Agricultural Land Use and Management in the Swan Lake Watershed

Submitted by

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and

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A. Executive Summary

The Swan Lake watershed is 613,899 ha in size (Manitoba's portion) and is located in Manitoba's Parkland Region. An Integrated Watershed Management Plan (IWMP) is being developed for this watershed by the Swan Lake Watershed Conservation District (SLWCD) in collaboration with Manitoba Water Stewardship and numerous other stakeholders.

Understanding changes in agricultural land use is essential for the development of the integrated watershed management plan. The overall objective of this report is to examine risks to key watershed resources by analyzing the physical characteristics of the landscape with consideration for how specific agricultural activities may be influencing them. This analysis also assists in identifying where soil and water management efforts could be directed to help address priority issues or identified risks within the watershed.

An assessment at a watershed scale provides a snapshot in time of the various agricultural activities in the Swan Lake Watershed. Census of Agriculture data, temporal in nature, illustrates influences from external factors like weather, government programs and policies, market drivers, and technology to land use and land management decisions and the community response to those interactions. Such events, with an examination of a watershed's physical resource characteristics and risks, assist to develop an understanding of potential impacts on the basin's water quality, and identify opportunities for future sustainable land use strategies. This information also assists in improving the understanding of the following six key issues that have been identified through public consultation for the Swan Lake IWMP: Groundwater, Surface Water, Soil Erosion, Flooding and Drainage, Natural Habitat, and Education. This report focuses on the first four concerns as they pertain to agriculture and the landscape.

Ag-Profiling examines variables from 2006 Census of Agriculture database depicted over three subwatershed regions, including farm area, type of farm, cropping practices, tillage practices, fertilizer and pesticide use, financial activity, and livestock numbers. The same variables from the 2006 Census of Agriculture data were used to examine 5-year changes in agricultural activities to the study area. Land cover data, derived from 1994, 2002, and 2005 satellite imagery, was analyzed to document temporal changes to land cover. Using soils data and modeling, environmental indicators were developed for Agricultural Capability, Wind and Water Erosion Risks, Soil Drainage, and Soil Texture characteristics. These were examined in combination with the annual cropland identified in the 2006 land cover. A review of recent federal and provincial policies and programs was conducted to assess their impact on agricultural land use and management.

The Swan Lake IWMP study area has a diverse agricultural landscape. Slight differences are evident from the northern part of the watershed compared to the southern areas with respect to soil types, land use, cropping practices, crop types, livestock types, and sizes of livestock operations. From 2001 to 2006, there were fewer but larger farms located in the study area, with a trend towards more modest, sustainable agriculture production. Crop production is important throughout the watershed, while livestock production tends to dominate in the north and southern portions. The watershed has an increasing reliance on commercial fertilizers and pesticides, with a larger proportion of cropland being treated with crop inputs. Compared to five years previous, there had been an overall decrease in annual cropland, treed/forested areas, and increases noted in wetlands, forages, and grasslands. Conventional tillage practices are dominant in the watershed. However, there has been an increase in the amount of farms practicing no-till and conservation tillage practices over the last five years.

Analysis of land cover over a 13-year period corresponds with results found in the Census data analysis, particularly with increases noted to grasslands and forages. Soil analysis revealed a trend towards a decrease in the amount of annual cropland on all soil classes. Areas were identified and mapped within the watershed where the combination of annual cropping and landscape risk factors such as wind erosion, agricultural capability, drainage, and texture indicate special management of these lands may be warranted. An examination of land cover data was undertaken to identify changes in land cover with respect to grasslands, forested areas, and annual cropland, and how they relate to the issues of flooding and natural area conservation. Due to data limitations, all spatial analyses using land cover and soils data require further verification for accuracy assessment.

The interest and willingness of producers in the watershed in addressing environmental issues is demonstrated by their participation in key environmental programs in the Agricultural Policy Framework (APF) and more recently under Growing Forward (program participation in the Environmental Farm Plan (EFP) Program and the Canada-Manitoba Farm Stewardship Program (CMFSP) were analyzed in this report). There was significant levels of uptake in both programs, as 310 Beneficial Management Practice (BMP) projects were completed with financial and technical assistance through the CMFSP. Over 59% were non-point source crop related BMPs and 16% were point source BMP projects.

Recommendations from the analysis to address groundwater and surface water protection include sustainable land management, water erosion mitigation practices such as grassed waterways, buffer establishment, and land conversion to forages, as well as, promoting BMPs that will reduce nutrient transport to waterbodies. These include adoption of BMPs where annual cropland is located on soils with agricultural capability of Class 4 or lower, protection and management of environmentally sensitive lands, and private source water assessments. Analysis of the erosion issue revealed the focus should be on wind and water erosion and those recommendations included use of cover crops and residue management to annual cropland areas. With respect to flooding and drainage, recommendations include water supply and surface water management studies conducted on the entire watershed to understand where opportunities exist for flood protection. In addition, the promotion of point specific BMPs (riparian buffer design, riffle structures/ headwater storage options, erosion control structures) and landscape related BMPs (sustainable woodlot management options and sustainable rotational grazing) need to be considered on a targeted watershed perspective. Using agro-forestry practices to reduce flood frequency could be further explored to determine if particular lands provide environmental benefits for reducing impacts of drainage and flooding. Potential indicators were also identified for each recommendation presented to allow the IWMP process to evaluate progress related to addressing issues in the future.

B. Acknowledgements:

The following individuals contributed to the compilation, interpretation, and derivation of information contained in this submission.

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MAFRI: Gauer, E., Mazur, J.,

C. Preface

The Swan Lake Watershed originally had a Basin Plan developed in 2001 that included the Manitoba and Saskatchewan portions of the watershed. For that plan, Agriculture and Agri-Food Canada- Agri Environment Services Branch (AESB) staff (formerly PFRA) had provided analyses and a literature review relevant to the issues identified in the watershed at that time.

In 2009, the Swan River Watershed Conservation District (SRWCD) was designated as the Watershed Planning Authority to develop a comprehensive integrated watershed plan (IWMP) for the Swan Lake Study Area. A Project Management Team (PMT) was formed to guide the watershed planning process. A formal request was made on behalf of the PMT and Manitoba Water Stewardship to AESB and Manitoba Agriculture Food and Rural Initiatives (MAFRI) to provide input into the IWMP process. Agriculture is a shared responsibility between the federal and provincial governments. As such, AESB and MAFRI are partnering to provide professional and technical guidance to the IWMP process on agricultural issues and agri–environmental priorities.

This report focuses on information related to agricultural activities and land resources in the watershed. It is important to note that in addition to agriculture, there are other industries, sectors, and users of the watershed's resources that also have an impact on the watershed. As there are scale and accuracy limitations associated with the data, it should be noted that the information contained within this report does not replace the need for site-specific analysis; rather, it serves as a guide for general planning purposes in the Swan Lake Study Area. More information on the data used in this document can be found within the Appendices section of the report.

D. Introduction

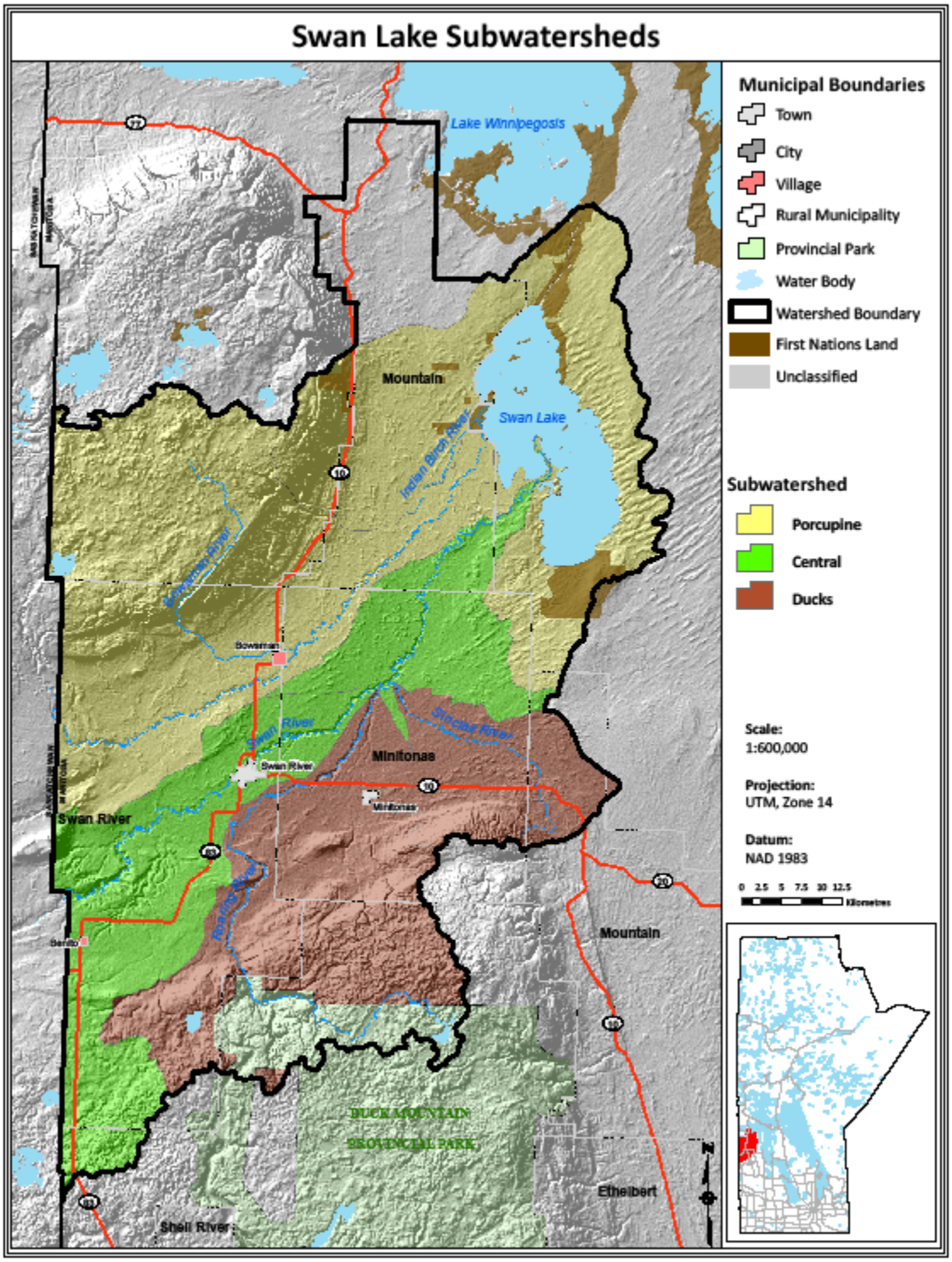
The Swan Lake Integrated Watershed Management Plan (IWMP) Area is defined by Manitoba Water Stewardship as a watershed "05LE" that drains into Swan Lake in Manitoba. It is located on the Manitoba-Saskatchewan border and between the Duck Mountains and the Porcupine Hills (***Figure 1***). The Swan Lake IWMP study area is 613,899 ha in size. The main topographic features of the basin include the upland areas of the Porcupine Hills and the Duck Mountains, the Swan Lake Valley, the Swan Lake Plain, Thunder Hill, the Swan and Woody River channels and their many tributaries. Some of the larger communities located within the study area include Benito, Bowsman, Minitonas, and Swan Lake. The Town of Swan River and the Key First Nations Communities are all located within this IWMP study area.

Objective

Understanding the current state and trends in agricultural land use and practices along with landscape characteristics is essential for developing an integrated watershed management plan. Agricultural land use and associated land cover can influence watershed processes and impact issues like water quality and hydrological flow within the watershed. Knowledge of these factors contributes to developing sustainable land use strategies that will lead to a healthier and more ecologically functioning landscape. To better understand agricultural changes and impacts within the watershed, AESB and MAFRI partnered to analyze agricultural aspects, focusing on the major issues identified in the 2009 public consultations in support of the IWMP. Specifically, the document will examine the following in order to help guide watershed management:

- **"Near-current" Agricultural Land Use and Management using the latest available Census of Agriculture data and satellite imagery.**
- **Five-year change in agricultural land use and management using 2001 and 2006 Census of Agriculture data and a time series of satellite imagery.**
- **Land cover data in combination with landscape risk factors pertaining to the soil and water resource.**
- **The impact of recent federal and provincial initiatives, policies and regulations impacting agricultural land management and land use planning activities in the watershed**.

Figure 1: Swan Lake Watershed Study Area and Subwatersheds Groupings



E. Agricultural Land Use and Management

i. Current Agricultural Land Use of the Swan Lake IWMP Study Area

a) Agricultural Profile

Agricultural profiling refers to the characterization of agricultural production in a specified area or region. The ability to use Census of Agriculture information collected from producers can provide a snapshot in time of the agricultural footprint on the landscape. This information can be portrayed either on a municipal or geographic boundary (like a watershed) and can provide value to understanding the influence and trends of the industry in the area.

Census of Agriculture data at a subwatershed scale has been obtained from Statistics Canada for the 2006 Census year. Further details on the method used to interpolate Statistics Canada's Census of Agriculture from a geographic boundary to a subwatershed boundary are provided in ***Appendix A***. For reporting purposes, numbers have been rounded to the nearest 5 for farm numbers, 10 for livestock and smaller area data, and 100 for poultry, financial data and larger areas.

Due to differences in the boundaries between the Manitoba subwatershed layer and the subwatershed boundaries for the Census data, only 94% of the IWMP study area can be accurately represented in the agricultural profiling of the watershed. Agricultural activities were analyzed for the Porcupine, Central and Ducks subwatersheds (***Figure 1***). The Porcupine Subwatershed refers to the northwestern part of the IWMP study area and contains part of the Porcupine Provincial Forest. Land within this subwatershed drains into the Woody River and Indian Birch River, as well as directly into Swan Lake. The Central Subwatershed refers to the area draining into the Swan River. The Ducks Subwatershed is the southeastern portion of the study area and contains part of the Duck Mountain Provincial Forest. This area drains into the Roaring River and Sinclair River (see ***Figure 1***). A portion of the Swan Lake IWMP study area cannot be profiled due to insufficient census data, and is located in the northern part of the Rural Municipality of Mountain North. ***Table 1*** lists these subwatersheds with their respective sizes and proportion of the IWMP study area.

Table 1: Subwatershed Areas

Subwatershed	Area (hectares)	Percent of Swan Lake IWMP study area
Porcupine	265,818	43%
Central	126,401	21%
Ducks	154,912	25%
Northern part of RM of Mountain North (not profiled)	35,745	6%
Water – Swan Lake	31,023	6%
Swan Lake IWMP	613,899	

Land Use and Land Management

Porcupine Subwatershed:
In 2006, the Porcupine Subwatershed reported approximately 210 farms with 32% of the subwatershed area being used for farming. According to the 2006 Census of Agriculture data, over 54% of the farmland in the Porcupine Subwatershed was dedicated to annual crop production and 30% to pasture, alfalfa, hay and fodder crops. Cereals made up almost 43% of the cultivated land while almost 37% was seeded to oilseeds (mainly canola). Approximately 15% of the cultivated land was in forages. Farmers employed conservation and zero tillage practices on 62% of land under crop production.

