blind Souris) can be seen and has Variable Textured Alluvium soils. The other notable feature are the eroded slopes which are visible in the Turtle Mountain and Boissevain Plain area as well as in the north section of the watershed in the headwaters of the Chain Lakes sub-watershed and along the old Souris River Channel.

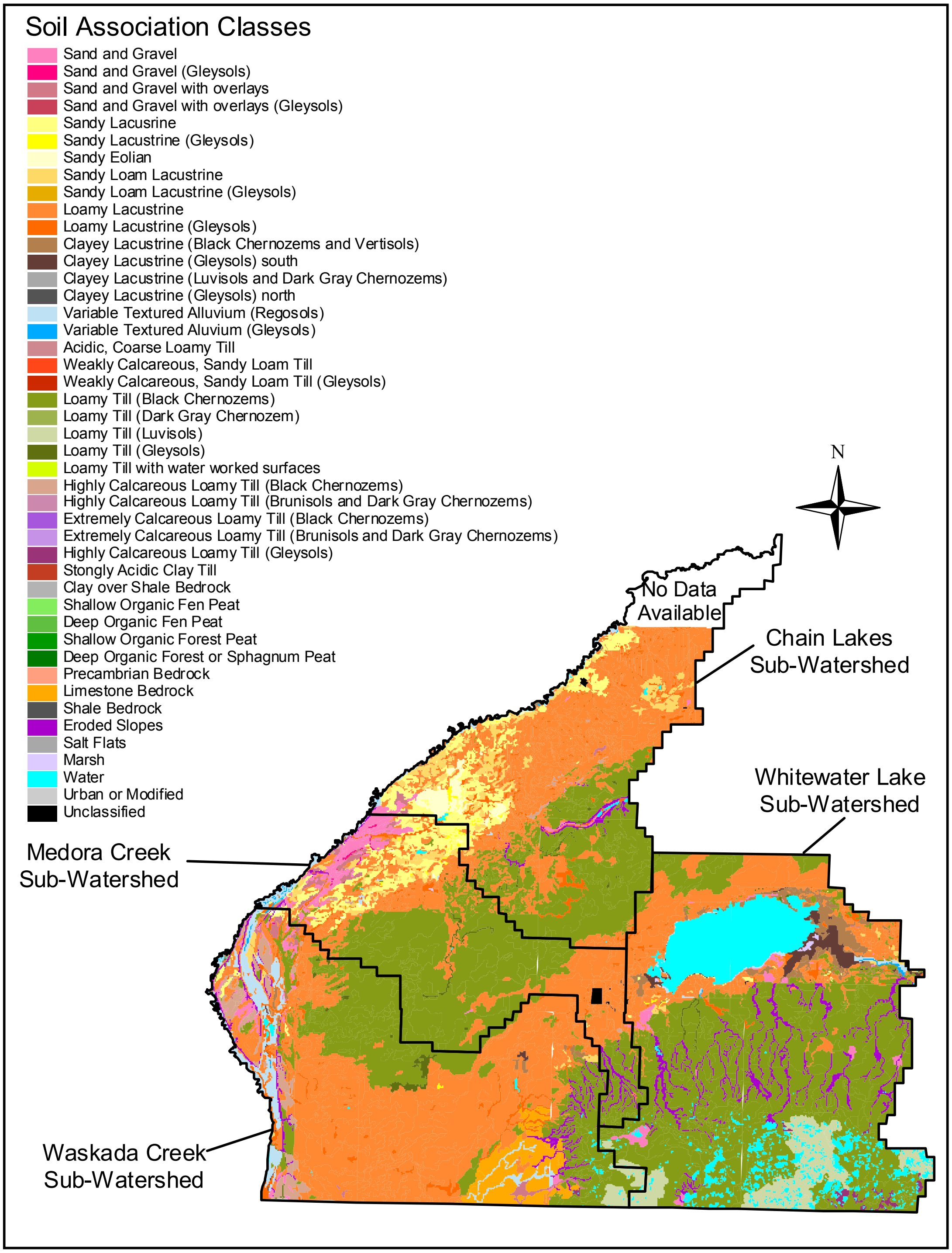


Figure 55. Soil Association map for the East Souris River IWMP study area.

Agricultural Use in the Study Area

As mentioned earlier in the report there are portions or entire areas of six rural municipalities within the East Souris River study area. From each R.M. in this study area information on the agriculture use has been collected, by Statistics Canada in 1996 and 2001, and relevant details from this data will be explained in this section. Conservation practices used on the land for agriculture purposes are essential in maintaining healthy soil and good quality water. For this reason some of the following information will include census data on conservation practices still in use and those which are used less frequently. For further information on agriculture census information not included in the written portion of this section please refer to Appendices 11 to 17.

In the R.M. of Arthur, there was a slight increase in numbers of farms from 158 in 1996 to 164 in 2001. The average acreage per farm also increased from 1,051 acres to 1,146 acres. Of the three main livestock farm practices cattle farms remained the same at 91. No information on the number of hog and horse farms was available in 1996 but there were 5 and 18 farms, respectively for the 2001 census year. There was a decrease in summer-fallow farms from 66 to 58 from 1996 to 2001. There was a decrease from 79 to 56 for conventional tillage farms along with a decrease in conservation tillage farms from 60 to 56 and there was an increase of zero tillage farms from 35 to 61 over that same time period. There was an increase in winter wheat farms from three to 28 over the 5-year period. The number of alfalfa farms increased from 1996 to 2001 and the total acres grown also went from 8,051 acres to 11,062 respectively. The same trend was also displayed with tame hay farms which increased from 23 to 25 and the number of acres jumped from 1,506 acres to 2,256 acres.

Within the R.M. of Brenda, there was a decrease from 177 farms in 1996 to 150 in 2001 and the average farm size increased from 1,070 acres to 1,248 acres. The number of cattle farms increased from 85 to 87 and once again no data was available for hog and horse farms in 1996 but in 2001 they numbered 2 and 34, respectively. From 1996 to 2001 the number of summer-fallow farms decreased from 79 to 52, conventional tillage farms decreased from 106 to 65, conservation tillage farms decreased from 61 to 54 and the number of farms using zero tillage increased from 30 to 54. From 1996 to 2001 the number of winter wheat farms increased from 0 to 14. The number of alfalfa farms increased from 53 to 67 and the same trend was shown with tame hay farms that rose from 27 to 30. The amount of acres seeded to alfalfa increased from 4,392 acres to 8,343 acres in 2001 and tame hay acres increased from 1,970 acres to 3,185 acres.

From 1996 to 2001 the number of farms decreased from 137 to 131 in the R.M. of Cameron and there was a decrease in the average size of farms from 1,317 acres to 1,265 acres. The number of cattle farms increased slightly from 87 to 88, while the number of hog and horse farms in 2001 was two and 26 respectively and no data was available of hog and horse farms in 1996. The number of summer fallow farms remained the same between the two census years at 41. Conventional tillage farms and conservation tillage farms both decreased in numbers from 55 to 42 and 43 to 39, respectively from 1996 to 2001 and the number of zero tillage farms displayed a small increase from 30 to 34. The number of winter wheat producers increased from three to 18. There was also an increase in the number of alfalfa farms from 57 to 76 and the acreage increased from 8,998 to 14,083 and the number of tame hay farms also showed an increase from 30 to 34 farms with acreages grown increasing from 5,182 to 5,268.

Within the R.M. of Glenwood the number of farms decreased from 151 to 130 between 1996 and 2001 and the average size per farm increased from 901 acres to 1,053 acres. The number of cattle farms decreased from 80 to 74 and once again no figures were available on the number of hog and horse farms in 1996 however there were 3 hog farms and 31 horse farms in 2001. The trend in the number of farms using the summer fallow practice continued to decline from 48 to 35, and there was also a decrease in conventional and conservation tillage farms from 67 to 53 and 54 to 45, respectively from 1996 to 2001. The number of zero tillage farms increase from 15 to 20 and the number of farms growing winter wheat increased from one farm to five. Both the number of alfalfa farms and tame hay farms decreased from 1996 to 2001. Alfalfa farms went from 73 to 66 and tame hay farms decreased from 21 to 20. The area planted into alfalfa increased from 10,557 acres to 12,357 and the amount of tame hay went from 2,818 acres to 2,087 acres.

The number of farms within the R.M. of Morton decreased from 213 to 187 between 1996 and 2001, while the average acreage per farm increased from 989 acres to 1,106 acres. The number of cattle farms declined from 125 to 112 from 1996 to 2001 and hog and horse farm numbers were noted to be 8 and 37, respectively for 2001. There was a decrease in the number of summer fallow farms from 63 to 45, conventional tillage and conservation tillage farms decreased from 107 to 75 and 56 to 54, respectively and the number of zero tillage farms rose from 24 to 29 farms from 1996 to 2001. There was an increase in the number of winter wheat farms from 0 to 14. From 1996 to 2001 the amount of acres planted to alfalfa increased from 15,571 to 16,125, while the number of alfalfa farms declined from 112 to 108. The number of tame hay farms also declined over that same time period from 32 to 19 and the numbers of acres in tame hay decreased from 2,533 to 1,660.

From 1996 to 2001 the number of farms within the R.M. of Winchester decreased from 169 to 143, while the average farm size increased from 1,068 acres to 1,255 acres. Over that same time frame the number of cattle farms went from 107 to 94 and in 2001 there was one hog farm and 44 horse farms. No data was available for hog and horse farms in 1996. A positive trend from 1996 to 2001 showed that the number of summer fallow farms decreased from 65 to 41 and the number of conventional tillage farms decreased from 89 to 62. The number of conservation tillage farms decreased from 55 to 43 and the number of zero tillage farms increased from 17 to 35. The number of number of winter wheat farms increased from 2 to 7, meanwhile the number of alfalfa farms increased from 80 to 81 and tame hay farms increased from 20 to 22. The total acres planted to alfalfa increased from 9,854 acres to 10,411 acres and the total number of acres in tame hay increased from 1154 acres to 3,376 acres.