Beef production is the main form of livestock production in the area, with over 95 farm operations managing an average of 55 cows per farm for a total of over 5,300 beef cows in the subwatershed. Total cattle and calves in the area added up to over 11,100 animals. Over 50 farms reported a total of almost 780 horses and ponies. Over 10 farms reported an estimated 5,400 poultry and 14 farms reported an estimated 4,500 pigs. Data regarding the total number of poultry and pigs was suppressed by Statistics Canada to protect confidentiality, and estimates were calculated using average birds or animal numbers per farm of nearby subwatersheds which did not contain suppressed data.

Central Subwatershed:
In 2006, the Central Subwatershed reported approximately 285 farms with 84% of the subwatershed area being used for farming. Sixty percent of the farmland in the Central Subwatershed was dedicated to annual crop production, and over 25% to pasture, alfalfa, and hay and fodder crops. Cereals made up over 45% of the cultivated area, oilseeds (mainly canola) over 37%, and forages less than 15%. Farmers employed conservation and zero tillage on 60% of land under crop production.

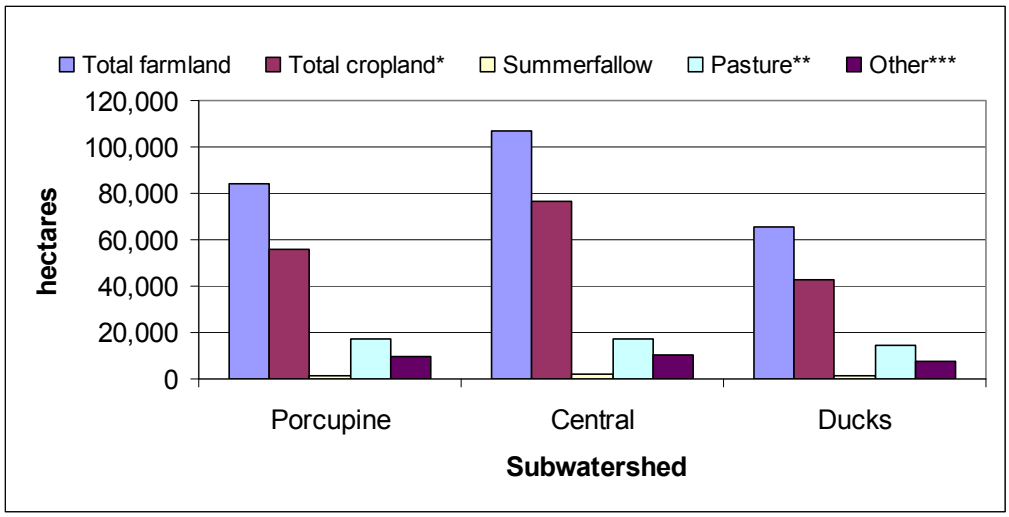
Beef production is the main form of livestock production in the subwatershed, with 120 farm operations reporting almost 6,900 beef cows, an average of almost 60 cows per farm. Total cattle and calves reported in the area added up to 14,400 animals. Over 10 farms reported a total of almost 8,000 pigs, with 5 farms reporting almost 1,100 sows. Over 55 farms reported a total of over 1,350 horses and ponies. Almost 15 farms reported an estimated 26,700 poultry. Data regarding the total number of poultry was suppressed by Statistics Canada to protect confidentiality, and estimates were calculated using average bird numbers per farm of nearby subwatersheds which did not contain suppressed data.

Ducks Subwatershed:
The Ducks Subwatershed reported 170 farms with over 40% of the subwatershed area being used for farming. In 2006, over 50% of the farmland in the Ducks Subwatershed was used for annual crop production, and almost 40% for pasture, alfalfa, hay and fodder crops. Cereals made up almost 45% of the cultivated area, oilseeds (mainly canola) a third, and forages almost 20%. Farmers employed conservation and zero tillage practices on approximately 50% of annually cropped land.

Beef production is the main form of livestock production in the subwatershed, with over 80 farm operations reporting almost 5,200 beef cows, an average of almost 65 cows per farm. Total cattle and calves reported in the area added up to almost 11,000 animals. Almost 40 farms reported a total of almost 2,400 horses and ponies. Over 10 farms reported a total of almost 3,200 pigs, with over 5 farms reporting sows. Over 10 farms reported a total of almost 3,200 poultry.

Although the Central Subwatershed reported the largest area of the farmland, all three subwatersheds had similar proportions of farmland under cropland and pasture production (***Figure 2***). Cropland made up the majority of farmland, indicating that crop production is an important activity throughout the agricultural extent of the study area.

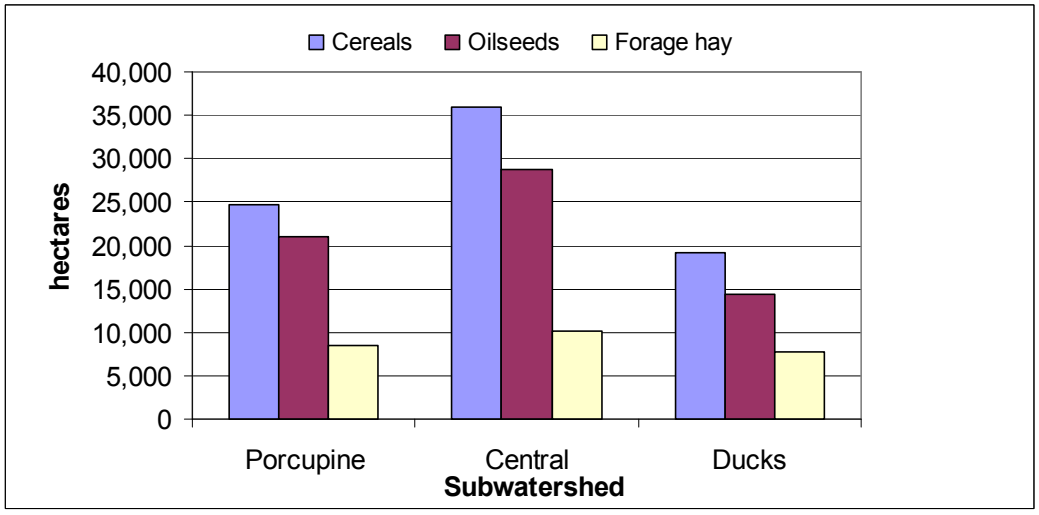
Figure 2: Distribution of Agricultural Land Use (2006 Census of Agriculture)



* Total cropland includes all field crops and forages, vegetables, fruit and nuts and sod
** Pasture includes tame pasture and natural areas used for pasture
*** Other category includes all other land uses including farmyard, woodlots, Christmas trees, wetlands, etc.

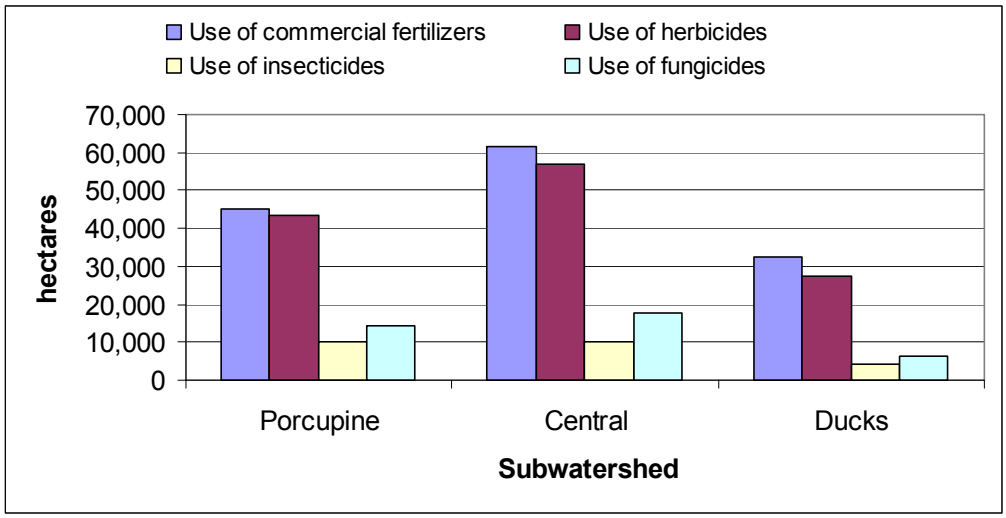
With respect to crops grown in 2006, approximately 80% of the cropland in the Porcupine and Central Subwatersheds was dedicated to cereals (mainly wheat) and oilseeds (mainly canola). In the Ducks Subwatershed this number was slightly less at 75% (***Figure 3***). The production of forage was more prominent in the Ducks Subwatershed, representing 20% of the total cropland.

Figure 3: Distribution of the main crop types grown in the Swan Lake Watershed (2006 Census of Agriculture)



As for crop inputs, cropland in the Ducks Subwatershed received, on average, less inputs than crops in the other two subwatersheds (***Figure 4***). Fungicides and insecticides were applied, to varying extents, in all three subwatersheds.

Figure 4: Area treated to crop inputs in the 2005 crop year (2006 Census of Agriculture)



With respect to tillage practices, conservation and zero tillage practices were more predominantly used in the Porcupine and Central Subwatersheds. In the Ducks Subwatershed, conventional tillage is more prevalent, with approximately 50% of the land prepared using conventional tillage practices (***Figure 5***).

Figure 5: Tillage practices in the Swan Lake Watershed (2006 Census of Agriculture)

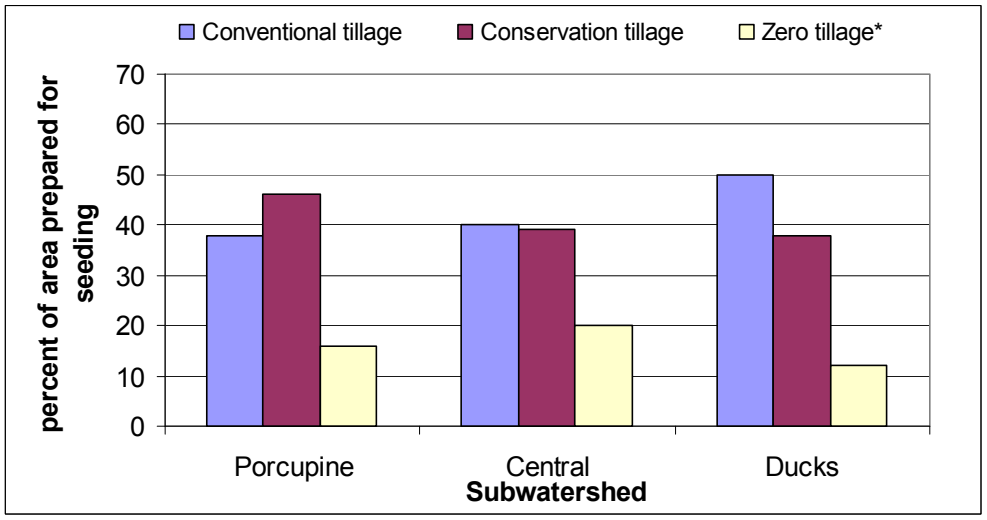
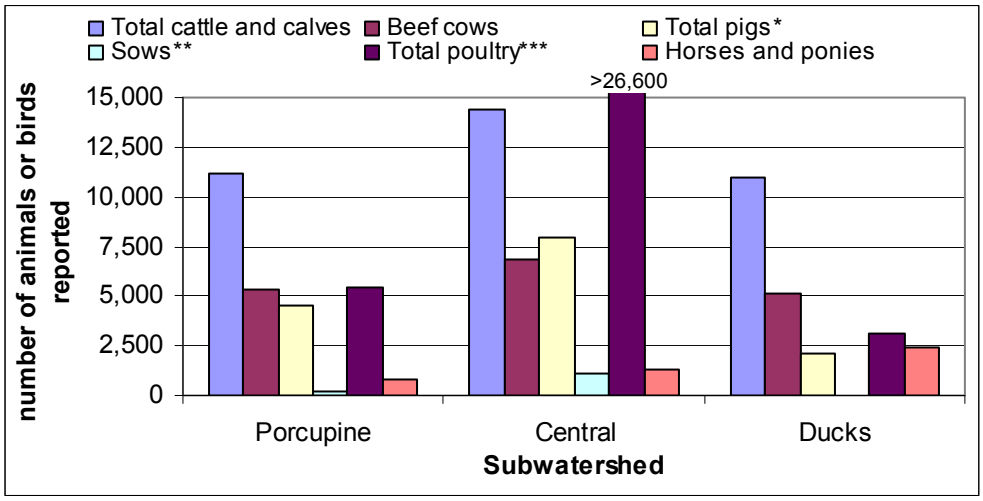


Figure 6 summarizes the livestock numbers in the Swan Lake Watershed. A significant amount of livestock is raised in the watershed, with beef being the main livestock raised by producers. In all three subwatersheds, beef cows made up almost half of the total cattle and calves number, indicating the prevalence of cow/calf operations. Dairy cows were present, although numbers have been suppressed due to the small number of farms reporting in the Central and Ducks Subwatersheds. The Central Subwatershed had the highest number of poultry (the majority of

which are broilers, roasters or Cornish hens) and total hogs. The Ducks Subwatershed had the highest number of horses and ponies.

Figure 6: Total livestock numbers in the Swan Lake Watershed (2006 Census of Agriculture)



* Totals were estimated for the Porcupine Subwatershed due to some data suppression
** Data for the Ducks Subwatershed has been suppressed and could not be estimated.
*** Totals were estimated for the Porcupine and Central Subwatersheds due to some data suppression

Total Animal Units (AU) produced in the watershed (based on annual nitrogen production) has been estimated using Manitoba's AU coefficients and by making several assumptions (refer to ***Appendix B***). As represented in ***Table 2***, cattle and calves, consisting mainly of beef cattle, contributed the majority of animal units produced in each of the subwatersheds (over 75% in all subwatersheds). Since beef production consists of mainly cow/calf operations, manure nitrogen and phosphorous tend to be deposited directly onto pastureland by the animals during the grazing season, and possibly accumulated in more concentrated areas during the winter season.

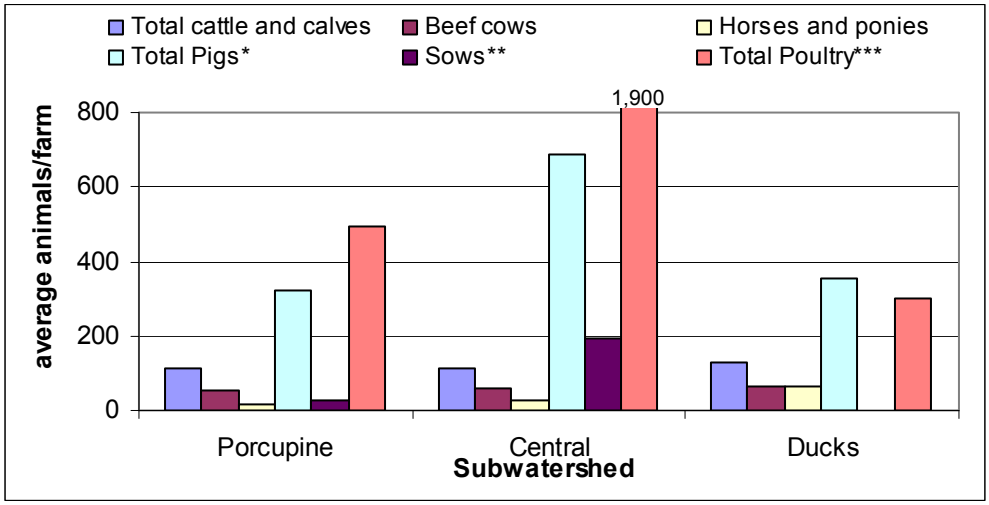
Table 2: Estimated annual animal units produced in the Swan Lake Watershed* (2006 Census of Agriculture)

Livestock Type	Animal Units (AU)			Total Animal Units
	Porcupine	Central	Ducks	
Total Cattle and Calves	7,084	9,109	7,006	23,199
Total Pigs*	623	915	86	1,623
Total Poultry *	6	156	**	162
Total Horses and Ponies	778	1,358	2,376	4,511
Other Livestock* (sheep, goats, bison, elk)	124	60	**	184
TOTAL AU*	8,615	11,597	9,467	29,680

* where livestock and poultry numbers have been suppressed to preserve confidentiality of the Census data, estimates were calculated using average number of animals or birds per farm from data available within the subwatershed
** estimates were not calculated due to suppression of all data in subwatershed

Intensity of the livestock production can be determined by the average size of flocks and herds. In all of the subwatersheds, the average number of total cattle and calves and beef cows per farm is similar, although farms in the Ducks Subwatershed had slightly larger herds compared to the other subwatersheds ***(Figure 7)***. Poultry and hog farms in the Central Subwatershed tended to have larger flocks or herds, while farms in the Ducks Subwatershed have, on average, more horses and ponies per farm.