Appendices

Appendix 1. Normal climate and weather information for Deloraine (1971-2001).

Temperature:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-15.5	-12.2	-4.7	4.9	12.6	17.1	19.5	18.5	12.2	5.4	-4.5	-13.2	3.3
Standard Deviation	4.8	4.1	3.6	2.6	2.3	1.7	1.8	2.0	1.7	1.4	2.9	3.9	2.1
Daily Maximum (°C)	-9.7	-6.7	0.6	11.2	19.3	23.5	26.1	25.4	18.6	11.5	0.3	-7.9	9.3
Daily Minimum (°C)	-21.3	-17.6	-9.9	-1.3	5.8	10.6	12.8	11.6	5.7	-0.9	-9.2	-18.5	-2.7
Extreme Maximum (°C)	7.8	16.5	21.7	35.0	41.1	37.5	40.6	38.5	38.3	32.0	21.1	16.1	
Date (yyyy/dd)	1926/03+	1988/27	1963/23	1980/21	1934/30	1979/13	1934/17	1988/06	1978/05	1992/01	1965/02	1925/03+	
Extreme Minimum (°C)	-43.3	-46.1	-39.4	-31.1	-10.0	-3.3	-1.1	-3.0	-7.8	-21.0	-33.3	-41.5	
Date (yyyy/dd)	1954/20	1936/15	1962/01	1936/06	1954/01	1926/02	1934/06	1982/27	1926/23	1991/31	1958/29	1983/23	
Precipitation:													
Rainfall (mm)	0.4	0.3	3.7	22.8	47.8	85.3	67.4	58.5	50.7	24.2	4.1	0.8	366.0
Snowfall (cm)	19.1	14.0	20.7	11.0	2.1	0.2	0.0	0.0	0.5	9.8	16.5	18.5	112.3
Precipitation (mm)	19.6	14.3	24.4	33.8	49.9	85.3	67.4	58.5	51.2	33.9	20.6	19.3	478.1
Days with Maximum Temperature:													
<= 0 °C	25.9	21.6	14.2	2.3	0.0	0.0	0.0	0.0	0.0	1.6	14.4	25.9	106.0
> 0 °C	5.1	6.6	16.8	27.7	31.0	30.0	31.0	31.0	30.0	29.4	15.6	5.1	259.3
> 10 °C	0.0	0.19	2.1	15.3	27.9	30.0	31.0	31.0	26.9	16.9	3.4	0.0	184.6
> 20 °C	0.0	0.0	0.0	3.3	14.1	22.1	28.3	25.8	11.5	3.1	0.0	0.0	108.2
> 30 °C	0.0	0.0	0.0	0.11	1.3	2.4	5.2	5.6	1.3	0.06	0.0	0.0	16.0
> 35 °C	0.0	0.0	0.0	0.0	0.14	0.24	0.35	0.72	0.20	0.0	0.0	0.0	1.7
Days with Minimum Temperature:													
> 0 °C	0.06	0.06	1.0	11.1	26.4	29.9	31.0	31.0	25.9	12.8	1.6	0.06	170.8
<= 2 °C	31.0	28.3	30.6	23.4	8.4	0.58	0.0	0.37	7.2	22.3	29.3	31.0	212.4
<= 0 °C	30.9	28.2	29.9	18.9	4.6	0.11	0.0	0.05	4.1	18.2	28.4	30.9	194.4
< -2 °C	30.8	27.5	26.6	12.6	1.8	0.0	0.0	0.05	1.4	11.4	25.3	30.7	168.1
< -10 °C	26.5	20.5	13.5	2.0	0.0	0.0	0.0	0.0	0.0	1.5	11.9	24.4	100.2
< -20 °C	16.8	11.6	4.7	0.37	0.0	0.0	0.0	0.0	0.0	0.11	2.9	13.5	49.9
< - 30 °C	6.7	3.2	0.39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.27	2.2	12.7
Days with Precipitation:													
>= 0.2 mm	7.0	5.7	5.6	5.4	8.3	11.0	9.7	8.6	8.7	5.3	5.4	6.1	86.7
>= 5 mm	1.3	1.1	1.9	2.1	3.4	5.1	4.1	3.0	2.8	2.1	1.7	1.3	29.9
>= 10 mm	0.27	0.05	0.59	1.3	1.7	2.9	2.2	1.6	1.7	1.2	0.55	0.24	14.3
>= 25 mm	0.0	0.0	0.05	0.18	0.14	0.65	0.43	0.61	0.35	0.19	0.0	0.0	2.6
Degree Days:													
Above 24 °C	0.0	0.0	0.0	0.1	1.0	2.9	5.5	4.5	0.9	0.0		0.0	
Above 18 °C	0.0	0.0	0.0	1.3	14.0	37.0	70.2	58.4	8.5	0.2		0.0	
Above 15 °C	0.0	0.0	0.0	4.1	36.2	86.6	144.8	120.7	25.7	1.2		0.0	
Above 10 °C	0.0	0.0	0.0	18.1	113.0	217.2	295.9	262.3	95.0	14.5		0.0	
Above 5 °C	0.0	0.1	2.0	64.0	237.6	366.3	450.9	417.0	217.5	70.6		0.0	
Above 0 °C	0.7	2.7	20.7	162.6	386.5	516.3	605.9	572.0	363.5	182.2		1.0	
Below 0 °C	482.7	347.5	194.5	25.4	0.2	0.0	0.0	0.0	0.0	16.8		418.4	
Below 5 °C	636.9	486.2	330.7	76.8	6.3	0.0	0.0	0.0	4.1	60.3		572.4	
Below 10 °C	791.9	627.3	483.8	180.8	36.7	0.9	0.0	0.4	31.5	159.2		727.4	
Below 15 °C	946.9	768.6	638.8	316.8	114.9	20.3	3.8	13.7	112.3	300.8		882.4	
Below 18 °C	1039.9	853.3	731.8	404.1	185.7	60.7	22.3	44.5	185.0	392.8		975.4	

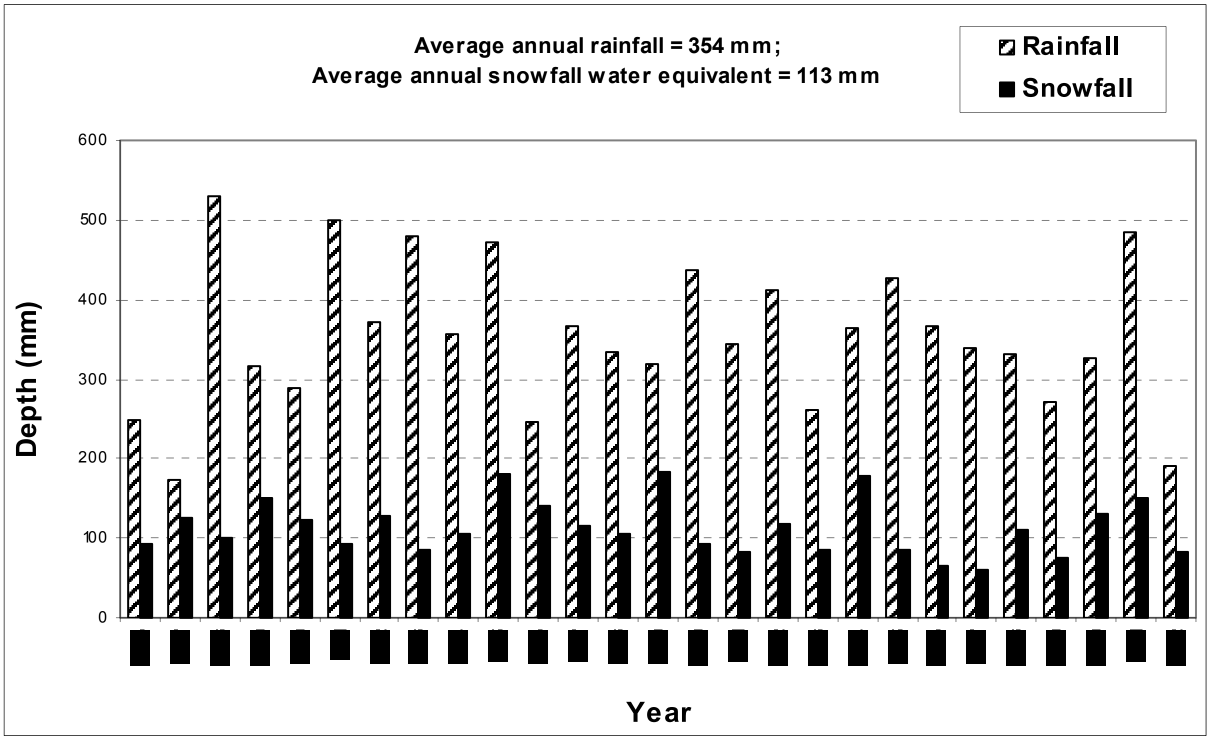
Appendix 2. Normal climate and weather information for International Peace Gardens (1971-2001).

Temperature:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-16.2	-12.1	-6.1	2.8	10.8	15.4	17.9	17.1	10.9	4.3	-6.2	-13.3	2.1
Standard Deviation	4.2	3.8	3.1	2.9	2.2	1.7	1.6	2.0	1.6	1.6	2.9	3.8	1.8
Daily Maximum (°C)	-10.6	-6.3	-0.6	9.1	17.7	21.9	24.5	23.9	17.3	10.2	-1.6	-8.1	8.1
Daily Minimum (°C)	-21.7	-17.8	-11.5	-3.4	4.0	8.9	11.3	10.2	4.5	-1.7	-10.7	-18.4	-3.9
Extreme Maximum (°C)	11.0	13.0	16.7	33.0	36.0	35.5	35.6	38.5	36.1	32.0	22.0	11.7	
Date (yyyy/dd)	1981/23	1992/01	1973/26	1980/21	1980/21	1995/16	1975/30	1989/01	1976/06	1992/01	1999/08	1969/01	
Extreme Minimum (°C)	-40.5	-43.0	-36.7	-26.0	-9.5	-3.3	0.0	-4.0	-7.5	-22.0	-34.0	-40.0	
Date (yyyy/dd)	1996/19+	1996/01+	1974/24	1995/04	1989/06	1969/12	1972/03	1982/27	1995/22	1991/31	1985/29	1983/23+	
Precipitation:													
Rainfall (mm)	0.2	1.1	4.9	24.2	65.3	97.8	81.4	74.7	54.6	30.6	3.5	0.6	438.9
Snowfall (cm)	27.5	25.5	28.8	15.6	4.1	0.1	0.0	0.0	2.0	11.6	26.4	26.1	167.7
Precipitation (mm)	27.7	26.6	33.8	39.9	69.4	97.9	81.4	74.7	56.5	42.2	29.9	26.7	606.6
Days with Maximum Temperature:													
<= 0 °C	27.5	22.5	17.3	3.7	0.14	0.0	0.0	0.0	0.05	2.2	18.5	27.0	118.9
> 0 °C	3.5	5.8	13.7	26.3	30.9	30.0	31.0	31.0	30.0	28.8	11.6	4.0	246.5
> 10 °C	0.0	0.18	1.8	12.0	26.8	29.5	31.0	31.0	26.2	15.0	1.5	0.0	174.9
> 20 °C	0.0	0.0	0.0	2.2	11.6	19.4	26.4	23.2	10.0	2.4	0.10	0.0	95.3
> 30 °C	0.0	0.0	0.0	0.08	0.33	1.1	2.1	2.2	0.59	0.05	0.0	0.0	6.5
> 35 °C	0.0	0.0	0.0	0.0	0.05	0.04	0.04	0.0	0.05	0.0	0.0	0.0	0.18
Days with Minimum Temperature:													
> 0 °C	0.04	0.04	0.27	7.1	22.4	29.5	31.0	30.7	24.1	10.8	0.61	0.04	156.5
<= 2 °C	31.0	28.3	31.0	25.7	12.2	1.8	0.04	0.60	8.7	23.9	29.2	30.8	223.0
<= 0 °C	30.9	28.2	30.7	22.9	8.6	0.54	0.04	0.10	5.8	19.6	28.8	30.7	207.1
< -2 °C	30.8	27.7	27.9	16.3	4.0	0.07	0.0	0.0	2.2	12.9	26.9	30.6	179.2
< -10 °C	27.7	21.4	16.2	3.1	0.0	0.0	0.0	0.0	0.0	1.0	13.7	23.5	106.6
< -20 °C	17.3	11.1	5.3	0.35	0.0	0.0	0.0	0.0	0.0	0.08	2.8	11.9	48.8
< - 30 °C	6.2	2.5	0.73	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.17	2.2	11.7
Days with Precipitation:													
>= 0.2 mm	9.3	7.6	6.5	5.9	9.0	12.0	11.0	9.0	9.2	6.7	7.0	8.0	101.3
>= 5 mm	2.0	1.8	2.3	2.6	4.2	6.1	4.4	3.8	3.2	2.5	2.1	1.8	36.8
>= 10 mm	0.48	0.38	1.2	1.4	2.5	3.6	2.7	2.3	1.7	1.2	0.92	0.48	18.9
>= 25 mm	0.0	0.04	0.08	0.19	0.64	0.55	0.68	0.54	0.38	0.34	0.0	0.0	3.4
Degree Days:													
Above 24 °C	0.0	0.0	0.0	0.0	0.3	0.5	0.9	0.9	0.2	0.0	0.0	0.0	2.7
Above 18 °C	0.0	0.0	0.0	0.4	5.8	17.7	36.8	33.6	4.2	0.0	0.0	0.0	98.3
Above 15 °C	0.0	0.0	0.0	1.4	18.6	52.5	94.7	85.5	14.9	0.4	0.0	0.0	267.9
Above 10 °C	0.0	0.0	0.0	10.8	79.8	166.4	240.3	220.3	72.8	8.2	0.7	0.0	799.3
Above 5 °C	0.0	0.0	0.8	42.8	191.2	312.1	395.1	374.8	188.0	51.9	3.5	0.0	1560.3
Above 0 °C	0.8	3.2	15.7	119.2	335.2	462.0	550.1	529.8	330.9	152.4	18.0	1.1	2518.3
Below 0 °C	509.3	342.5	223.0	41.7	1.0	0.0	0.0	0.0	0.3	18.0	190.3	405.7	1731.8
Below 5 °C	663.5	480.9	363.1	115.2	12.1	0.2	0.0	0.0	7.4	72.6	325.8	559.6	2600.3
Below 10 °C	818.5	622.4	517.3	233.3	55.6	4.5	0.2	0.6	42.2	183.8	473.0	714.6	3665.8
Below 15 °C	973.5	763.9	672.3	373.9	149.4	40.5	9.6	20.7	134.3	331.0	622.3	869.6	4960.9
Below 18 °C	1066.5	848.8	765.3	462.8	229.6	95.7	44.7	61.9	213.5	423.6	712.3	962.6	5887.2

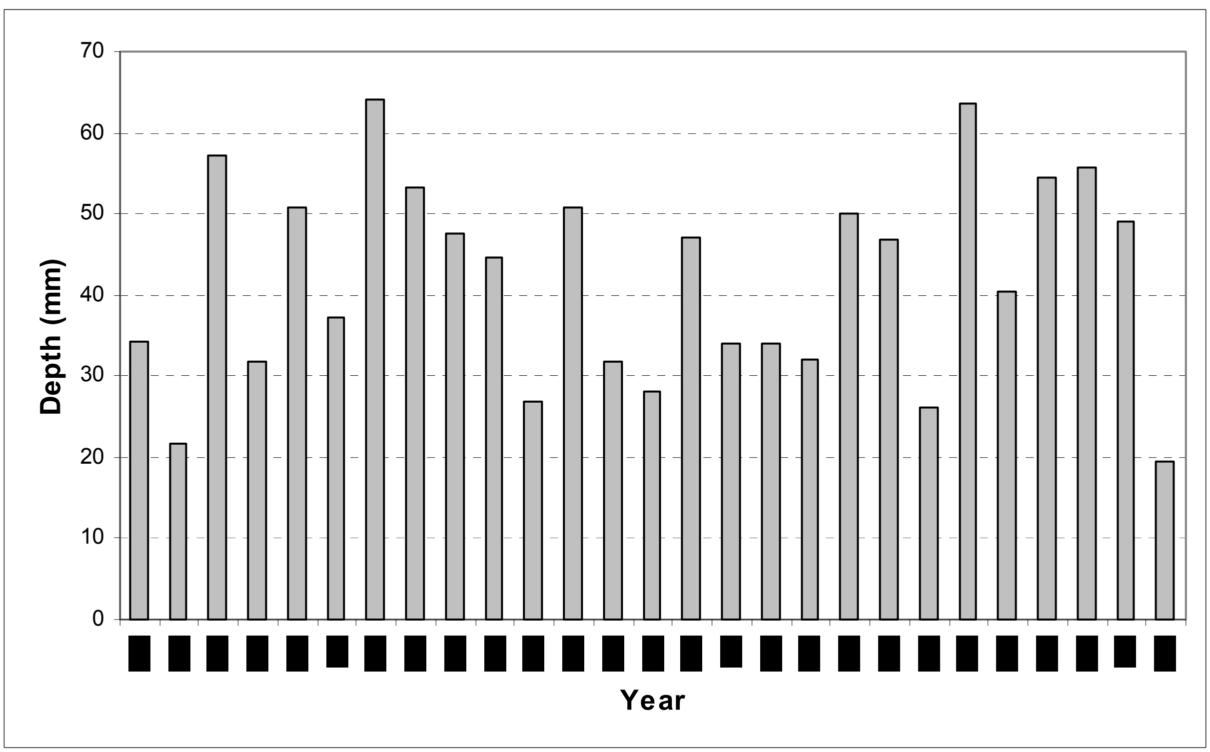
Appendix 3. Normal climate and weather information for Souris, MB (1971-2001).