Figure 7: Average number of livestock or poultry per farm in the Swan Lake Watershed (2006 Census of Agriculture)



* Totals were estimated for the Porcupine Subwatershed due to data suppression
** Data for the Ducks Subwatershed has been suppressed and could not be estimated.
*** Totals were estimated for the Porcupine and Central Subwatersheds due to data suppression

Farm Financial Characteristics

Porcupine Subwatershed:
In 2006, the Porcupine Subwatershed reported approximately 210 farms with over 30% of the subwatershed area being used for farming. The average farm size was approximately 402 ha/farm (993 acres/farm) with an average capital investment of over $1,720 per hectare of farmland (or almost $691,200/farm). Livestock-related expenses per hectare of farmland were over $25/ha and crop-related expenses were about $175/ha. Net cash income per farm was estimated to be over $16,500 and the sales to expense ratio was reported to be 1.13 (farm operations received $1.13 gross revenue for every $1 of agricultural expense).

Central Subwatershed:
In 2006, the Central Subwatershed reported approximately 283 farms with almost 85% of the subwatershed area being used for farming. The average farm size was approximately 378 ha/farm (934 acres/farm) with an average capital investment of almost $1,960 per hectare of farmland (or $739,900/farm). Livestock-related expenses per hectare of farmland were approximately $30/ha and crop-related expenses were about $180/ha. Net cash income per farm was estimated to be almost $15,000 and the sales to expense ratio was reported to be 1.11 (farm operations received $1.11 gross revenue for every $1 of agricultural expense).

Ducks Subwatershed:
The Ducks Subwatershed reported almost 170 farms with over 40% of the subwatershed area being use for farming. The average farm size was around 386 ha/farm (954 acres/farm) and

farms had an average capital investment of $1,915 per hectare (or over $739,600 per farm). Average livestock-related expenses per hectare of farmland were almost $40/ ha farmland, while crop-related expenses were over $165/ha. Net cash income was estimated to be approximately $20,700 per farm and the sales to expense ratio was reported to be 1.17.

Farms in all three subwatersheds were similar in size, although they tended to be slightly larger in the Porcupine Subwatershed (***Figure 8***). Total farm receipts and expenses, calculated as total gross farm receipts plus total farm operating expenses, provide a means to measure financial activity. A look at the farm financial activity shows that farms in the Central Subwatershed tended to have higher sales and expenses, but farms in the Ducks Subwatershed, on average, had a higher net cash income per farm (***Figure 9***).

Figure 8: Total number of farms and average farm size in the Swan Lake Watershed (2006 Census of Agriculture)

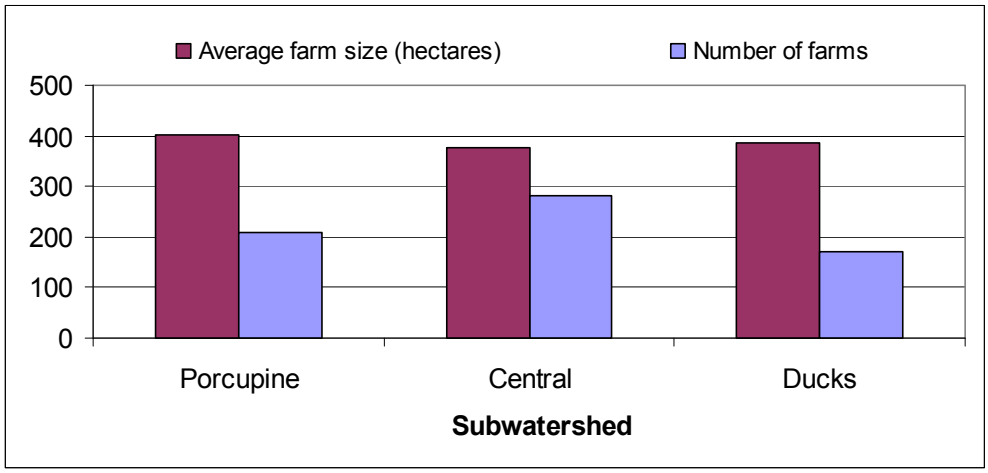
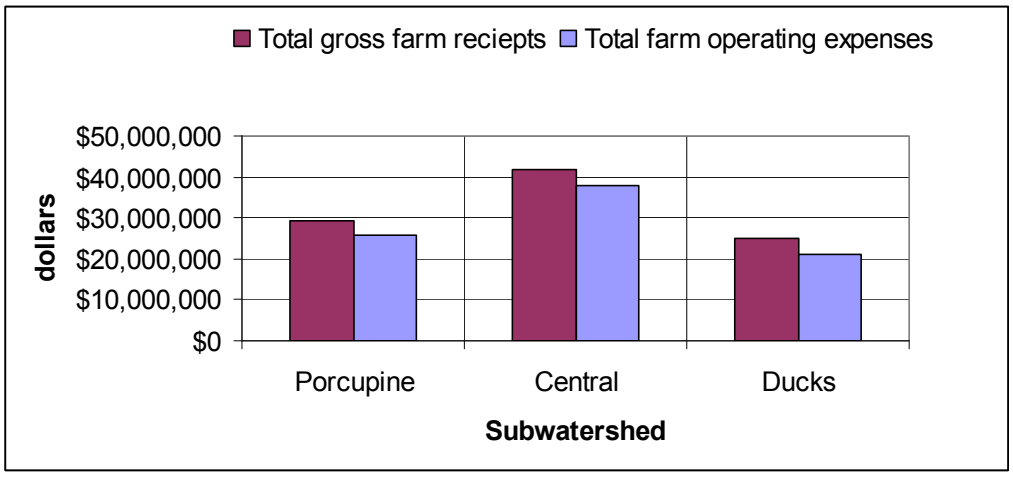


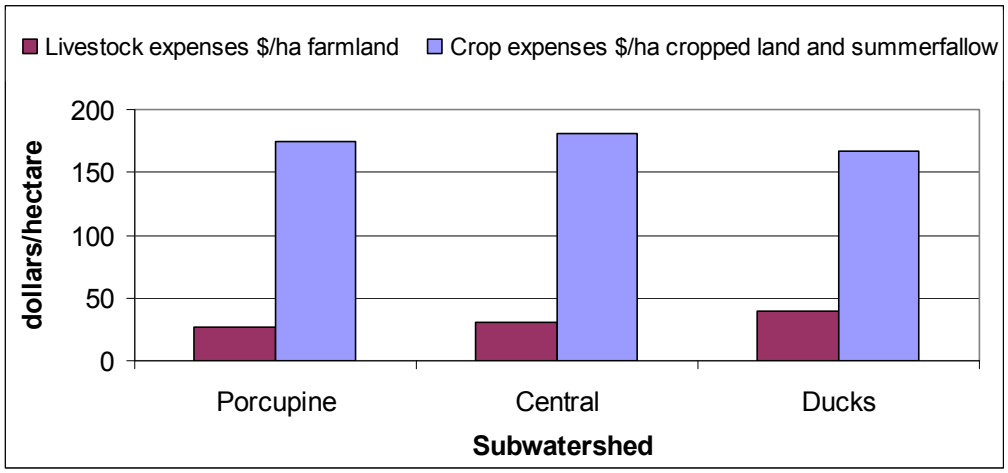
Figure 9: Summary of farm financial activity for the 2005 calendar year (2006 Census of Agriculture)



Livestock and crop-related expenses reported for the 2005 crop year have been determined on a per hectare basis. ***Figure 10*** shows that, on average, farm operations in the Ducks Subwatershed had the highest livestock-related expenses per hectare of farmland. With respect to crop-related expenses, average dollars spent per hectare of cropland and summerfallow were

similar in all three subwatersheds. A closer look at the crop input costs shows that farms in Porcupine Subwatershed had the lowest costs of fertilizers and pesticides per hectare of applied chemical (***Table 3***).

Figure 10: Average livestock and crop-related expenses per hectare for the 2005 calendar year (2006 Census of Agriculture)



* Livestock-related expenses include total feed, supplements, and hay purchases, livestock and poultry purchases, veterinary services, drugs, semen, breeding feeds, etc
** Crop-related expenses include purchases of fertilizer, lime, herbicides, insecticides, fungicides, and seed and plant (excluding materials purchased for resale)

Table 3: Average dollars per hectare spent on fertilizer and pesticides in the 2005 calendar year (2006 Census of Agriculture)

Subwatershed name	Dollars spent on fertilizer per hectare applied	Dollars spent on pesticides per hectare applied
Porcupine	$111	$52
Central	$117	$59
Ducks	$119	$64

2006 Agriculture Profile Summary

- **Less than half of the land in the watershed is owned and managed by farm operations. The Central Subwatershed has the largest area in agricultural land use.**
- **Agricultural activities tend to be quite similar throughout the watershed with some differences observed between the three subwatersheds.**
- **Crop production is the main use of agricultural land in the watershed with annual crops making up nearly three quarters of the farmland. In all three subwatersheds, over 80% of the cultivated land was seeded to cereals or oilseeds (mainly wheat and canola).**
- **In the Central and Porcupine Subwatersheds, conservation and zero tillage practices were reported on 60% of the annually cropped lands, while in the Ducks Subwatersheds the two combined for about 50%.**
- **In the Central and Porcupine Subwatersheds, 80% of the cropland had fertilizer applied while in the Ducks Subwatershed, fertilizer was applied on 75% of the cropland. A similar trend was observed for herbicide application, though with slightly lower percentages. In the Central and Porcupine Subwatersheds, approximately 75% of cropland was treated with herbicides, while this number was reduced to approximately two thirds of the cropland in the Ducks Subwatershed. Crop-related expenses are similar in all three subwatersheds, when analyzed by hectares of cropland and summerfallow.**

- **Beef production is the main livestock production in the watershed. In the Ducks Subwatershed, land use for beef production (pastures and seeded forage for hay) made up almost 40% of the farmland, while in the Porcupine and Central Subwatersheds, it made up a 30% and 25% of the farmland respectively. With respect to beef herds, on average, farms in all three subwatersheds reported very similar number of cattle and calves per farm, with farms in the Ducks Subwatershed having a slightly larger herd size. Farms in the Central Subwatershed reported 75% of the total poultry and half of the total pigs in the Swan Lake Watershed. Farms in the Ducks Subwatershed report 40% of the horses and on average have the largest number of horses per farm. Farms in the Ducks Subwatershed spend more on livestock-related expenses per hectare of farmland.**

b) 2005 Land Cover Summary

Land cover data was derived from 30 metre resolution LANDSAT Thematic Mapper satellite imagery taken on September 11th, 2005. The land cover data provides information on the spatial extent of general types of land cover within a given area at that point in time. Further details on the land cover data, and the constraints associated with this data are provided in ***Appendix C***.

Imagery was not available for approximately 64,800 ha in the northeast corner of the watershed. Analysis of other land cover information indicates lands in this area are primarily forest and wetlands with very little land used for agricultural purposes.

- **Lands that are easily identified for agricultural use (Annual Croplands, Forage, and Pasture/Grasslands) accounted for approximately 229,000 ha, roughly 42% of the watershed in 2005.**
- **Over half (303,585 ha- 56%) of the land was classified as trees, water, or wetlands (*Table 4, Figures 11* and *12*).**
- **Annual Cropland accounted for approximately 30% of the land use in the Swan Lake watershed.**
- **Grassland/pasture areas cover another 8% (or 43,401 ha) of the watershed and were mainly located in the central portions of the watershed.**
- **Forage land, usually represented by alfalfa stands, made up 5% of the watershed.**
- **Wetlands occupied 13% of the watershed (approximately 37,000 ha) with the majority found in the headwater - western portion of the watershed.**
- **Approximately 7% of the watershed was classified as water.**
- **Trees were the predominant land cover in the watershed covering 37% of the area (or 49,383 ha.)**

With Respect to Subwatersheds:

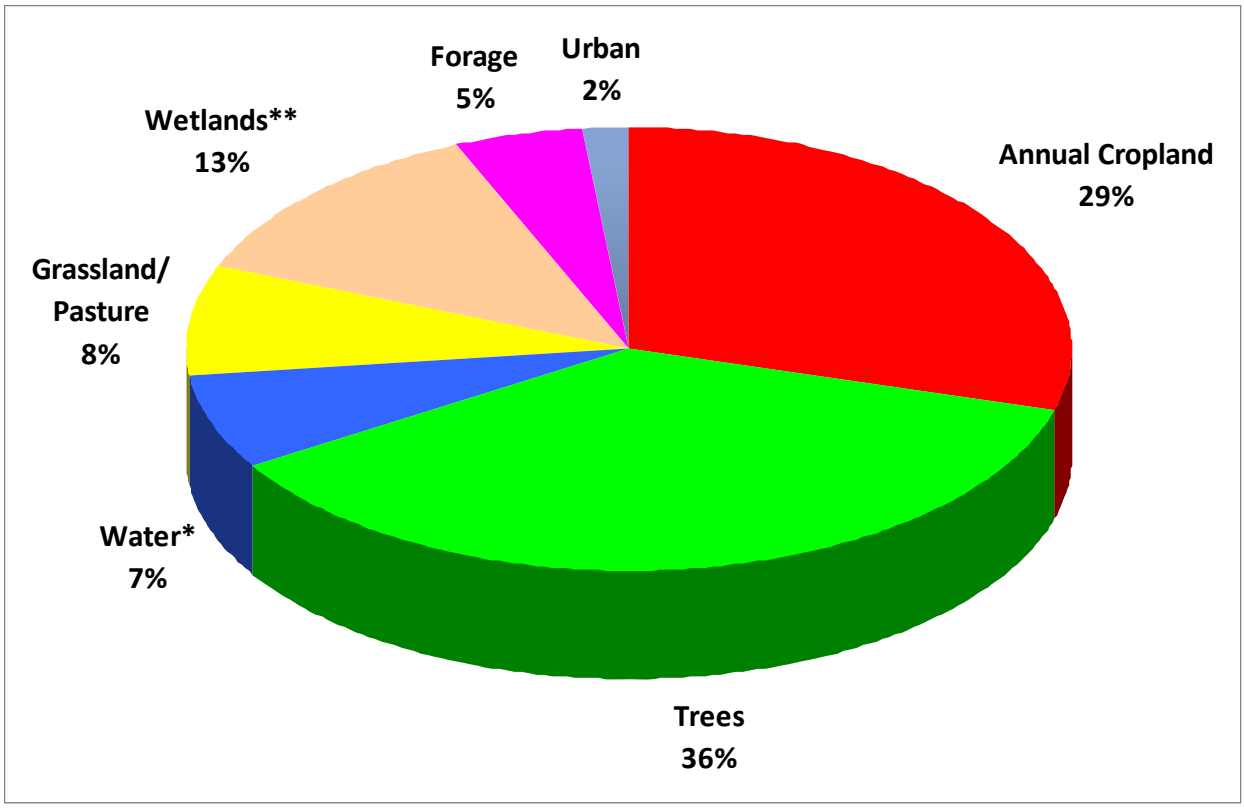
- **The Central Subwatershed had a greater proportion of Annual Cropland and Forages, and urban landcover than the other two watersheds.**
- **The Central Subwatershed also had a lower proportion of wetlands, water, and trees than the other two watersheds.**
- **Almost half of the Porcupine and Ducks Subwatersheds have been identified as forested cover.**