Temperature:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-16.0	-12.5	-5.3	4.3	11.5	16.3	18.4	18.0	11.7	4.5	-6.2	-14.2	2.5
Standard Deviation	4.1	4.1	3.2	2.6	1.7	2.0	1.4	1.8	1.8	1.4	3.6	5.0	1.7
Daily Maximum (°C)	-10.2	-6.7	0.1	10.8	18.8	23.0	25.3	25.5	18.8	11.0	-1.4	-8.7	8.9
Daily Minimum (°C)	-21.7	-18.2	-10.7	-2.4	4.1	9.6	11.6	10.3	4.5	-2.1	-11.0	-19.6	-3.8
Extreme Maximum (°C)	8.0	16.0	17.5	30.0	34.5	36.0	35.0	38.0	36.0	31.5	20.0	9.0	
Date (yyyy/dd)	1993/31	1988/27	1986/27	1987/28	1988/29+	1988/05+	1989/04+	1989/01	1982/10+	1992/01	1999/08	1997/15	
Extreme Minimum (°C)	-45.0	-42.5	-36.0	-22.5	-8.5	-3.0	0.0	-3.5	-8.0	-25.0	-34.0	-43.0	
Date (yyyy/dd)	1996/19	1996/02	1998/11	1996/01	1989/06	1989/08	1984/06	1982/27	1982/15+	1991/30	1985/27+	1983/23	
Precipitation:													
Rainfall (mm)	0.6	1.6	8.2	17.2	57.8	87.1	77.8	57.2	44.4	29.6	7.0	0.9	389.4
Snowfall (cm)	23.0	17.6	19.3	11.1	3.3	0.0	0.0	0.0	0.4	8.7	20.7	22.2	126.1
Precipitation (mm)	23.5	19.2	27.4	28.5	61.6	87.1	77.8	57.2	44.8	38.3	27.7	23.1	516.2
Days with Maximum Temperature:													
<= 0 °C	27.4		13.6	2.5	0.17	0.0	0.0	0.0	0.0	1.7	17.4	26.2	
> 0 °C	3.6		17.4	27.5	30.8	30.0	31.0	31.0	30.0	29.3	12.6	4.8	
> 10 °C	0.0		2.1	15.6	27.9	29.8	31.0	31.0	27.2	16.0	0.88	0.0	
> 20 °C	0.0		0.0	3.5	13.1	20.3	28.5	26.1	11.8	2.9	0.0	0.0	
> 30 °C	0.0		0.0	0.0	1.2	2.0	2.9	5.1	1.1	0.05	0.0	0.0	
> 35 °C	0.0		0.0	0.0	0.0	0.22	0.0	0.58	0.11	0.0	0.0	0.0	
Days with Minimum Temperature:													
> 0 °C	0.0	0.06	0.94	7.8	23.4	29.3	30.9	30.7	24.3	9.6	0.67	0.0	157.7
<= 2 °C	30.8	28.1	30.8	25.7	11.2	1.4	0.11	1.1	9.6	24.6	29.8	31.0	224.1
<= 0 °C	30.8	28.1	30.1	22.2	7.6	0.72	0.06	0.21	5.7	21.4	29.3	31.0	207.1
< -2 °C	30.8	27.3	25.1	13.2	2.6	0.06	0.0	0.05	2.1	13.3	27.3	30.7	172.4
< -10 °C	27.7	19.9	13.4	2.2	0.0	0.0	0.0	0.0	0.0	1.8	14.2	25.1	104.3
< -20 °C	16.9	11.0	4.6	0.18	0.0	0.0	0.0	0.0	0.0	0.22	3.4	15.1	51.5
< - 30 °C	6.2	3.1	0.59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	5.4	15.7
Days with Precipitation:													
>= 0.2 mm	7.1	4.7	5.9	6.2	10.2	12.8	11.0	9.7	9.0	8.3	5.8	7.1	97.9
>= 5 mm	1.7	1.3	1.6	1.8	3.6	5.7	4.3	3.2	2.5	2.6	2.0	1.4	31.5
>= 10 mm	0.35	0.47	0.75	1.0	2.1	2.8	2.5	1.6	1.3	1.1	0.74	0.33	15.1
>= 25 mm	0.06	0.12	0.13	0.06	0.50	0.33	0.84	0.42	0.26	0.11	0.05	0.06	2.9
Degree Days:													
Above 24 °C	0.0		0.0	0.0	0.2	1.8	1.0	2.3	0.1	0.0	0.0	0.0	
Above 18 °C	0.0		0.0	0.1	7.7	28.4	47.5	48.1	4.9	0.2	0.0	0.0	
Above 15 °C	0.0		0.0	1.2	23.0	71.3	116.9	107.0	18.7	0.9	0.0	0.0	
Above 10 °C	0.0		0.0	12.9	89.8	192.3	266.6	245.2	83.9	10.4	0.0	0.0	
Above 5 °C	0.0		2.5	55.8	208.6	339.4	421.6	399.6	205.7	58.0	1.7	0.0	
Above 0 °C	0.5		23.7	151.9	356.6	489.4	576.6	554.6	350.4	160.8	13.9	1.1	
Below 0 °C	500.3		189.5	26.3	0.6	0.0	0.0	0.0	0.0	21.1	200.4	452.1	
Below 5 °C	654.8		323.3	80.2	7.7	0.0	0.0	0.0	5.4	73.3	338.2	606.1	
Below 10 °C	809.8		475.8	187.3	43.8	2.9	0.0	0.6	33.5	180.7	486.5	761.1	
Below 15 °C	964.8		630.8	325.6	132.0	31.9	5.3	17.4	118.3	326.2	636.5	916.1	
Below 18 °C	1057.8		723.8	414.5	209.8	79.0	28.9	51.4	194.5	418.5	726.5	1009.1	

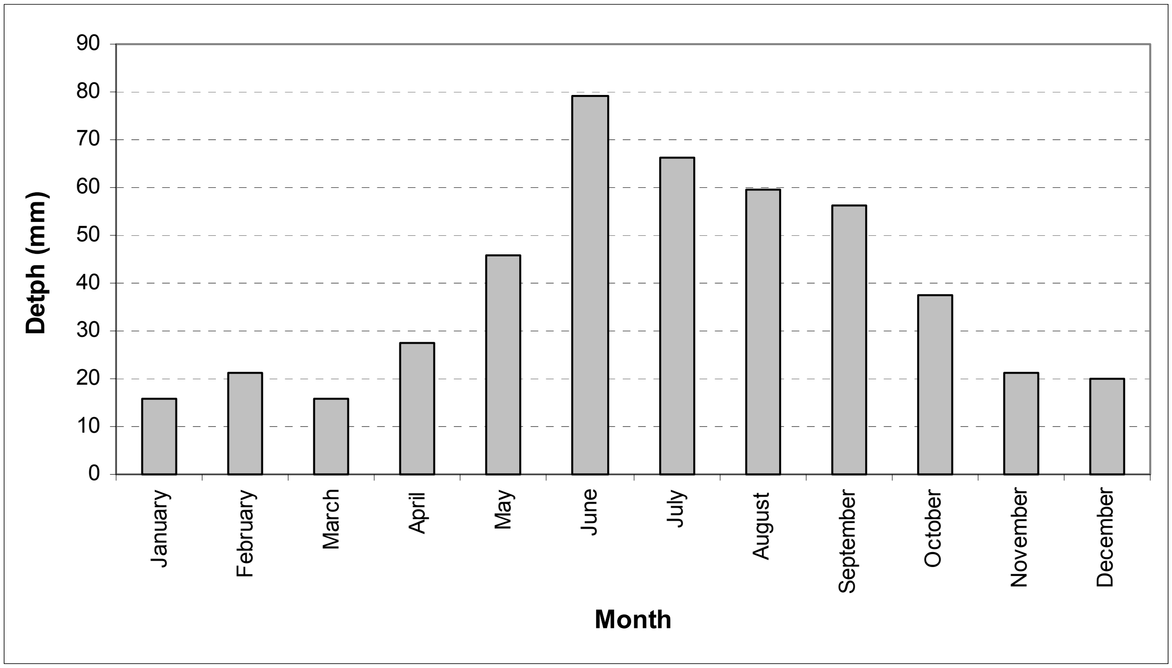
Appendix 4. Total annual rainfall and snowfall from 1966 – 1992 for Deloraine.



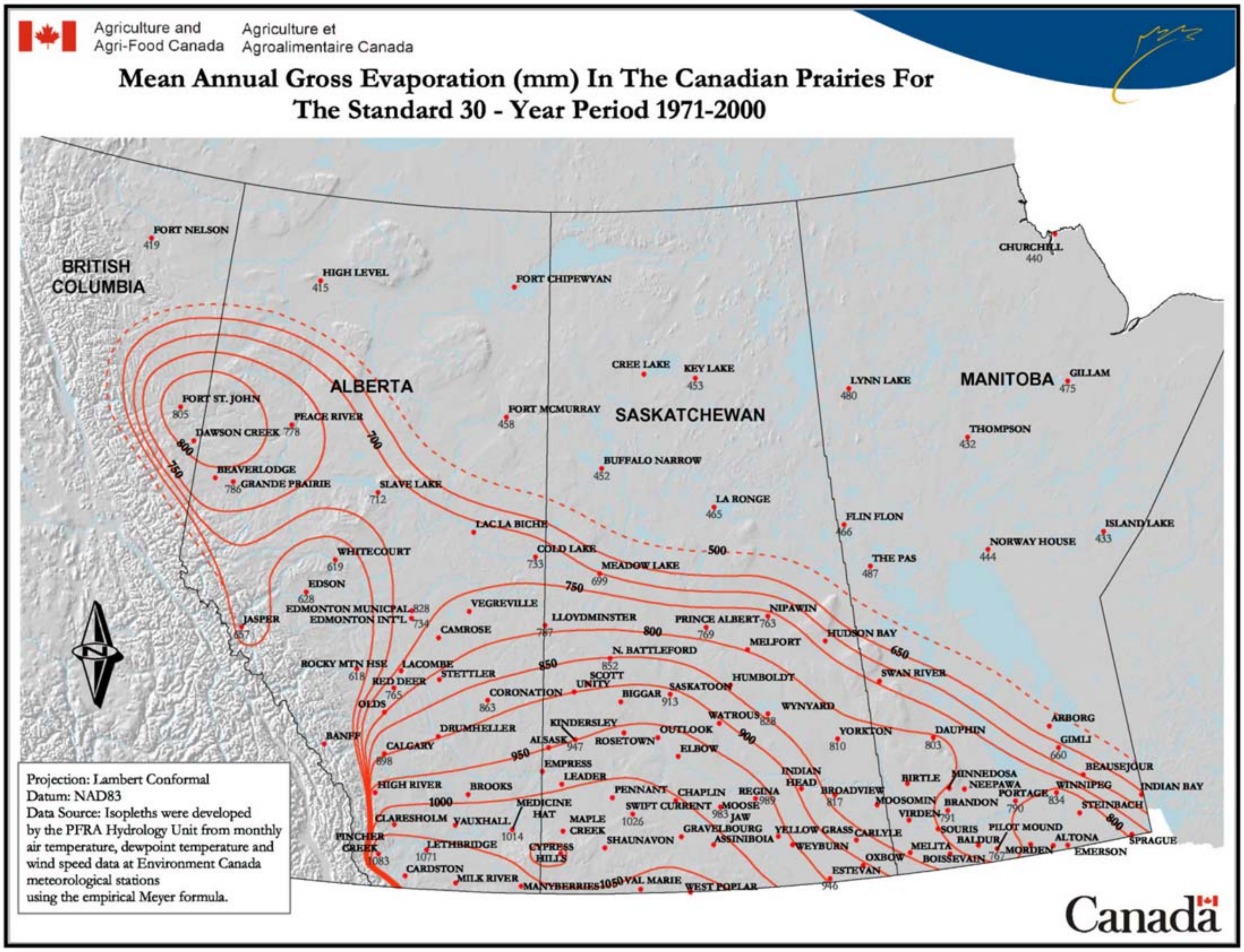
Appendix 5. Maximum annual daily rainfall from 1966 – 1992 for Deloraine.