Table 4: 2005 Land Cover by Subwatershed (hectares)*

Subwatershed	Annual Cropland	Trees	Water	Grassland/ Pasture	Wetlands**	Forage	Urban	Total***
Porcupine	55,131	100,157	4,473	15,401	45,131	8,868	3,165	232,326
Central	66,374	24,885	1,167	15,157	6,065	9,268	3,493	126,409
Ducks	38,645	73,070	3,023	12,843	17,240	7,448	2,365	154,635
Swan Lake			28,374					
Total	**160,150**	**198,112**	**37,037**	**43,401**	**68,436**	**25,583**	**9,024**	**541,744**

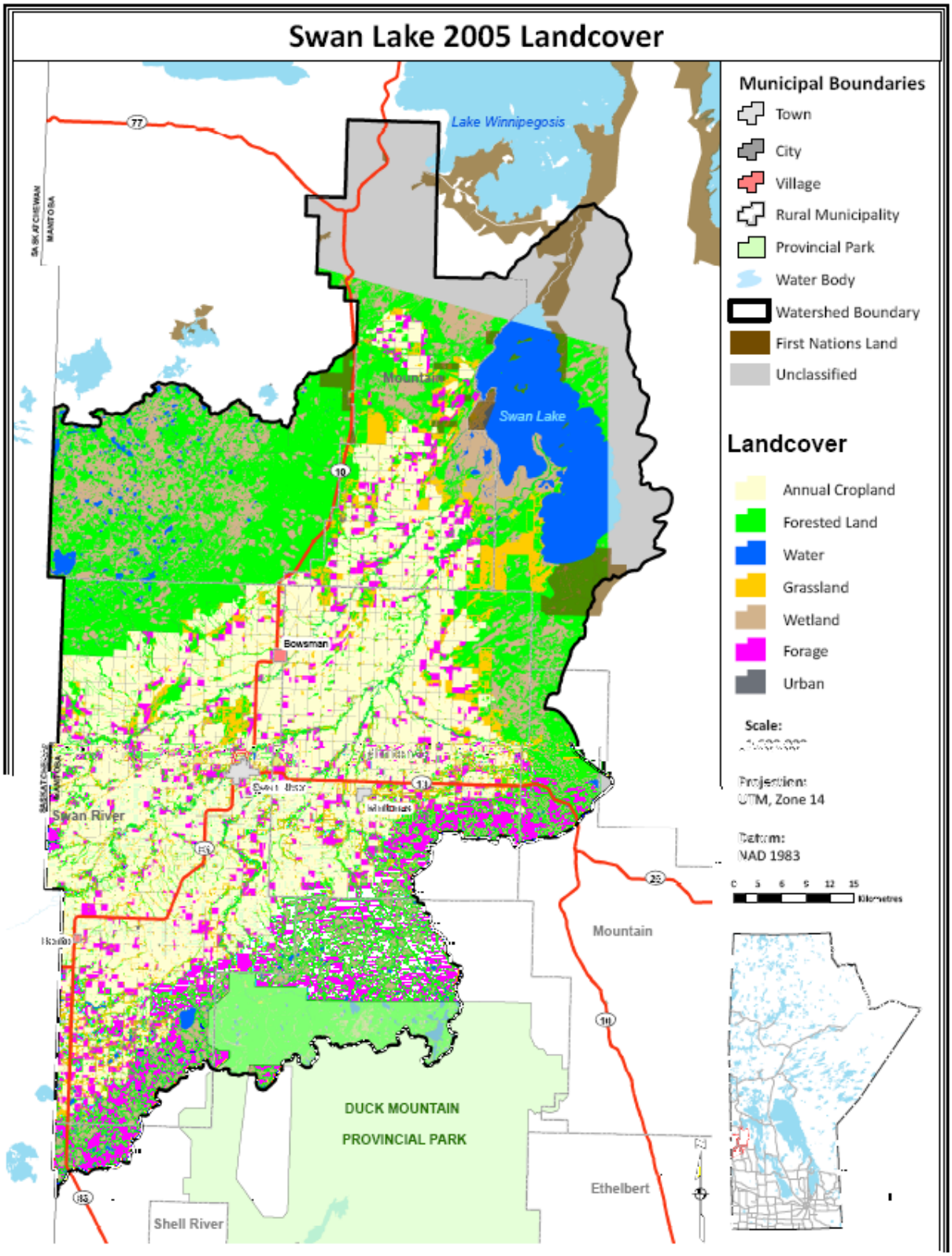
*Area totals are approximate due to the nature of the image analysis procedure
**Due to seasonal changes in wetland size, date of imagery will affect area
***Area calculations are for the portion of the Swan Lake watershed which is located within the IWMP study area

Figure 11: Land Cover of the Swan Lake Watershed in 2005



* Area totals are approximate due to the nature of the image analysis procedure
** Due to seasonal changes in wetland size, date of imagery will affect area

Figure 12: 2005 Land Cover in the Swan Lake Watershed*



*Land cover was derived from satellite imagery captured September 11, 2005.

ii. Agricultural Land Use Trends

Agricultural land use is diverse and there are many factors influencing changes over time. Influences include economic drivers like commodity prices, land values, input costs, and government programs to social influences like changing demographics and increasing environmental awareness. Understanding land use trends can guide the development of future activities and initiatives that encourage sustainable resource management in the watershed.

a) Changes in Agricultural Production (2001 to 2006 Census Data)

2001 and 2006 Census of Agriculture data acquired from Statistics Canada, has been extrapolated to the subwatershed boundaries within the study area. The data can be analyzed to reveal changes in agricultural production and to better understand agricultural management practices within the Swan Lake IWMP study area and its three subwatersheds. For more detailed data from the 2001 and 2006 Census of Agriculture, refer to ***Appendix I*** and ***J***.

There are many factors that influence decisions made on individual farms. In order to understand if changes are the result of adaptation in farming systems and/or practices, or due to weather, market and other influences, it is important to also be aware of local conditions. As such, it is recommended that findings from this report be further verified by land use and industry specialists and individuals with significant local watershed knowledge.

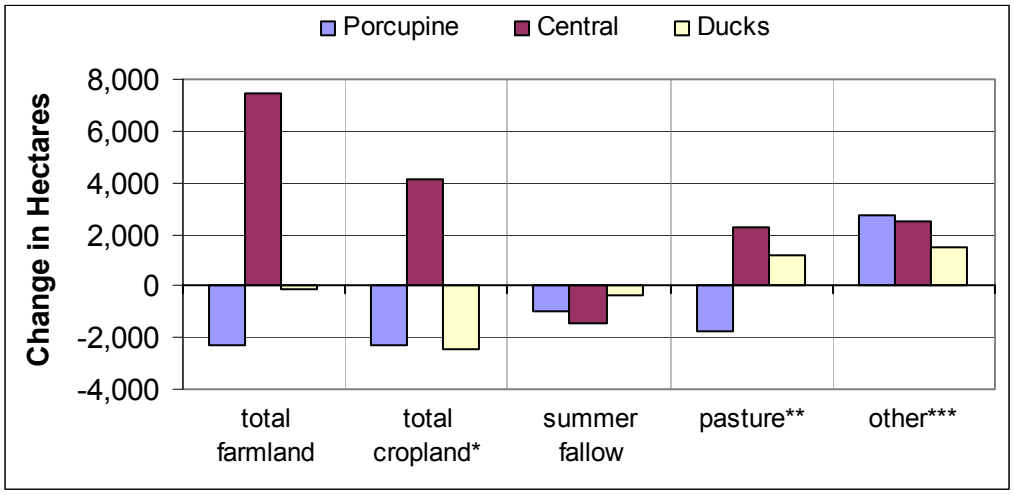
Five-Year Change in Land Use

The analysis of the Census of Agriculture from 2001 to 2006 showed a slight reduction in the number of farms in the watershed. This corresponds with an increase in average farm size in all three subwatersheds (***Table 5***). In the Central Subwatershed, there was a large overall increase in total area of farmland reported, mainly due to the increase in cropland, but also in pasture and other land uses to a lesser extent (***Figure 13***). Analysis of land tenure shows that the majority of the increase in farmland in the Central Subwatershed could be due to a large increase in leased or rented land ***(Table 6)***. In the Porcupine Subwatershed, there was a slight decrease in total farmland, possibly due to a decrease in land leased from government. The amount of land used for pasture increased in the Ducks Subwatershed while the amount of cropland was reduced in the Porcupine and Ducks Subwatersheds. The large decrease in pasture reported in the Porcupine Subwatershed is most likely due to a decrease in area leased from governments ***(Table 6)***. In all three subwatersheds, there was a general decrease in the area of summerfallow (***Figure 13***).

Table 5: Change in number of farms reporting, and average farm size from 2001 to 2006.

Subwatershed	Number of Farms			Average Farm size (ha/farm)		
	2001 Census	2006 Census	5-Year Change	2001 Census	2006 Census	5-Year Change
Porcupine	239	210	-29	363	402	39
Central	308	283	-25	322	377	55
Ducks	205	170	-35	321	387	65

Figure 13: Change in agricultural land use types from 2001 to 2006 (Census of Agriculture)



* Total cropland includes all field crops, forages, vegetables, fruit and nuts and sod
** Pasture includes tame pasture and natural areas used for pasture
*** Other category includes all other land uses including farmyard, woodlots, Christmas trees, wetlands, etc.

Table 6: Summary of Change in Land Tenure from 2001 to 2006 (Census of Agriculture)

	Total Area of Land (ha):			
2006 Census	**operated by farmers**	**owned and operated**	**leased from government**	**rented, leased or crop-shared from others**
Porcupine	84,425	52,163	9,769	22,493
Central	106,764	64,830	4,630	37,304
Ducks	65,755	43,145	5,756	16,854
2001 Census				
Porcupine	86,720	52,185	11,611	22,926
Central	99,282	62,524	4,546	32,213
Ducks	65,900	42,500	4,752	18,649
5-Year Change				
Porcupine	-2,295	-22	-1,842	-433
Central	7,482	2,306	84	5,091
Ducks	-145	645	1,005	-1,795

Changes to Annual Cropping Practices
Figure 14 outlines the changes in annual cropping practices between 2001 and 2006. Specifically the following trends were noted:

In the Porcupine Subwatershed:

- There was an overall decrease in cropland (~2,300 ha). Although there was a major decrease in cereals (~5,700 ha), there was an increase in oilseeds (~3,600 ha). There was no real change in land used for forages.

In the Central Subwatershed:

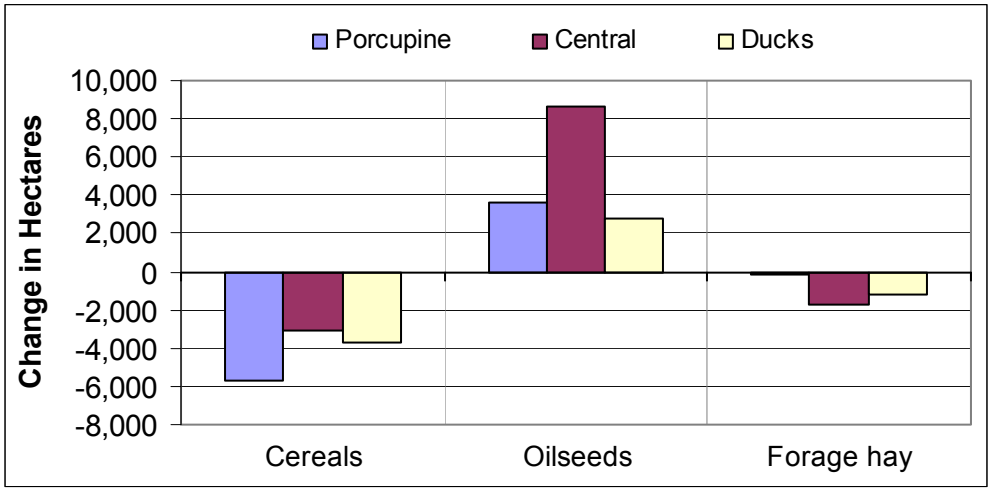
- There was an overall increase in cropland (~4,100 ha). Although there was a decrease in cereals (~3,000 ha), there was an even greater increase in oilseeds (~8,600 ha). There was a slight decrease in land used for forages (~1,700 ha).

In the Ducks Subwatershed:

- There was an overall decrease in cropland (~2,500 ha). Although there was a decrease in cereals (~3,700 ha), there was an even greater increase in oilseeds (~2,700 ha). There was a slight decrease in land used for forages (~1,200 ha).

These changes are likely in direct response to market trends, as producers aim at maximizing profits through the production of higher value crops.

Figure 14: Change in area of crop types from 2001 to 2006 (Census of Agriculture)



Over the five-year period, changes in tillage practices were similar in all three subwatersheds. Decreases in the use of conventional tillage (incorporating most crop residue in the soil) were observed in all three subwatersheds (***Table 7***) with the Porcupine Subwatershed experiencing the largest decrease. In the Ducks Subwatershed, census data for conservation and zero tillage usage was suppressed.

Table 7: Comparison of distribution of tillage practices between 2001 and 2006

Subwatershed	Percent of area prepared for seeding using:					
	Tillage incorporating most crop residue into the soil		Tillage retaining most crop residue on the surface		No-till or zero-till seeding	
	2001	2006	2001	2006	2001	2006
Porcupine	76%	38%	22%	46%	2%	16%
Central	62%	40%	33%	39%	6%	20%
Ducks	64%	50%	x	38%	x	12%

X – data has been suppressed by Statistics Canada

Change in Annual Cropping Inputs

Notable changes in crop inputs are summarized below for the three subwatersheds (***Figure 15*** and ***Tables 8*** and ***9***).

In the Porcupine Subwatershed, from 2001 to 2006:

- Despite a decrease in cropland, there was an increase in the application of fertilizers, and the use of fungicides nearly doubled. The use of herbicides decreased slightly.
- There was a slight increase in the proportion of cropland with fertilizer applications, while the proportion of cropland with herbicide applications remained the same.
- Farmers reported an increase in fertilizer costs of almost $15 per hectare. Pesticide costs per hectare remained the same.

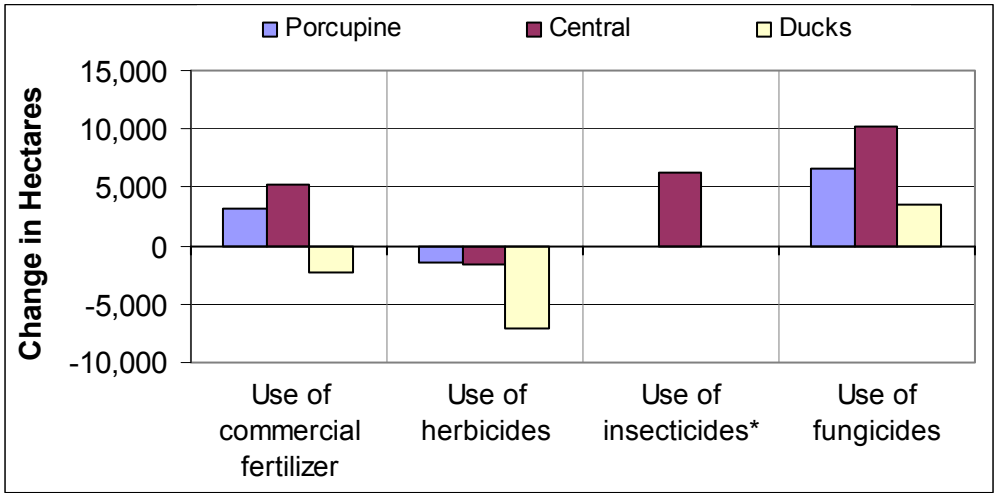
In the Central Subwatershed, from 2001 to 2006:

- There was an increase in the use of fertilizers, herbicides and fungicides, which may be attributed to an increase in cropland. The use of fungicides more than doubled in 2006 from 2001.
- There was a slight decrease in the proportion of cropland with herbicide applications, while the proportion of fertilizer applications remained the same.
- Farmers reported an increase in fertilizer costs of almost $25 per hectare. Average pesticide costs increased by $10 per hectare.

In the Ducks Subwatershed, from 2001 to 2006:

- Due to decrease in cropland, there was an overall decrease in the use of fertilizers and herbicides. The use of fungicides increased in the Subwatershed from 2001 to 2006.
- There was a decrease in the proportion of cropland with herbicide applications, while the proportion of fertilizer applications remained the same.
- Farmers reported an increase in fertilizer costs of over $30 per hectare. Average pesticide costs increased by $8 per hectare.

Figure 15: Change in crop inputs from 2001 to 2006 (Census of Agriculture)



* Data has been suppressed by Statistics Canada for area of insecticide application in the Porcupine and Ducks Subwatersheds

Table 8: Percent of cropland with fertilizer or herbicide applications in 2001 and 2006 (Census of Agriculture)*

Subwatershed	Percent of cropland with Fertilizer Application		Percent of cropland with Herbicide Application	
	2001	2006	2001	2006
Porcupine	72%	81%	77%	78%
Central	78%	80%	81%	74%
Ducks	77%	76%	77%	65%

* Cropland includes all field crops (including alfalfa and other seeded forages), vegetables, fruit and nuts and sod

Table 9: Comparison of average cost of fertilizer or pesticide inputs in 2001 and 2006 (Census of Agriculture)

Subwatershed	Average cost of fertilizer input ($/ha)		Average cost of pesticide input ($/ha)	
	2001	2006	2001	2006
Porcupine	97	111	55	52*
Central	92	117	49	59
Ducks	88	119	56	64*

* Data has been suppressed by Statistics Canada for area of insecticide application in the Porcupine and Ducks Subwatersheds, therefore average costs are underestimated.

Relative Change in the Livestock and Poultry Sector

Overall, there was a slight decrease in the number of farms reporting livestock or poultry (see ***Figures 16*** and ***17*** and ***Table 10)*** between 2001 and 2006.

Cattle Industry

In the Porcupine Subwatershed, there was:

- A small increase in total cattle reported, including beef cows;
- A decrease of approximately 10 farms reporting beef cattle;
- A small change in the average beef cow herd size, with an increase of almost 10 beef cows per farm.

In the Central Subwatershed, there was:

- A moderate increase in total cattle with a small increase in number of total beef cows;
- A decrease of about 15 farms reporting cattle, as well as, beef cows;
- A moderate increase in average herd size with an average increase of over 15 beef cows per farm.

In the Ducks Subwatershed, there was:

- Little change in total cattle reported but an increase in number of total beef cows;
- A decrease of 20 farms reporting cattle and 18 fewer farms with beef cows;
- A small increase in average herd size with an average increase of almost 20 beef cows per farm.

Hog Industry

In the Porcupine Subwatershed*, there was:

- A decrease of almost a third in total pigs reported. Total sows decreased by over half in 2006 from 2001;
- A decrease of almost half in the number of farms reporting pigs, with an even greater decrease in the number of farms reporting sows;
- A small increase in average number of pigs per farm, and no real change in average sows per farm;

** In the Porcupine Subwatershed, due to some suppression on total pig and total sow numbers, data are estimates.*

In the Central Subwatershed, there was:

- A 25% decrease in the total number of the total pigs but a small increase in sows from 2001 to 2006;
- A decrease of almost one third in the number of farms reporting pigs, while the number of farms reporting sows decreased by 50%;
- No real change in the average number of pigs per farm, but the average number of sows per farm more than doubled;

In the Ducks Subwatershed*, there was:

- A small decrease in total pigs;
- No real change in the number of farms reporting pigs or sows;
- A small increase in average number of pigs per farm;

** In the Ducks Subwatershed, due to some suppression on total pig and total sow numbers, data are estimates.*

Poultry Industry*

In the Porcupine Subwatershed, there was:

- An increase in the total number of birds reported (~3,000);
- A decrease of almost one third in the number of farms reporting poultry;
- A large increase in the average number of birds per farm (~350 birds).

In the Central Subwatershed, there was:

- A large increase in the number of birds from 2001 to 2006 (mainly broilers/roasters);
- No real change in the number of farms reporting poultry;
- A large increase in the average number of birds per farm (~1,700).

In the Ducks Subwatershed, there was:

- A large increase in total poultry, with the total number of birds increasing by over 2,000 birds;
- No real change in the number of farms reporting poultry;
- A large increase in average number of birds per farm (~200);

** In the all three subwatersheds, there was suppression on total poultry numbers, therefore reported numbers are estimates.*

Horses and Ponies:

In the Porcupine Subwatershed, there was:

- A moderate decrease in the total number of horses and ponies reported;
- A slight decrease in the number of farms reporting horses and ponies;
- A small decrease in the average herd size by approximately 5 horses or ponies per farm.

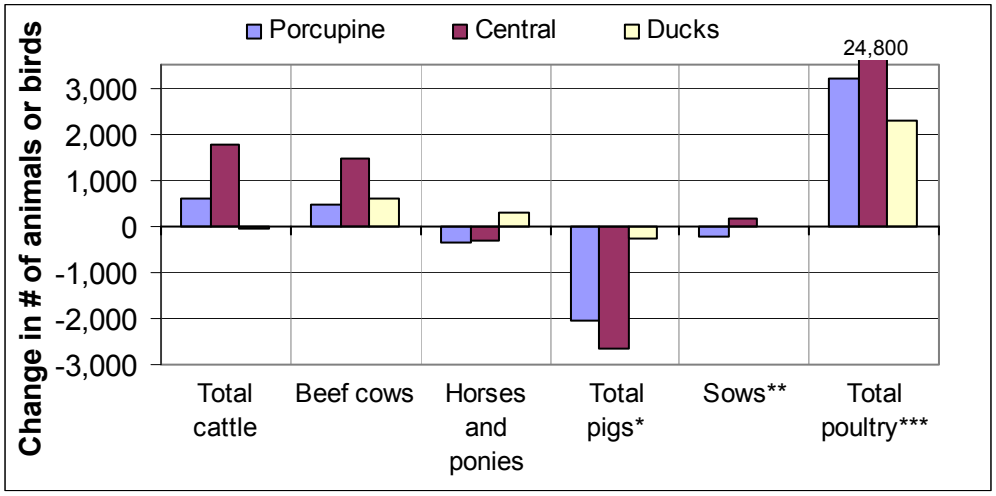
In the Central Subwatershed, there was:

- A small decrease in total horses and ponies reported;
- A slight decrease in the number of farms reporting horses and ponies;
- No real change in the average number of horses or ponies per farm.

In the Ducks Subwatershed, there was:

- A small increase in total horses and ponies reported;
- A slight decrease in the number of farms reporting horses and ponies;
- A small increase in average herd size with an average increase of almost 15 horses or ponies per farm.

Figure 16: Change in number of livestock from 2001 to 2006 (Census of Agriculture)

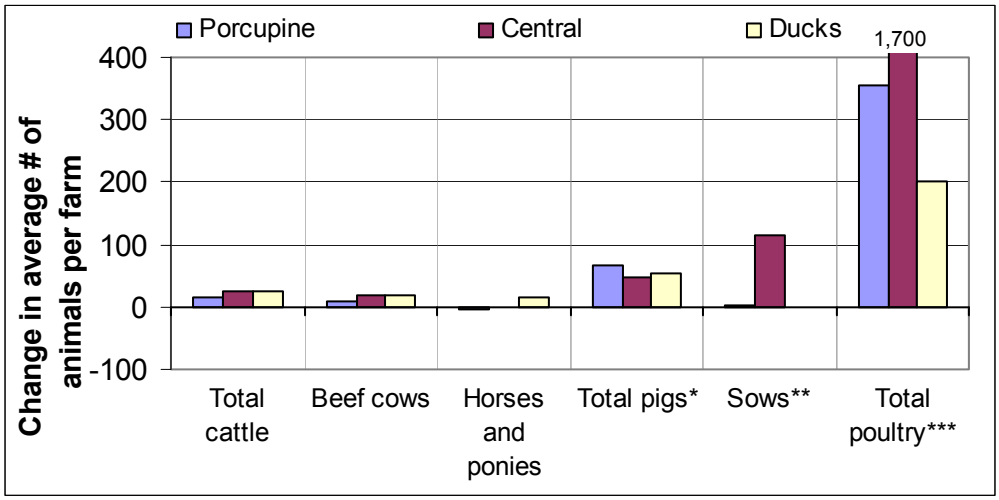


* Totals were estimated for the Porcupine Subwatershed due to some data suppression
** Data for the Ducks Subwatershed has been suppressed and could not be estimated.
*** Totals were estimated for the Porcupine and Central Subwatershed due to some data suppression

Table 10: Change in number of farms reporting livestock and poultry from 2001 to 2006 (Census of Agriculture)

Subwatershed/Census year		Number of Farms reporting:					
		Total cattle	Beef cows	Horses and Ponies	Total Pigs	Sows	Total Poultry
Porcupine	2001	110	106	57	26	17	17
	2006	100	97	51	14	6	11
	5-year change	-10	-9	-6	-12	-11	-6
Central	2001	145	133	63	17	11	16
	2006	128	119	56	12	5	14
	5-year change	-17	-14	-7	-5	-6	-2
Ducks	2001	106	99	43	8	5	9
	2006	86	81	38	6	3	11
	5-year change	-20	-18	-5	-2	-2	2

Figure 17: Change in average number of livestock per farm from 2001 to 2006, according to Census of Agriculture data.



* Totals were estimated for the Porcupine Subwatershed due to some data suppression
** Data for the Ducks Subwatershed has been suppressed and could not be estimated.
*** Totals were estimated for the Porcupine and Central Subwatersheds due to some data suppression

Summary of Changes in Agricultural from 2001 to 2006:

Over the five year period, there was/were:

- **Fewer but slightly larger farms. The Ducks Subwatershed experienced the largest increase in average farm size;**
- **A large increase in total farmland (over 7,000 ha) reported in the Central Subwatershed, the majority of the hectares coming from an increase in cropland, and less so from an increase in pasture and other land uses;**
- **A decrease in total farmland reported in the Porcupine Subwatershed, along with a reduction in area of cropland and pastures;**
- **An increase in area of cropland seeded to oilseeds, while area seeded to cereals decreased in all three subwatersheds;**
- **A general shift from conventional tillage to conservation or zero tillage practices in all three subwatersheds, as well as a decrease in summerfallow;**
- **A slight increase in the proportion of cropland of which fertilizer is applied;**
- **A slight decrease in the proportion of cropland with herbicide applications, especially in the Ducks Subwatershed;**
- **An increase in the use of fungicides in all three subwatersheds;**
- **An increase in the use of insecticides in the Central Subwatershed (data is suppressed for the other two subwatersheds);**
- **A small increase in average beef herd sizes, due to a decreased number of farms reporting a greater number of beef cattle;**
- **An increase in average pigs per farm, despite a large decrease in the total number of pigs in the Porcupine and Central Subwatersheds. Average sows per farm increased by over 100 animals in Central Subwatershed;**
- **A very large increase in total poultry in the Central Subwatershed mainly due to a large increase in the number of broilers or roasters.**

b) Land Cover – 1994, 2002, 2005

In 2001, an initial landcover analysis was conducted by PFRA for ***Detecting Land Use Change in the Swan Lake Basin*** as part of an overall basin plan. 1994 and 1999 LANDSAT imagery was used for the watershed report. The imagery from both time periods was classified into 16 different land cover classes. The analysis looked at change between two time periods and indicated that change was evident in annual cropland, forages, grasslands, and forest block cutovers (AAFC, 2001).

Land cover maps used in the analysis of this report were developed from 30 metre resolution LANDSAT Thematic Mapper satellite imagery. These data sets are point in time and allow users to see the spatial extent of general types of land cover within a given area over time. Further details on the information used for the land cover analysis and the constraints associated with this data are provided in ***Appendix C***. The 1994 land cover was derived from satellite imagery captured on May 26th, 1994, and the 2002 land cover is from imagery taken on September 11th, 2002, while the 2005 land cover was captured on September11th, 2005.

Summary of Land Cover Change

An analysis of land cover data from 1994, 2002 and 2005 satellite imagery supports the trends seen in the census data, with modest declines in cropland since the 1990s, and increases in forages over the same period (***Table 11***, ***Figure 18***).