Appendix 6. Mean monthly total precipitation (rainfall and snowfall water equivalent) from 1966-1992 for Deloraine.



Appendix 7. Mean annual gross evaporation (mm) in the Canadian Prairies for the Standard 30-Year Period (1971-2000).



Appendix 8. Provincial ranking classes for Species at Risk.

SPECIES PROVINCIAL SRANK BRIEF DEFINITIONS

S1	Very rare throughout its range in Manitoba (typically 5 or fewer occurrences or very few remaining individuals). May be especially vulnerable to extirpation.
S2	Rare throughout its range in Manitoba (6 to 20 occurrences or few remaining individuals). May be vulnerable to extirpation.
S3	Uncommon throughout its range in Manitoba (21 to 100 occurrences).
S4	Widespread, abundant, and apparently secure throughout its range in Manitoba, with many occurrences, but the Element is of long-term concern (100+ occurrences).
S5	Demonstrably widespread, abundant, and secure throughout its range in Manitoba, and essentially ineradicable under present conditions.
S#S#	Numeric range rank: A range between two consecutive numeric ranks. Denotes range of uncertainty about the exact rarity of the Element (e.g., G1G2).
SH	Historical: Element occurred historically throughout its range in Manitoba (with expectation that it may be rediscovered), perhaps having not been verified in the past 20 years, and suspected to be still extant.
SU	Unrankable: Possibly in peril throughout its range in Manitoba, but status uncertain; need more information.
SX	Extinct/Extirpated: Element is believed to be extirpated within Manitoba.
S?	Unranked: Element is not yet ranked.
B	Breeding: Basic rank refers to the breeding population of the element in the province.
N	Non-breeding: Basic rank refers to the non-breeding population of the element in the province.
SA	Accidental: Accidental or casual in Manitoba (i.e., infrequent and far outside usual range). Includes species (usually birds or butterflies) recorded once or twice or only at very great intervals, hundreds or even thousands of miles outside their usual range; a few of these species may even have bred on the one or two occasions they were recorded.
SE	Exotic: An exotic established in Manitoba (e.g., house sparrow or common carp); may be native in nearby regions.
SE#	Exotic numeric: An exotic established in Manitoba that has been assigned a numeric rank.
SP	Potential: Potential that Element occurs in Manitoba, but no occurrences reported.

SR Reported: Element reported in Manitoba but without persuasive documentation which would provide a basis for either accepting or rejecting (e.g., misidentified specimen) the report.

SRF Reported falsely: Element erroneously reported in Manitoba and the error has persisted in the literature.

SZ Zero occurrences: Not of practical conservation concern in Manitoba, because there are no definable occurrences, although the taxon is native and appears regularly. An NZ rank will generally be used for long distance migrants whose occurrences during their migrations are too irregular (in terms of repeated visitation to the same locations) or transitory. In other words, the migrant regularly passes through Manitoba, but enduring, mappable Element Occurrences cannot be defined.

Appendix 9. Species at Risk within the East Souris River IWMP study area.

Scientific name	Common name	Global G rank	Provincial S rank	Data last observed	Sub-Watershed
Andropogon hallii	Sand Bluestem	G4	S2	1951-07-29	Chain Lakes
Arnica fulgens	Shining Arnica	G5	S2?	1985-06-04	Chain Lakes
Asarum canadense	Wild Ginger	G5	S3?	1927-05-31	Chain Lakes
Athene cunicularia	Burrowing Owl	G4	S1B	1994	Chain Lakes
Buteo regalis	Ferruginous Hawk	G4	S2B	1994	Chain Lakes
Calamagrostis montanensis	Plains Reed Grass	G5	S3	1950-06-26	Chain Lakes
Carex prairea	Prairie Sedge	G5?	S4?	1990-06-13	Chain Lakes
Coreopsis tinctoria	Common Tickseed	G5	S1	1951-07-18	Chain Lakes
Cymopterus acaulis	Plains Cymopterus	G5	S3	1990-06-15	Chain Lakes
Cyperus schweinitzii	Schweinitz's Flatsedge	G5	S2	1990-07-28	Chain Lakes
Dalea villosa var. villosa	Silky Prairie-clover	G5TNR	S2	2001-08-20	Chain Lakes
Escobaria vivipara	Pincushion Cactus	G5	S2	1953-06-30	Chain Lakes
Euphorbia geyeri	Prostrate Spurge	G5	S1	1960-09-02	Chain Lakes
Franseria acanthicarpa	Sandbur	G5	S2	1960-09-02	Chain Lakes
Juncus interior	Inland Rush	G4G5	S1	1951-07-25	Chain Lakes
Lanius ludovicianus	Loggerhead Shrike	G4	S2S3B	2000	Chain Lakes
Lomatium orientale	White-flowered Parsley	G5	S1	1950-06-26	Chain Lakes
Lygodesmia rostrata	Annual Skeletonweed	G5?	S1S2	1960-09-02	Chain Lakes
Orobanche ludoviciana	Louisiana Broom-rape	G5	S2	1951-07-25	Chain Lakes
Parietaria pensylvanica	American Pellitory	G5	S4	1990-06-13	Chain Lakes
Potentilla plattensis	Low Cinquefoil	G4	S2	1953-07-03	Chain Lakes
Schedonnardus paniculatus	Tumble-grass	G5	S2	1951-07-29	Chain Lakes
Thermopsis rhombifolia	Golden Bean	G5	S2	1950-06-27	Chain Lakes
Ammodramus bairdii	Baird's Sparrow	G4	S2S3B	1998	Medora Creek
Artemisia cana	Silver Sagebrush	G5	S2	1951-07-23	Medora Creek
Asarum canadense	Wild Ginger	G5	S3?	1927-05-31	Medora Creek
Asclepias verticillata	Whorled Milkweed	G5	S2	1983-07-21	Medora Creek
Athene cunicularia	Burrowing Owl	G4	S1B	1993	Medora Creek
Atriplex argentea	Saltbrush	G5	S2	1951-07-23	Medora Creek
Boltonia asteroides var. recognita	White Boltonia	G5TNR	S2S3	1951-07-21	Medora Creek
Bouteloua curtipendula	Side-oats Grama	G5	S2	1953-08-02	Medora Creek
Buteo regalis	Ferruginous Hawk	G4	S2B	1994	Medora Creek
Calamagrostis montanensis	Plains Reed Grass	G5	S3	1953-06-29	Medora Creek
Carex bicknellii	Bicknell's Sedge	G5	SH	1921-06-25	Medora Creek
Carex prairea	Prairie Sedge	G5?	S4?	1990-06-13	Medora Creek
Coreopsis tinctoria	Common Tickseed	G5	S1	1951-07-18	Medora Creek
Cymopterus acaulis	Plains Cymopterus	G5	S3	1990-06-14	Medora Creek
Dalea villosa var. villosa	Silky Prairie-clover	G5TNR	S2	1975-08-14	Medora Creek
Lanius ludovicianus	Loggerhead Shrike	G4	S2S3B	1999	Medora Creek
Lomatium orientale	White-flowered Parsley	G5	S1	1950-06-26	Medora Creek
Myosurus minimus ssp. minimus	Least Mousetail	G5T5	S1	1935-06-08	Medora Creek
Plagiobothrys scouleri var. scouleri	Scouler's Allocarya	G5TNR	S1	1953-07-01	Medora Creek
Plantago elongata ssp. elongata	Linear Leaved-plantain	G4T4	S2	1953-07-01	Medora Creek
Poa arida	Plains Blue Grass	G5	S4	1953-07-01	Medora Creek
Potentilla plattensis	Low Cinquefoil	G4	S2	1953-07-03	Medora Creek
Schedonnardus paniculatus	Tumble-grass	G5	S2	1953-07-01	Medora Creek
Stipa viridula	Green Needle Grass	G5	S3	1951-07-20	Medora Creek
Verbena bracteata	Bracted Vervain	G4G5	S3	1951-07-23	Medora Creek

Appendix 9. Cont'd.