Although there are some inherent limitations in analyzing land cover data to determine changes in land use, some changes can be noted:

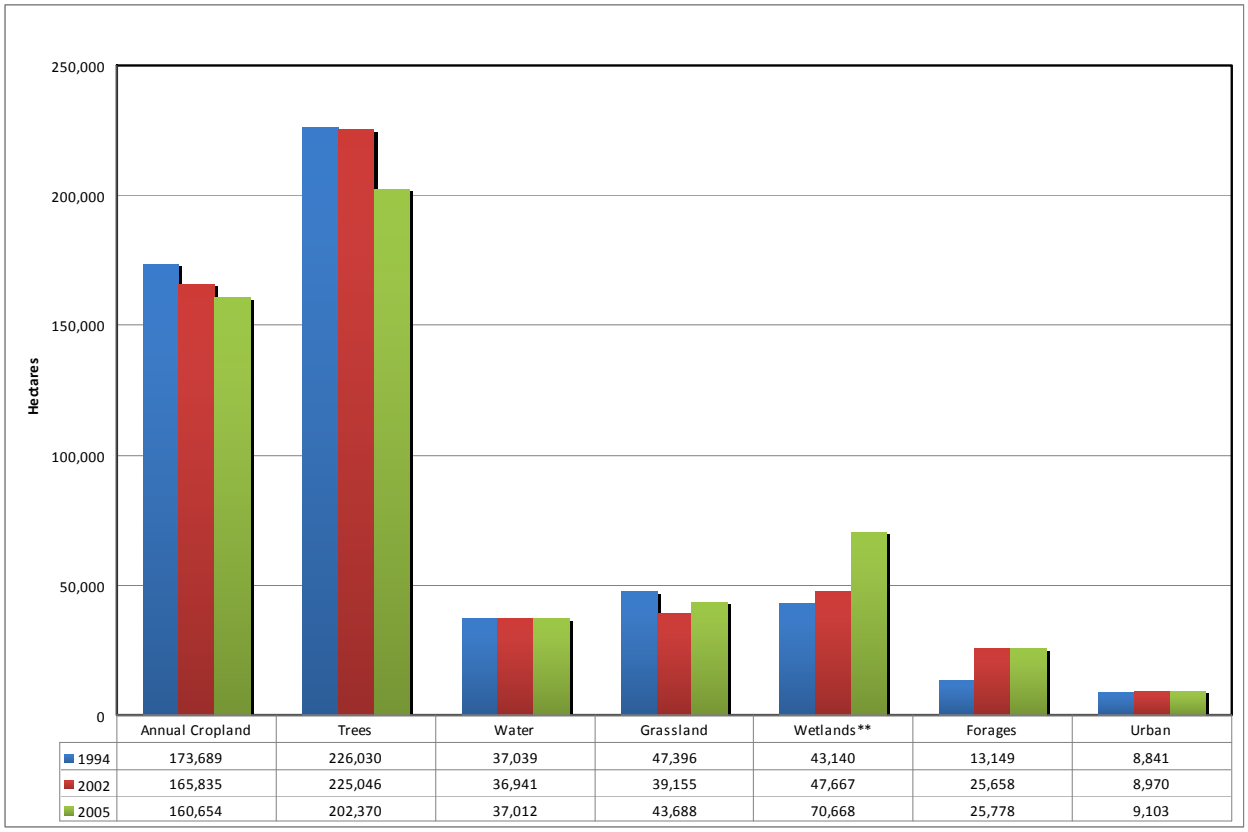
- **The largest change in land cover was an increase of 65% in wetlands from 1994 to 2005 (from 43,000 ha to 71,000 ha). This may be attributed to total precipitation and total rainfall annual amounts which exceeded the 30 year average for five of the six years surrounding the dates of the landcover imagery (*see Appendix N)*.**
- **Wetlands showed the largest change, an increase of approximately 27,500 hectares (from 43,000 to 70,500 ha). These changes have been linked to decreases in forested areas (down 10%).**
- **Forestry showed the next largest change, a decrease of approximately 27,500 hectares (from 226,000 to 202,000 ha.). These changes have been linked to increases in wetlands (up 65%), and forages (up 96%), all showing significant increases within their individual class.**
- **Local knowledge suggests that some of the forest areas reduction may be related to Louisiana Pacific harvesting softwood on Crown Lands in the watershed.**
- **Annual Cropland also showed a significant change, with a decrease of approximately 13,035 hectares (from 174,000 to 161,000 ha.). This decrease could be primarily attributed to changes in forage production, excess moisture (as evident by the increase in the wetland class), or movement to winter site management practices for livestock.**
- **Decreases noted in the annual cropland were almost offset by the increases noted in the Forage landcover class (an increase of 12,500 ha to 25, 800 ha, almost 96%). These increases are primarily be attributed to forage rejuvenation based on local knowledge. The changes are mostly noted along the south and southwest portion of the watershed, with a majority of those areas affected by forest encroachment.**
- **While forages increased, grassland decreased (from 47,400 ha in 1994 to 39,100 ha in 2002), suggesting that forage gains may have come from grassland losses. This may be the result of forage rejuvenation, or an increase in hay production associated with a strong livestock industry prior to BSE.**
- **Landcover changes observed with the 1994-1999 dataset conducted for the 2001 Basin plan showed consistency with the 13 year landcover analysis completed for this report. A decrease in annual cropland and forested areas, and increase in forage and grasslands were noted during the same time period.**

Table 11: Change in land cover from 1994 to 2002 to 2005[1]

Land Cover	1994 Area (ha)	2002 Area (ha)	2005 Area (ha)	Change from 1994 to 2002 (ha)	Change from 2002 to 2005 (ha)
Annual Cropland	173,689	165,835	160,654	-7,853	-5,181
Trees	226,030	225,046	202,370	-984	-22,675
Water	37,039	36,941	37,012	-98	71
Grassland	47,396	39,155	43,688	-8,240	4,533
Wetlands	43,140	47,667	70,668	4,527	23,001
Forages	13,149	25,658	25,778	12,510	119
Urban	8,841	8,970	9,103	129	133
Totals[2]	**549,283**	**549,273**	**549,272**		

1. Area totals are approximate due to the nature of the image analysis procedure
2. Extent of Land Cover image does not encompass entire IWMP study area.

Figure 18: Comparison of change in land cover from 1994 to 2005*



* Area totals are approximate due to the nature of the image analysis procedure
** Due to seasonal changes in wetland size, date of imagery will affect area

iii. Other Agricultural Land Use Trends/Impacts

Agricultural land use is constantly changing due to factors such as weather, markets, crop rotation or changes in agricultural production systems (livestock versus crop production). In this section, a more detailed examination of the land cover classes from 1994 is compared to the 2005 imagery in order to assess how much one classification has changed over a time period. It can also identify where changes in land use are occurring, thereby giving some indication of influences of land management or land use change. It should be noted that data classification limitations and the acquisition dates of the satellite images can introduce discrepancies into these values. As noted in the earlier section, precipitation levels noted for the landcover dates may also influence land cover classifications. Further field investigations would be required to verify these findings.

Changes in Annual Cropland Area

Changes in land use can reflect changes in land management practices, and possible impacts on environmentally sensitive areas. Annual cropland changes can be attributed to a number of factors including crop rotations, market and economic drivers, as well as, environmental factors. ***Figure 19*** identifies where changes in annual cropland have taken place from 1994 to 2005.

In the Swan Lake IWMP:

- **The area of annual cropland dropped by approximately 7.5% or 13,000 ha from 1994 to 2005** (***Table 11***).
- **Analysis indicates that annual cropland was most often converted to forages. Approximately 17,500 ha. of annual cropland in 1994 was converted to forages in 2005 (*Figure 19*).**
- **Approximately 5,600 ha. experienced a reciprocal conversion of forages in 1994 to annual cropland in 2005, resulting in a net decrease of annual cropland (approximately 11,900 ha). This change occurred throughout the watershed with a concentration in the very southwest portion of the watershed (*Figure 20*).**
- **Most of the remaining land that was converted to annual cropland in 2005 came largely from grasslands that were present in 1994 (*Table 11*).**

Figure 19: Total change in area of annual cropland, in relation to other land cover types, in the Swan Lake IWMP study area (from 1994 to 2005)

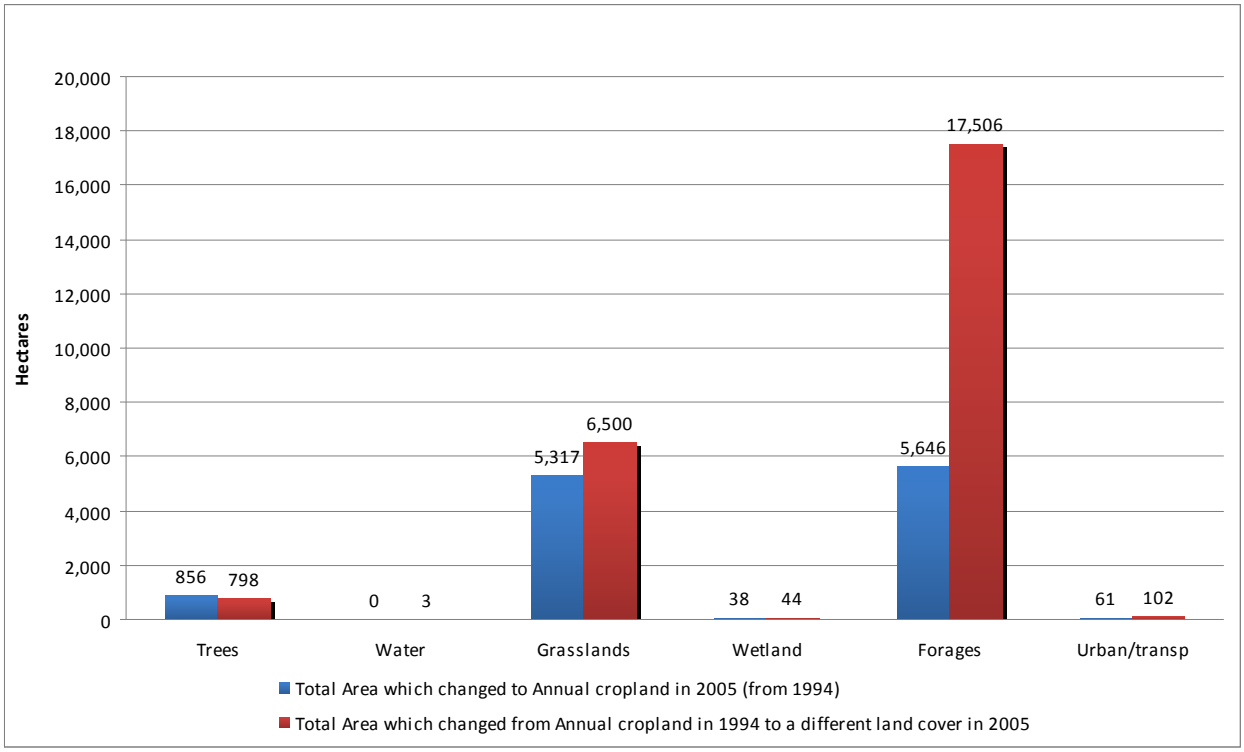
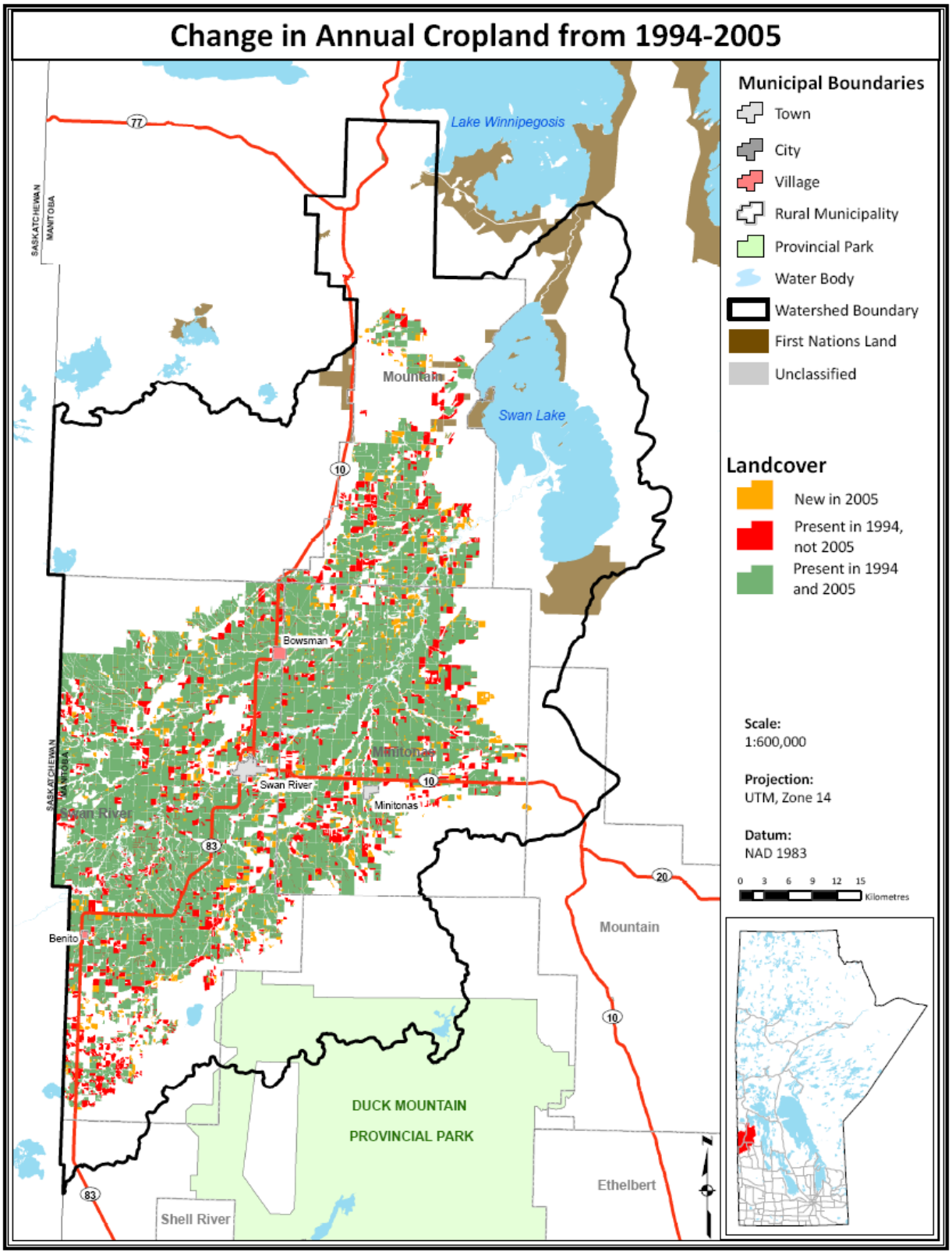


Figure 20: Analysis of Annual Cropland changes between the 1994 and 2005 Land Cover data*



* Land cover is derived from satellite imagery taken May 14, 1994 and September 9, 2005

Changes in Grassland Area

Analyzing changes in grassland cover can be useful to understand potential water quality risks. Grasslands can also be beneficial for reducing runoff and flood mitigation. ***Figure 21*** summarizes the amount of land which changed to or from grassland from 1994 to 2005.

While conversion to grasslands may be due to market and economic pressures, producers may also choose to convert land to decrease environmental risks. For example, the increased conversion of grasslands to annual cropland on soils prone to erosion could impact water quality, as well as increase flooding downstream due to the potential of increased runoff. As a result, this could also lead to increased contaminants in water if appropriate management practices are not applied.