Scientific name	Common name	Global G rank	Provincial S rank	Data last observed	Sub-Watershed
Ammodramus bairdii	Baird's Sparrow	G4	S2S3B	1998	Waskada Creek
Arnica fulgens	Shining Arnica	G5	S2?	1990-06-11	Waskada Creek
Artemisia cana	Silver Sagebrush	G5	S2	1951-07-23	Waskada Creek
Asarum canadense	Wild Ginger	G5	S3?	1927-05-31	Waskada Creek
Asclepias verticillata	Whorled Milkweed	G5	S2	1983-07-21	Waskada Creek
Astragalus gilviflorus	Cushion Milkvetch	G5	S1	1983-06-29	Waskada Creek
Athene cunicularia	Burrowing Owl	G4	S1B	1994	Waskada Creek
Atriplex argentea	Saltbrush	G5	S2	1951-07-23	Waskada Creek
Boltonia asteroides var. recognita	White Boltonia	G5TNR	S2S3	1951-07-21	Waskada Creek
Bouteloua curtipendula	Side-oats Grama	G5	S2	1953-08-02	Waskada Creek
Buchloe dactyloides	Buffalo Grass	G4G5	S1	2001-07-25	Waskada Creek
Buteo regalis	Ferruginous Hawk	G4	S2B	1994	Waskada Creek
Calamagrostis montanensis	Plains Reed Grass	G5	S3	1953-06-29	Waskada Creek
Carex bicknellii	Bicknell's Sedge	G5	SH	1921-06-25	Waskada Creek
Carex gravida	Heavy Sedge	G5	S1	1985-07-19	Waskada Creek
Carex torreyi	Torrey's Sedge	G4	S4	1990-06-12	Waskada Creek
Coreopsis tinctoria	Common Tickseed	G5	S1	1951-07-18	Waskada Creek
Eleocharis engelmannii	Engelmann's Spike-rush	G4?	S1	1983-07-21	Waskada Creek
Festuca hallii	Plains Rough Fescue	G4	S3	1983-06-09	Waskada Creek
Lanius ludovicianus	Loggerhead Shrike	G4	S2S3B	1999	Waskada Creek
Lomatium orientale	White-flowered Parsley	G5	S1	1990-06-11	Waskada Creek
Mertensia lanceolata	Tall Lungwort	G5	S2	1990-06-11	Waskada Creek
Musineon divaricatum	Leafy Musineon	G5	S2	1990-05-16	Waskada Creek
Myosurus minimus ssp. minimus	Least Mousetail	G5T5	S1	1935-06-08	Waskada Creek
Odocoileus hemionus	Mule or Black-tailed Deer	G5	S3	2001-11-13	Waskada Creek
Plagiobothrys scouleri var. scouleri	Scouler's Allocarya	G5TNR	S1	2001-07-25	Waskada Creek
Plantago elongata ssp. elongata	Linear Leaved-plantain	G4T4	S2	1990-06-11	Waskada Creek
Poa arida	Plains Blue Grass	G5	S4	1953-07-01	Waskada Creek
Poa cusickii	Mutton-grass	G5	S1	1990-06-11	Waskada Creek
Schedonnardus paniculatus	Tumble-grass	G5	S2	1953-07-01	Waskada Creek
Stipa viridula	Green Needle Grass	G5	S3	1994-06-14	Waskada Creek
Verbena bracteata	Bracted Vervain	G4G5	S3	1951-07-23	Waskada Creek
Ammodramus bairdii	Baird's Sparrow	G4	S2S3B	1994	Whitewater Lake
Asarum canadense	Wild Ginger	G5	S3?	1927-05-31	Whitewater Lake
Astragalus gilviflorus	Cushion Milkvetch	G5	S1	1975-06-02	Whitewater Lake
Athene cunicularia	Burrowing Owl	G4	S1B	1991	Whitewater Lake
Buteo regalis	Ferruginous Hawk	G4	S2B	1994	Whitewater Lake
Charadrius melodus	Piping Plover	G3	S2B	1986-06-15	Whitewater Lake
Coreopsis tinctoria	Common Tickseed	G5	S1	1951-07-18	Whitewater Lake
Coturnicops noveboracensis	Yellow Rail	G4	S4B		Whitewater Lake
Dalea villosa var. villosa	Silky Prairie-clover	G5TNR	S2	1975-07-12	Whitewater Lake
Eurotia lanata	Winterfat	G5	S2	1983-07-29	Whitewater Lake
Helianthus nuttallii ssp. rydbergii	Tuberous-rooted Sunflower	G5T5	S2	1952-08-25	Whitewater Lake
Heliotropium curassavicum	Seaside Heliotrope	G5	S2	1953-07-15	Whitewater Lake
Lanius ludovicianus	Loggerhead Shrike	G4	S2S3B	2000	Whitewater Lake
Mentzelia decapetala	Gumbo-lily	G5	S1		Whitewater Lake
Osmorhiza claytonii	Wooly or Hairy Sweet Cicely	G5	S2	1978-07-25	Whitewater Lake
Sisyrinchium campestre	White-eyed Grass	G5	SU	1953-07-15	Whitewater Lake
Wolffia columbiana	Water-meal	G5	S1	1984-07-29	Whitewater Lake

Appendix 10. Wetland statistics for Air Ground surveys within the East Souris River IWMP study area.

Gross and Net Wetland Area Change by Transect

Boissevain

Base Year:	1985	**Total Wetland Area:**	195.34 **Ha**	**Gross Wetland Loss:**	19.47 **Ha**	9.97 **%**
Update Year:	1999	**Total Wetland Area:**	177.17 **Ha**	**Gross Wetland Gain:**	1.30 **Ha**	0.67 **%**
		Net Change:	18.16 **Ha** 9.30 **%**	**Net Change:**	18.16 **Ha**	

Hartney

Base Year:	1985	**Total Wetland Area:**	34.49 **Ha**	**Gross Wetland Loss:**	2.76 **Ha**	7.99 **%**
Update Year:	2003	**Total Wetland Area:**	33.02 **Ha**	**Gross Wetland Gain:**	1.28 **Ha**	3.72 **%**
		Net Change:	1.47 **Ha** 4.27 **%**	**Net Change:**	1.47 **Ha**	

Melita East

Base Year:	1985	**Total Wetland Area:**	134.16 **Ha**	**Gross Wetland Loss:**	9.26 **Ha**	6.90
Update Year:	2003	**Total Wetland Area:**	132.78 **Ha**	**Gross Wetland Gain:**	7.88 **Ha**	5.87
		Net Change:	1.38 **Ha** 1.03 **%**	**Net Change:**	1.38 **Ha**	

Melita West

Base Year:	1985	**Total Wetland Area:**	79.13 **Ha**	**Gross Wetland Loss:**	3.84 **Ha**	4.85
Update Year:	2003	**Total Wetland Area:**	75.32 **Ha**	**Gross Wetland Gain:**	0.03 **Ha**	0.03
		Net Change:	3.81 **Ha** 4.82 **%**	**Net Change:**	3.81 **Ha**	

Transect-level Summary Statistics

Net Change in Wetland Area (Ha)					Net Change in Wetland Area (%)		
	Mean:	6.21				Mean:	4.86
	Sample Variance:	64.80				Sample Variance:	11.58
	Sample Std. Dev.:	8.05				Sample Std. Dev.:	3.40
	Maximum:	1.38				Maximum:	1.03
	Minimum:	18.16				Minimum:	9.30
Total Wetland Area: Base Year (Ha)					**Total Wetland Area: Update Year (Ha)**		
	Mean:	110.78				Mean:	104.57
	Sample Variance:	4839.25				Sample Variance:	4014.08
	Sample Std. Dev.:	69.56				Sample Std. Dev.:	63.36
	Maximum:	195.34				Maximum:	177.17
	Minimum:	34.49				Minimum:	33.02
Gross Wetland Loss (Ha)					**Gross Wetland Loss (%)**		
	Mean:	8.83				Mean:	2.62
	Sample Variance:	58.37				Sample Variance:	12.63
	Sample Std. Dev.:	7.64				Sample Std. Dev.:	3.55
	Maximum:	19.47				Maximum:	7.88
	Minimum:	2.76				Minimum:	0.03
Gross Wetland Gain (Ha)					**Gross Wetland Gain (%)**		
	Mean:	7.43				Mean:	2.57
	Sample Variance:	4.56				Sample Variance:	7.42
	Sample Std. Dev.:	2.13				Sample Std. Dev.:	2.72
	Maximum:	4.85				Maximum:	5.87
	Minimum:	9.97				Minimum:	0.03

Boissevain

			Cultivated	Improved Grass	Wooded	Grass & Sedges	Bulrush / Cattail	Saline Lakes & Ponds	Natural Open Water	Artificial Open Water	Other
Total Wetland area (1985):	195.34	Ha	43.31	0.00	18.46	106.34	22.42	0.00	1.14	2.80	0.86
		%	22.17	0.00	9.45	54.44	11.48	0.00	0.58	1.43	0.44
Total Wetland area (1999):	177.17	Ha	28.47	0.85	17.79	99.56	22.47	0.00	3.62	4.33	0.08
		%	16.07	0.48	10.04	56.19	12.68	0.00	2.04	2.45	0.04
Change in Percent Composition:		%	6.10	0.48	0.59	1.75	1.20	0.00	1.46	1.01	0.79

Hartney

			Cultivated	Improved Grass	Wooded	Grass & Sedges	Bulrush / Cattail	Saline Lakes & Ponds	Natural Open Water	Artificial Open Water	Other
Total Wetland area (1985):	34.49	Ha	15.62	1.87	2.71	10.85	2.30	0.00	0.00	1.15	0.00
		%	45.27	5.42	7.87	31.46	6.65	0.00	0.00	3.33	0.00
Total Wetland area (2003):	33.02	Ha	9.88	6.65	2.71	9.59	2.30	0.00	0.00	1.88	0.00
		%	29.93	20.15	8.22	29.06	6.95	0.00	0.00	5.69	0.00
Change in Percent Composition:		%	15.34	14.73	0.32	2.40	0.30	0.00	0.00	2.37	0.00

Meltia East

			Cultivated	Improved Grass	Wooded	Grass & Sedges	Bulrush / Cattail	Saline Lakes & Ponds	Natural Open Water	Artificial Open Water	Other
Total Wetland area (1985):	134.16	Ha	60.64	2.70	1.45	67.41	0.12	0.00	0.00	1.60	0.40
		%	45.20	2.01	1.08	50.25	0.09	0.00	0.00	1.19	0.18
Total Wetland area (2003):	132.78	Ha	35.43	4.35	0.53	78.23	12.16	0.00	0.26	1.82	0.00
		%	26.68	3.27	0.40	58.92	9.16	0.00	0.20	1.37	0.00
Change in Percent Composition:		%	18.52	1.26	0.68	8.67	9.07	0.00	0.20	0.18	0.24

Melita West

			Cultivated	Improved Grass	Wooded	Grass & Sedges	Bulrush / Cattail	Saline Lakes & Ponds	Natural Open Water	Artificial Open Water	Other
Total Wetland area (1985):	79.13	Ha	20.13	0.09	0.76	48.02	3.34	0.00	0.32	0.47	6.01
		%	25.44	0.11	0.96	60.69	4.22	0.00	0.40	0.59	7.59
Total Wetland area (2003):	75.32	Ha	14.76	12.54	0.76	37.01	3.34	0.00	0.32	0.58	6.01
		%	19.60	16.65	1.01	49.14	4.43	0.00	0.42	0.77	7.98
Change in Percent Composition:		%	5.84	16.54	0.05	11.55	0.21	0.00	0.02	0.18	0.00

Number of Transects: 4											
			Cultivated	Improved Grass	Wooded	Grass & Sedges	Bulrush / Cattail	Saline Lakes & Ponds	Natural Open Water	Artificial Open Water	Other
Total Wetland area (base):	443.12	Ha	139.70	4.66	23.39	232.62	28.17	0.00	1.46	6.01	7.11
		%	31.53	1.05	5.28	52.50	6.36	0.00	0.33	1.36	1.60
Total Wetland area (update):	418.29	Ha	88.55	24.39	21.79	224.39	40.27	0.00	4.20	8.61	6.09
		%	21.17	5.83	5.21	53.64	9.63	0.00	1.00	2.06	1.45
Change in Percent Composition:		%	**10.36**	**4.78**	**0.07**	**1.15**	**3.27**	**0.00**	**0.67**	**0.70**	**0.15**

Appendix 11. Community well information within the East Souris River IWMP study area.

PROJECT	LOCATION	WATER TYPE	YEAR INST.	CASING SIZE INCHES	CASING TYPE	DEPTHS IN FEET TOTAL	DEPTHS IN FEET SCREEN	DEPTHS IN FEET OPEN HOLE	S.W.L. (ft.)	SPEC. CAP.	REC. CAP. USGPM	ACCESS	OTHER
WASKADA COOP	NE.26-1-26W	1&3	1988	8	PVC	340	320-340		49	7.2	120	-	Pipeline source
WARD 1	NW.25-1-26W	1&4	1986	8	PVC	169	154-169		38	1.8	130	O	
HIPKINS SPRING	SE-29-3-26	1&4											
GOODLANDS	GOODLANDS	2&3	1980			DUGOUT					85	O	Tank loading from dugout
GOODLANDS V. #1(M)	SE.10-1-24W	1&3	1978	5	BI	36	25-36		7	1.7	25		
GOODLANDS V. #2(S)	SE.10-1-24W	1&3	1978	5	BI	36	25-36		6	2	25	O	Village system, also
GOODLANDS V. #3(N)	SE.10-1-24W	1&3	1986	5	PVC	26	21-26		6	4	35		Loading station at well site
GOODLANDS #1(N)	SW.28-2-24W	1&4	1978	5	BI	19	14-19		9	3.6	25		Marginal Source
GOODLANDS #1(S)	SW.28-2-24W	1&4	1978	5	BI	19	14-19		12.5	9	25	O	
GOODLANDS N.#2	SE.30-2-24	1&4	1982	6	PVC	27	21-27		10	24	120		
MEDORA #2	MEDORA	2&4	1985			DUGOUT					200+	O	Tank loading & V. supply
NAPINKA, V. NO.1	SE.24-4-26W	1&3	1982	30	G	22	18-20		14	13	18	-	
NAPINKA, V. NO.2	NW.23-4-26W	1&3	1990	5	PVC	38	33-38		12	6	72	-	Village supply
NAPINKA NE #2, MIDDLE	NW.29-4-25	1&4	1989	30	FG	16	9-16		8	16	60	O	1 loading station
NAPINKA NE. #3, S.	NW.29-4-25	1&4	1989	30	FG	16	9-16		8	5	24		
VOTH	SW.29-3-25W	2&4	1985			DUGOUT					200+	O	
WASKADA	NE.36-1-26W	1&3	1977	7	BI	224	202-224		7(ORIG)	6	175	-	Village supply
WASKADA NORTH	SE.18-2-25	1&4	1988	8	PVC	324	298-324		64	3.2	125	O	
WASKADA SOUTH	NE.7-1-24W	1&4	1984	6	PVC	34	25-31		8.5	15	125	O	
HARTNEY E.	SE.9-6-22W	1&3	1978	30	FG	20	10-20		8	135	250	O	Orig. wells aband, upgd. '93
HARTNEY S. NO.2 N	SW.27-5-23W	1&3	1989	30	FG	24	12-24		8.6	24	100		
HARTNEY S. NO.2 S	SW.27-5-23W	1&3	1989	30	FG	23	13-23		8.8	48	180	O	280 gpm
CHAIN LAKES WELL	NE-3-5-23	1&4											
DERKSON-HEIDE	SW.6-3-20W	2&4	1990	TANK LOADING FROM RESERVOIR							200+		
SMITH	SW.21-04-21	2&4	1997	TANK LOADING FROM DUGOUT							+200		
ADAMS	SE.03-03-23	2&4	1996	TANK LOADING FROM DELORAINE SUPPLY PIPELINE							100		
TOWN	SE-10-3-23	2&3		TANK LOADING FROM DELORAINE SUPPLY PIPELINE (TREATED)									
MILLER WELL	NW-4-1-22	1&4											
DELORAINE NE.	NE.09-04-22	2&4	1996	TANK LOADING FROM DUGOUT							200		
Deloraine S	NW.32-01-22w	2&4	1999	TANK LOADING FROM DUGOUT							200		

Appendix 12. R.M. of Arthur Ag Census Data.

	1996	2001	Change
# of Farms	158	164	6
Area of Farms (acres)	166092	188020	21928
Average Farm Size (acres)	1051	1146	95
Area Owned (acres)	109291	124911	15620
Area Rented (acres)	56801	63109	6308
# of Cropland Farms	150	153	3
Area of Cropland (acres)	126461	144253	17792
# of Summerfallow Farms	66	58	-8
Area of Summerfallow (acres)	9416	6679	-2737
Area of Pasture (acres)	24794	27976	3182
Area of Otherland (acres)	5421	9112	3691
# of Conventional Tillage Farms	79	56	-23
Area of Conventional Tillage Farms (acres)	43799	27874	-15925
# of Conservation Tillage Farms	60	56	-4
Area of Conservation Tillage Farms (acres)	44671	56814	12143
# of Zero Tillage Farms	35	61	26
Area of Zero Tillage Farms (acres)	29508	50222	20714
# of Cattle Farms	91	91	0
# of Cattle	9076	10594	1518
# of Hog Farms	N/A	5	
# of Hogs	N/A	N/A	
# of Horse Farms	N/A	18	
# of Horses	N/A	164	
# of Wheat Farms	119	96	-23
Area of Wheat (acres)	70002	68069	-1933
# of Spring Wheat Farms	113	93	-20
Area of Spring Wheat (acres)	60681	60299	-382
# of Winter Wheat Farms	3	28	25
Area of Winter Wheat (acres)	405	6497	6092
# of Oats Farms	78	61	-17
Area of Oats (acres)	12762	12231	-531
# of Barley Farms	46	41	-5
Area of Barley (acres)	6648	8491	1843
# of Alfalfa Farms	66	78	12
Area of Alfalfa (acres)	8051	11062	3011
# of Tame Hay Farms	23	25	2
Area of Tame Hay (acres)	1506	2256	750
# of Canola Farms	52	59	7
Area of Canola (acres)	10917	22367	11450
# of Flax Farms	28	30	2
Area of Flax (acres)	3303	4159	856
# of Pea Farms	0	16	16
Area of Peas (acres)	0	4228	4228
# of Sunflower Farms	10	15	5
Area of Sunflowers (acres)	2120	5595	3475
# of Potato Farms	1	1	0
Area of Potatoes (acres)	N/A	---	

Appendix 13. R.M. of Brenda Ag Census Data.

	1996	2001	Change
# of Farms	177	150	-27
Area of Farms (acres)	190364	187159	-3205
Average Farm Size (acres)	1076	1248	172
Area Owned (acres)	135186	125521	-9665
Area Rented (acres)	55178	61638	6460
# of Cropland Farms	172	146	-26
Area of Cropland (acres)	149679	143548	-6131
# of Summerfallow Farms	79	52	-27
Area of Summerfallow (acres)	11102	6577	-4525
Area of Pasture (acres)	25118	30181	5063
Area of Otherland (acres)	4465	6853	2388
# of Conventional Tillage Farms	106	65	-41
Area of Conventional Tillage Farms (acres)	74074	36604	-37470
# of Conservation Tillage Farms	61	54	-7
Area of Conservation Tillage Farms (acres)	51142	42869	-8273
# of Zero Tillage Farms	30	54	24
Area of Zero Tillage Farms (acres)	19426	56763	37337
# of Cattle Farms	85	87	2
# of Cattle	8408	10768	2360
# of Hog Farms	N/A	2	
# of Hogs	N/A	N/A	
# of Horse Farms	N/A	34	
# of Horses	N/A	1063	
# of Wheat Farms	147	107	-40
Area of Wheat (acres)	89833	71034	-18799
# of Spring Wheat Farms	146	107	-39
Area of Spring Wheat (acres)	74558	62268	-12290
# of Winter Wheat Farms	0	14	14
Area of Winter Wheat (acres)	0	3121	3121
# of Oats Farms	59	44	-15
Area of Oats (acres)	8703	6965	-1738
# of Barley Farms	78	47	-31
Area of Barley (acres)	13134	12752	-382
# of Alfalfa Farms	53	67	14
Area of Alfalfa (acres)	4392	8343	3951
# of Tame Hay Farms	27	30	3
Area of Tame Hay (acres)	1970	3185	1215
# of Canola Farms	81	60	-21
Area of Canola (acres)	16243	20865	4622
# of Flax Farms	19	33	14
Area of Flax (acres)	3510	7261	3751
# of Pea Farms	7	17	10
Area of Peas (acres)	1582	5172	3590
# of Sunflower Farms	7	19	12
Area of Sunflowers (acres)	2860	4244	1384
# of Potato Farms	0	1	1
Area of Potatoes (acres)	0	---	

Appendix 14. R.M. of Cameron Ag Census Data.