In the Swan Lake Study area:

- **There was an overall decrease of almost 8% or 3,700 ha of grassland from 1994 to 2005 (*Table 11*).**
- **The decrease of grassland cover was due primarily to a change in tree cover (approximately 6,700 ha.), which was larger than what was noted for the reciprocal conversion (almost 3,300 ha of grassland from trees in 2005). This suggests tree encroachment into natural grasslands and pastures is occurring more frequently (*Figures 21* and *22*).**
- **Another significant change noted was the conversion of approximately 6,500 ha of annual cropland in 1994 to grassland in 2005. Conversely, approximately 5,300 ha of grassland noted in 1994 was identified as annual cropland in 2005, indicating a net change of 1,200 ha to grasslands.**
- **Information from local sources suggests that this change may be more a result of pasture or forage rejuvenation for larger cattle herds, or a move toward winter site management by cattle producers.**
- **The third largest change surrounding grasslands in 1994 was to forages (approximately 3,300 ha). Near equal reciprocal changes were noted for new grassland landcover in 2005; 2,700 ha of forages previously identified in 1994 were noted as grasslands in 2005. This suggests a close relationship between the classes, and that beneficial management practices, such as pasture rejuvenation, may play a big role.**
- **The movement of grassed lands to trees is most likely a result of brush encroachment.**
- **Although changes to grassland cover were noted throughout the entire watershed, concentrations in the very southeast (near Duck Mountain Provincial Park) and eastern portions of the watershed contributed the majority of this change.**

Figure 21: Total change in area of grassland compared to other land cover types in the Swan Lake IWMP study area (from 1994 to 2005)

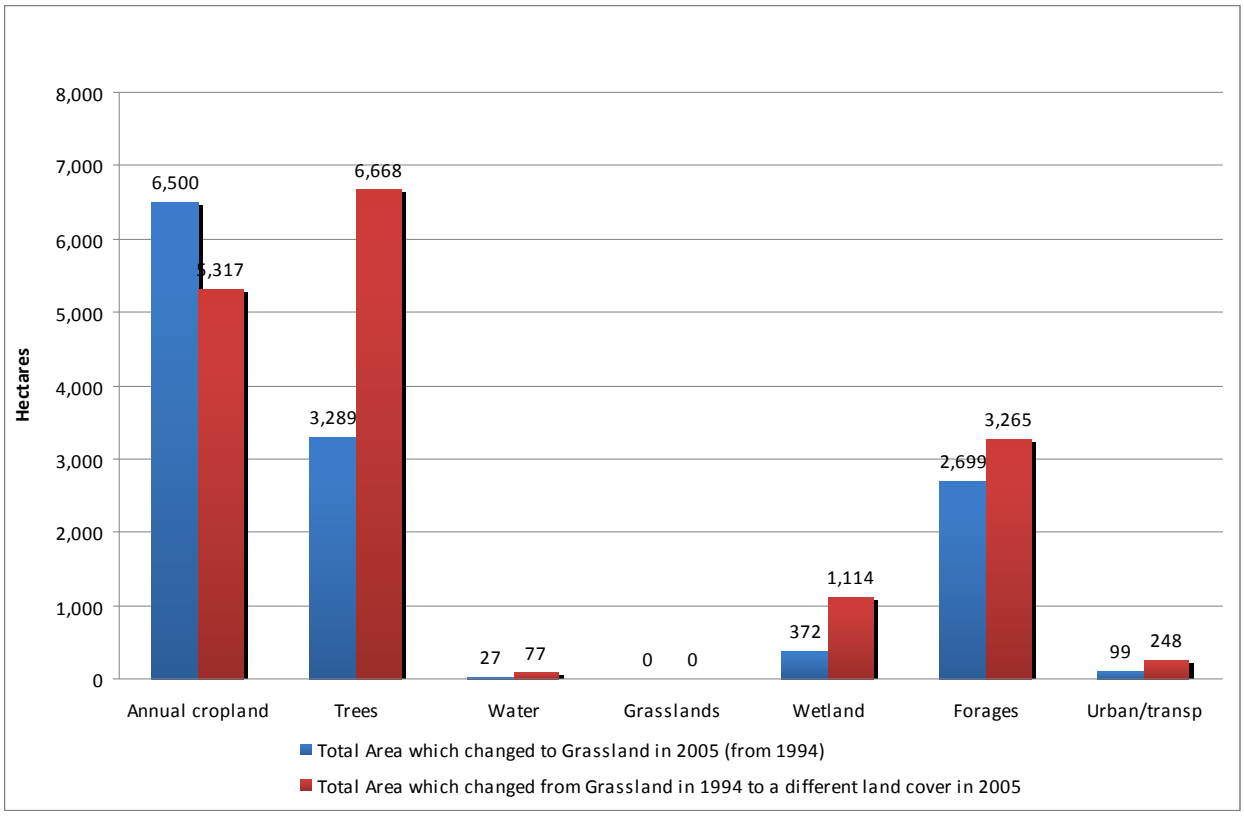
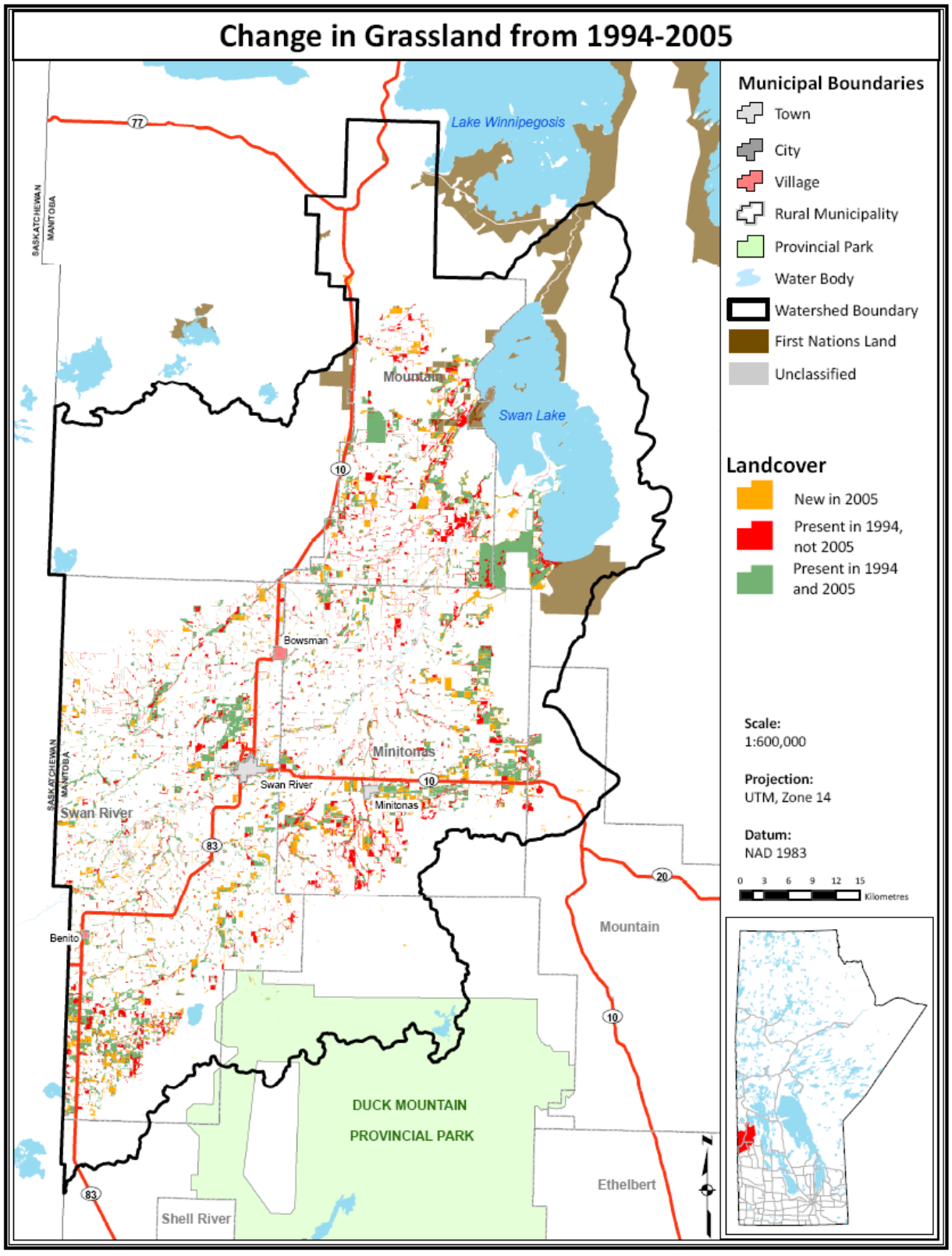


Figure 22: Analysis of Grasslands changes between the 1994 and 2005 Land Cover data*



* Land cover is derived from satellite imagery taken May 14, 1994 and July 14, 2005

Changes in Forested Areas

Assessing the Forested Areas classification change can provide information on the impacts of flooding, water supply and quality, as well as biodiversity. ***Figure 23*** summarizes the areas which experienced changes to and from forested cover from 1994 to 2005**.**

In the Swan Lake watershed:

- **There was a significant decrease of forested areas in 2005 (11% or approximately 24,000 ha) when compared to 1994 (*Table 11*).**
- **Approximately 7,000 ha of the forested areas in 1994 were identified as wetlands in 2005. At the same time, approximately 33,000 ha. of forested lands in 1994 were converted to wetlands.**
- **Most of the areas converted to forest in 2005 are dispersed throughout the watershed, with larger amounts found along the Duck Mountains Provincial Park and in the northwest portions of the watershed (*see Figure 24*).**
- **One possible consideration for the changes noted is the annual precipitation levels in the area, which showed above normal rainfall for the 2005 year (see *Appendix N)*. Some of this may also be attributed to the harvesting of poplar from Louisiana Pacific industry.**

Figure 23: Total Change Forested Lands compared to other land cover types, in the Swan Lake IWMP study area (from 1994 to 2005)

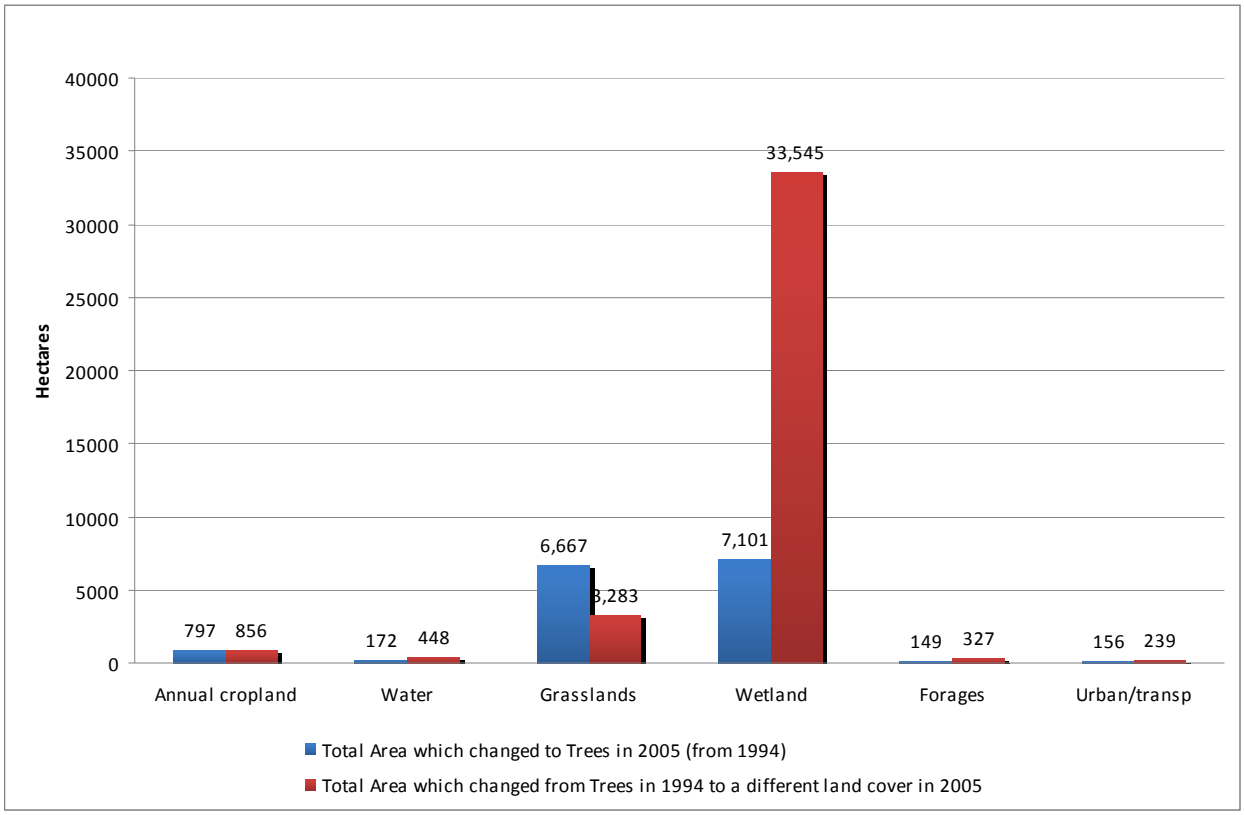
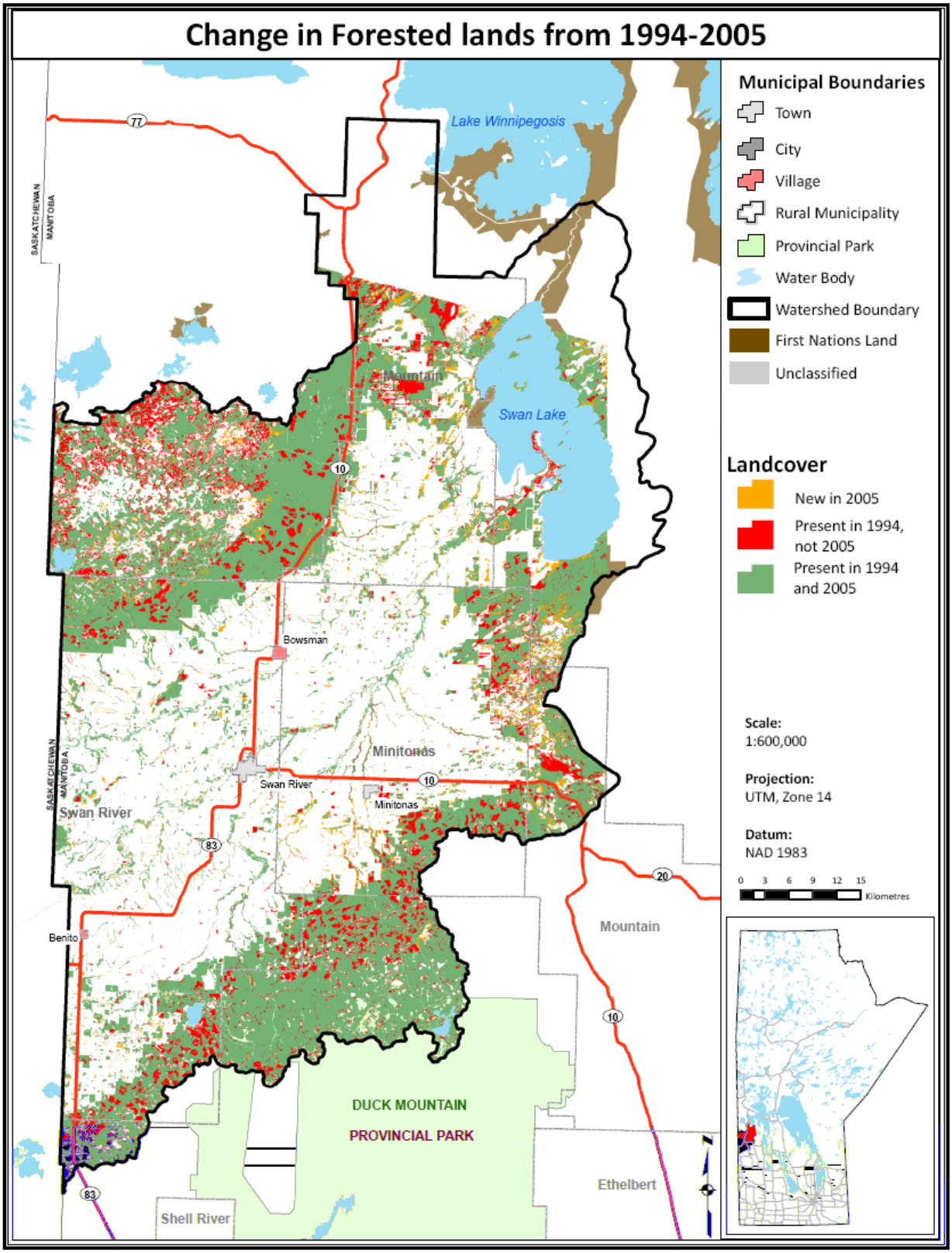


Figure 24: Analysis of Forested Areas change between the 1994 and 2005 Land Cover data*



* Land cover is derived from satellite imagery taken May 14, 1994 and July 14, 2005

F. Agricultural Land Use and Management Considerations

This section involves the analysis of a combination of factors including land use and the characteristics of the local landscape in order to determine where consideration should be given to how the land is used or managed, including the potential for adoption of Beneficial Management Practices (BMPs). Land cover data represents an indicator of how the land is being used, while relevant landscape characteristics and risk factors are contained within the soils dataset. Further information about land cover data can be found in ***Appendix C***, while more information regarding the soils data can be found in ***Appendix D***.

i. Agricultural Capability Analysis

The Canada Land Inventory System (CLI) was used to classify land based on agricultural capability. The CLI is a comprehensive survey of land capability and land use aimed at providing a basis for making land-use planning decisions. Under the CLI, lands are classified according to their physical capability for agricultural use (PFRA, 2005).