	1996	2001	Change
# of Farms	137	131	-6
Area of Farms (acres)	180362	165726	-14636
Average Farm Size (acres)	1317	1265	-51
Area Owned (acres)	126592	122431	-4161
Area Rented (acres)	53770	43295	-10475
# of Cropland Farms	125	124	-1
Area of Cropland (acres)	130713	112597	-18116
# of Summerfallow Farms	41	41	0
Area of Summerfallow (acres)	6677	4878	-1799
Area of Pasture (acres)	37708	40555	2847
Area of Otherland (acres)	5264	7696	2432
# of Conventional Tillage Farms	55	42	-13
Area of Conventional Tillage Farms (acres)	34861	19350	-15511
# of Conservation Tillage Farms	43	39	-4
Area of Conservation Tillage Farms (acres)	50676	27057	-23619
# of Zero Tillage Farms	30	34	4
Area of Zero Tillage Farms (acres)	31224	51236	20012
# of Cattle Farms	87	88	1
# of Cattle	13610	16460	2850
# of Hog Farms	N/A	2	
# of Hogs	N/A	N/A	
# of Horse Farms	N/A	26	
# of Horses	N/A	159	
# of Wheat Farms	69	55	-14
Area of Wheat (acres)	53300	46325	-6975
# of Spring Wheat Farms	69	53	-16
Area of Spring Wheat (acres)	47736	37268	-10468
# of Winter Wheat Farms	3	18	15
Area of Winter Wheat (acres)	624	---	
# of Oats Farms	50	33	-17
Area of Oats (acres)	8834	4251	-4583
# of Barley Farms	54	36	-18
Area of Barley (acres)	16501	9647	-6854
# of Alfalfa Farms	57	76	19
Area of Alfalfa (acres)	8998	14083	5085
# of Tame Hay Farms	30	34	4
Area of Tame Hay (acres)	5182	5268	86
# of Canola Farms	43	34	-9
Area of Canola (acres)	13980	12893	-1087
# of Flax Farms	30	21	-9
Area of Flax (acres)	5270	4031	-1239
# of Pea Farms	21	18	-3
Area of Peas (acres)	7626	6844	-782
# of Sunflower Farms	6	7	1
Area of Sunflowers (acres)	1510	2289	779
# of Potato Farms	1	1	0
Area of Potatoes (acres)	N/A	---	

Appendix 15. R.M. of Glenwood Ag Census Data.

	1996	2001	Change
# of Farms	151	130	-21
Area of Farms (acres)	136106	136941	835
Average Farm Size (acres)	901	1053	152
Area Owned (acres)	94307	86930	-7377
Area Rented (acres)	41799	50011	8212
# of Cropland Farms	137	120	-17
Area of Cropland (acres)	100239	99757	-482
# of Summerfallow Farms	48	35	-13
Area of Summerfallow (acres)	6650	4264	-2386
Area of Pasture (acres)	22413	25818	3405
Area of Otherland (acres)	6804	7102	298
# of Conventional Tillage Farms	67	53	-14
Area of Conventional Tillage Farms (acres)	34708	23400	-11308
# of Conservation Tillage Farms	54	45	-9
Area of Conservation Tillage Farms (acres)	42381	47799	5418
# of Zero Tillage Farms	15	20	5
Area of Zero Tillage Farms (acres)	10733	16503	5770
# of Cattle Farms	80	74	-6
# of Cattle	11023	11808	785
# of Hog Farms	N/A	3	
# of Hogs	N/A	N/A	
# of Horse Farms	N/A	31	
# of Horses	N/A	477	
# of Wheat Farms	81	67	-14
Area of Wheat (acres)	35199	37798	2599
# of Spring Wheat Farms	80	66	-14
Area of Spring Wheat (acres)	32557	36448	3891
# of Winter Wheat Farms	1	5	4
Area of Winter Wheat (acres)	N/A	---	
# of Oats Farms	50	30	-20
Area of Oats (acres)	6386	2487	-3899
# of Barley Farms	80	53	-27
Area of Barley (acres)	18812	13035	-5777
# of Alfalfa Farms	73	66	-7
Area of Alfalfa (acres)	10557	12357	1800
# of Tame Hay Farms	21	20	-1
Area of Tame Hay (acres)	2818	2087	-731
# of Canola Farms	65	56	-9
Area of Canola (acres)	14486	17034	2548
# of Flax Farms	25	30	5
Area of Flax (acres)	4932	7367	2435
# of Pea Farms	11	7	-4
Area of Peas (acres)	1935	1598	-337
# of Sunflower Farms	6	6	0
Area of Sunflowers (acres)	1615	1867	252
# of Potato Farms	1	0	-1
Area of Potatoes (acres)	N/A	0	

Appendix 16. R.M. of Morton Ag Census Data.

	1996	2001	Change
# of Farms	213	187	-26
Area of Farms (acres)	210713	206753	-3960
Average Farm Size (acres)	989	1106	116
Area Owned (acres)	127754	128227	473
Area Rented (acres)	82959	78526	-4433
# of Cropland Farms	202	174	-28
Area of Cropland (acres)	139523	135463	-4060
# of Summerfallow Farms	63	45	-18
Area of Summerfallow (acres)	6095	4176	-1919
Area of Pasture (acres)	38010	58377	20367
Area of Otherland (acres)	27085	8737	-18348
# of Conventional Tillage Farms	107	75	-32
Area of Conventional Tillage Farms (acres)	69746	39705	-30041
# of Conservation Tillage Farms	56	54	-2
Area of Conservation Tillage Farms (acres)	39172	54878	15706
# of Zero Tillage Farms	24	29	5
Area of Zero Tillage Farms (acres)	13827	24731	10904
# of Cattle Farms	125	112	-13
# of Cattle	16641	18266	1625
# of Hog Farms	N/A	8	
# of Hogs	N/A	23984	
# of Horse Farms	N/A	37	
# of Horses	N/A	862	
# of Wheat Farms	127	104	-23
Area of Wheat (acres)	68094	55576	-12518
# of Spring Wheat Farms	126	100	-26
Area of Spring Wheat (acres)	58248	51761	-6487
# of Winter Wheat Farms	0	14	14
Area of Winter Wheat (acres)	0	2099	2099
# of Oats Farms	57	43	-14
Area of Oats (acres)	4360	2597	-1763
# of Barley Farms	88	70	-18
Area of Barley (acres)	13422	15468	2046
# of Alfalfa Farms	112	108	-4
Area of Alfalfa (acres)	15571	16125	554
# of Tame Hay Farms	32	19	-13
Area of Tame Hay (acres)	2533	1660	-873
# of Canola Farms	90	83	-7
Area of Canola (acres)	21146	26621	5475
# of Flax Farms	34	34	0
Area of Flax (acres)	4523	5105	582
# of Pea Farms	21	24	3
Area of Peas (acres)	5318	9008	3690
# of Sunflower Farms	0	2	2
Area of Sunflowers (acres)	0	---	
# of Potato Farms	0	0	0
Area of Potatoes (acres)	0	0	0

Appendix 17. R.M. of Winchester Ag Census Data

	1996	2001	Change
# of Farms	169	143	-26
Area of Farms (acres)	180512	179422	-1090
Average Farm Size (acres)	1068	1255	187
Area Owned (acres)	123622	103792	-19830
Area Rented (acres)	56890	75630	18740
# of Cropland Farms	151	129	-22
Area of Cropland (acres)	126008	131756	5748
# of Summerfallow Farms	65	41	-24
Area of Summerfallow (acres)	8739	4716	-4023
Area of Pasture (acres)	35569	35168	-401
Area of Otherland (acres)	10196	7782	-2414
# of Conventional Tillage Farms	89	62	-27
Area of Conventional Tillage Farms (acres)	62874	34362	-28512
# of Conservation Tillage Farms	55	43	-12
Area of Conservation Tillage Farms (acres)	35812	44906	9094
# of Zero Tillage Farms	17	35	18
Area of Zero Tillage Farms (acres)	17561	41433	23872
# of Cattle Farms	107	94	-13
# of Cattle	10387	8535	-1852
# of Hog Farms	N/A	1	
# of Hogs	N/A	N/A	
# of Horse Farms	N/A	44	
# of Horses	N/A	1738	
# of Wheat Farms	119	85	-34
Area of Wheat (acres)	70681	65332	-5349
# of Spring Wheat Farms	117	83	-34
Area of Spring Wheat (acres)	56059	56172	113
# of Winter Wheat Farms	2	7	5
Area of Winter Wheat (acres)	N/A	2176	
# of Oats Farms	53	32	-21
Area of Oats (acres)	5441	4445	-996
# of Barley Farms	77	53	-24
Area of Barley (acres)	13033	11838	-1195
# of Alfalfa Farms	80	81	1
Area of Alfalfa (acres)	9854	10411	557
# of Tame Hay Farms	20	22	2
Area of Tame Hay (acres)	1154	3376	2222
# of Canola Farms	62	59	-3
Area of Canola (acres)	13313	20735	7422
# of Flax Farms	34	35	1
Area of Flax (acres)	5290	6556	1266
# of Pea Farms	14	9	-5
Area of Peas (acres)	2115	1619	-496
# of Sunflower Farms	5	10	5
Area of Sunflowers (acres)	1975	5755	3780
# of Potato Farms	1	0	-1
Area of Potatoes (acres)	N/A	0	