Agricultural capability can best be described as the ability of the land to support the appropriate type of crops and agriculture management practices. Soil properties and landscape conditions such as topography, stoniness, and other potential limitations all influence how the land is being used and what agricultural management practices should be in place to reduce environmental risks. Classes ranging from 1 to 7 have been established, with 1 being the highest rated land class with no limitations to annual crop production and 7 being the lowest rated land (not suitable for agriculture). Further information about CLI and specific characteristics and limitations associated with the various land classes is provided in ***Appendix E***.

Analytical Methods

Analysis of the land classes using CLI helps to understand the extent of agricultural activity on marginal lands. The analysis included determining how much annual crop production takes place on marginal lands, to what extend marginal lands are protected by perennial forage cover, and what changes in management practices have taken place between 1994 and 2005.

The analysis concludes the following:

- **A relatively large portion of the watershed is considered productive Class 1, 2 and 3 lands (41% or approximately 252,000 ha).**
- **59% (361,376 ha) of the soils in the watershed are Class 4 and lower.**
- **Approximately 7% of the watershed (43,094 ha) consists of organic soils.**

2005 Cropland on Class 4 and poorer soils

Within the Swan Lake Watershed study area:

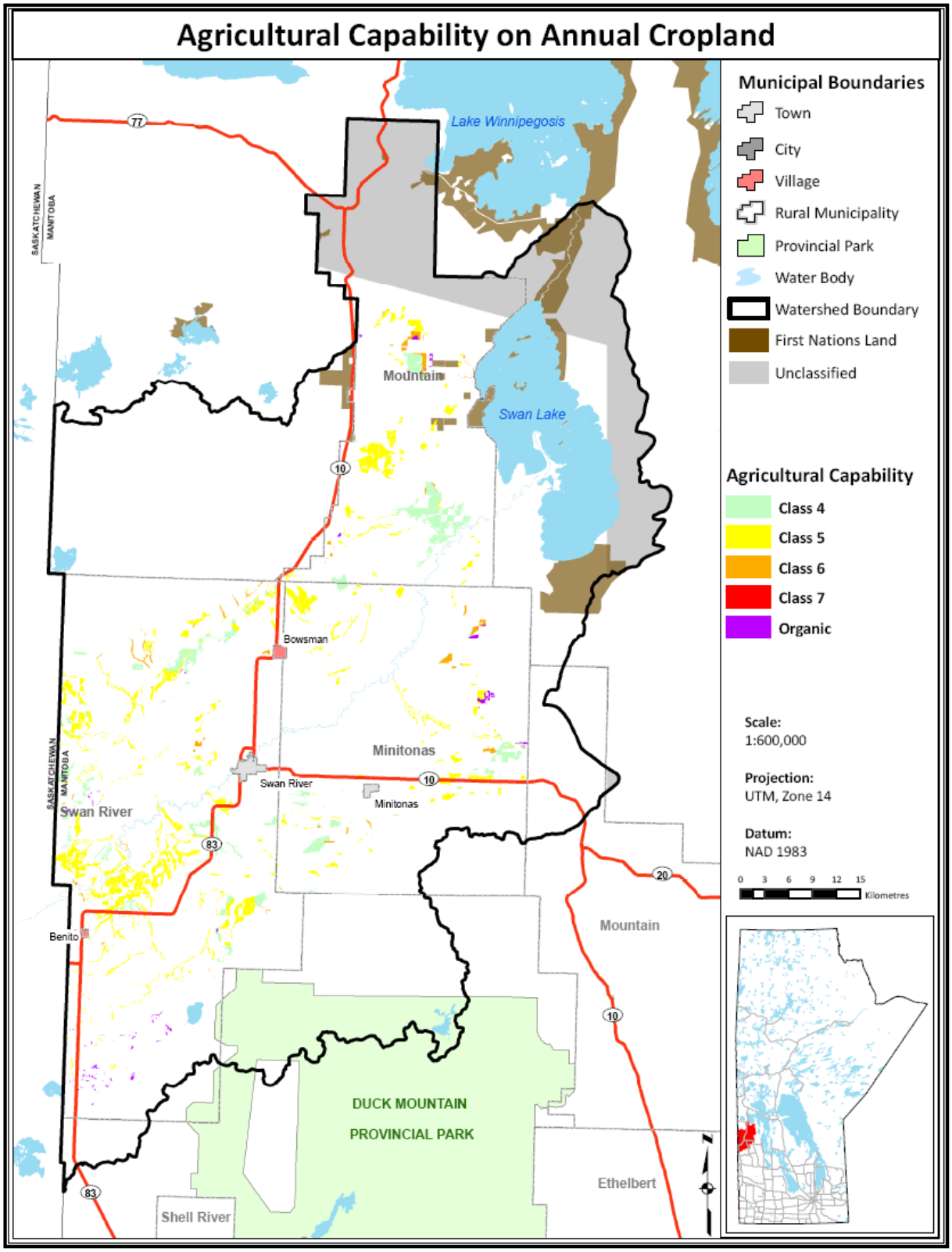
- **The majority of the annual cropland is located on what is considered productive agricultural land, classified as Class 1, 2 and 3 soils (86%, 138,100 ha)** (**see *Table 12***).
- **Approximately 13% (22,263 ha) of the annual cropland is on marginal lands (Class 4 or lower).**
- **Annual cropland on Class 4 and lower soils is scattered throughout the central portions of the watershed, with concentrations located in the western central portion.** (**see *Figure 25***).
- **The amount of marginal land being annually cropped has decreased since 1994.**
- **Decreases were reflected in all classes, with a majority of the decreases noted on Class 3 land.**
- **The decrease in annual crop production is associated with an increase in forage production and may be linked to livestock operations incorporating silage or annual forages in their feeding strategies or winter grazing/winter site management.**

Table 12: Agricultural Capability in the Swan Lake Watershed Study Area

Class[1]	Total Area in IWMP (ha)[5]	2005 Annual Cropland (ha)[2]	Distribution of Annual Cropland (%)	1994 Annual Cropland (ha)[3]	1994 to 2005 Change in Annual Cropland Area (ha)[4]
Class 1	8,833	7,114	4	7,489	-375
Class 2	110,781	79,582	50	84,097	-4,515
Class 3	132,212	51,445	32	56,527	-5,082
Class 4	26,096	6,819	4	7,651	-832
Class 5	43,863	13,644	8	15,543	-1,899
Class 6	24,366	1,254	1	1,383	-129
Class 7	329	4	0	13	-9
Organic	43,094	542	0	658	-116
Unclassified	220,334	0	0	0	0
Water	3,469	246	0	313	-67
TOTAL	**613,376**	**160,650**	**100**	**173,676**	**-13,025**

1. Agricultural Capability is based on the CLI Rating of the dominant soil series for each soil polygon
2. Annual Cropland taken from the 2005 Land Cover (from Landsat Imagery captured on September 11, 2005)
3. Annual Cropland taken from the 1994 Land Cover (from Landsat Imagery captured on May 14, 1994)
4. Figures are derived from the total area of annual cropland in 2005 minus total annual cropland in 1994 in each Class
5. Extent of Soils data is limited in size and does not encompass entire IWMP study area

Figure 25: Areas annually cropped in 2005 on soils with an agricultural capability of Class 4, 5, 6 or 7 in the Swan Lake Watershed IWMP study area[1]



1. Agricultural capability is based on the CLI Rating of the dominant soil series for each soil polygon

ii. Wind Erosion Risk Analysis

Wind erosion risk information in Manitoba has been developed from the provincial soil survey data and the Soil Landscapes of Canada (SLC Ver 1.0 - see ***Appendix G***). The Wind Erosion Risk model used for the Agriculture Canada Wind Erosion Risk Maps (1989) incorporates soil moisture, surface roughness and aggregate size, and drag velocity by wind. Erosion risk classes were assigned based on the weighted average soil loss for each map polygon. The five classes of soil erosion risk (ranging from negligible to severe) are based on a bare, unprotected soil condition and do not consider land use and crop management factors. Cropping and residue management practices can significantly reduce erosion risk depending on crop rotation, soil type, and landscape features. Basing soil erosion risk on a bare soil scenario helps to identify areas dominated by sensitive, erosive soils which may otherwise be masked if a land use or surface vegetation cover factor was considered (Eilers et. al. 1989).

In the Swan Lake Watershed:

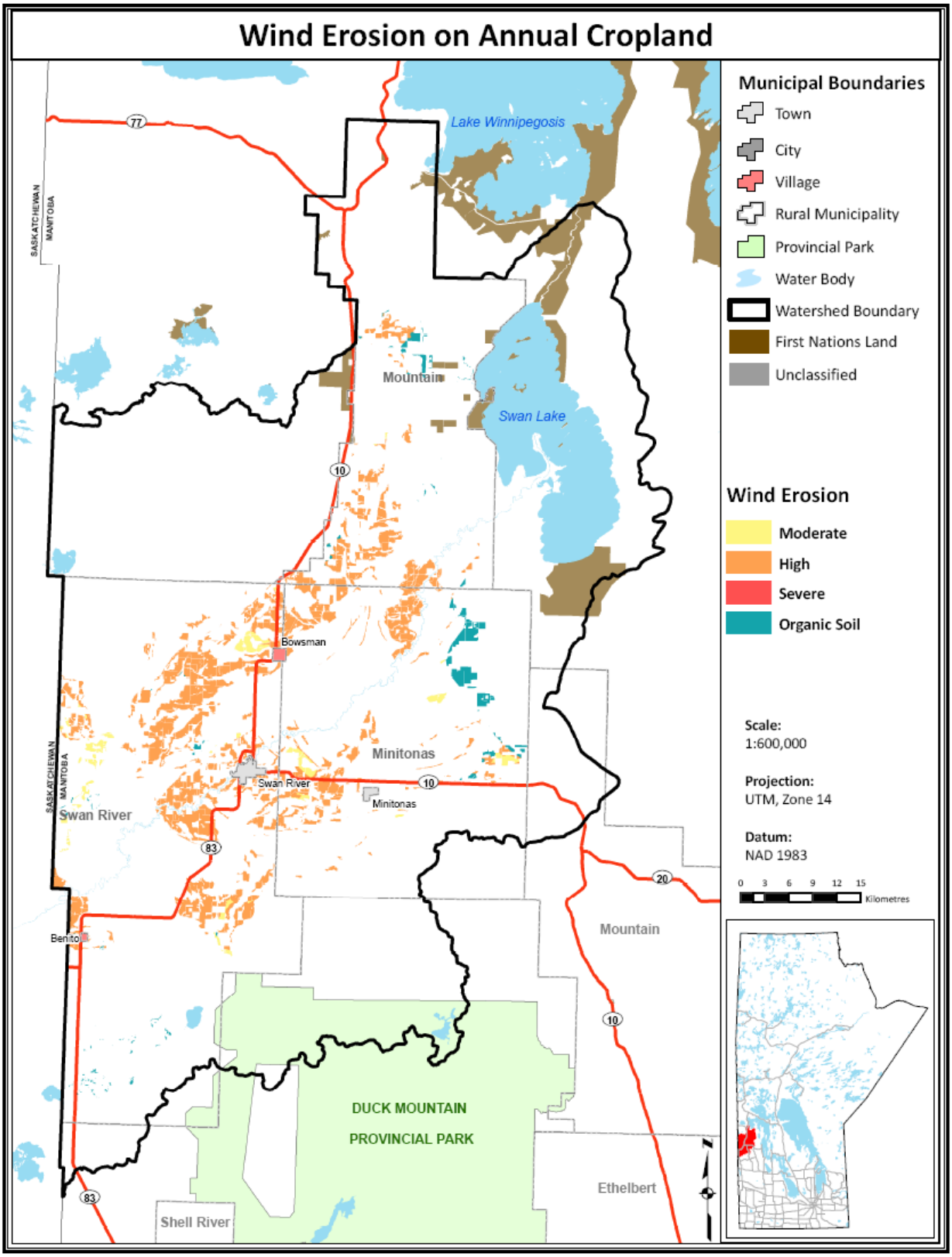
- **Approximately 11% (70,000 ha) consists of soils with a moderate, high, or severe wind erosion risk** (***see Table 13***).
- **40% of the watershed's soils are considered to have a negligible to low risk to wind erosion. As such, wind erosion is not considered to be a major issue in the watershed.**
- **Based on the 2005 land cover data, approximately 21% of the annual cropland was located on soils with moderate, high, to severe risk for wind erosion** (***see Table 13***). **This is a decrease of approximately 3,100 ha from what was identified for 1994 on these types of soils. This decrease may also be associated to the amount of available hectares for annual cropland in 2005, approximately 13,000 ha less than in 1994.**
- **Most of the 2005 annual cropland located on high, moderate, or severe soils was situated in central portions of the watershed (*see Figure 26*)**

Table 13: Wind Erosion Risk on Annual Cropland in the Swan Lake Watershed Study Area from 2005 Land Cover [1]

Wind Erosion[1]	Total Area in IWMP (ha)	2005 Annual Cropland (ha)[2]	Distribution of Annual Cropland (%)	1994 Annual Cropland (ha)[3]	1994 to 2005 Change in Annual Cropland Area (ha)[4]
Negligible	139,339	76,006	47	80,875	-4,869
Low	105,290	48,278	30	52,847	-4,569
Moderate	9,108	2,493	2	2,780	-287
High	61,052	30,465	19	33,365	-2,900
Severe	0	0	0	0	0
Organic Soil	85,194	2,766	2	3,041	-275
Water	32,835	246	0	313	-67
Unclassified	181,107	398	0	466	-68
TOTAL[5]	**613,925**	**160,653**	**100**	**173,687**	**-13,035**

1. Wind Erosion Risk is based on the weighted wind erosion rating for each soil polygon and assumes bare soil.
2. Annual Cropland taken from the 2005 Land Cover (from Landsat Imagery captured on July 14, 2005)
3. Annual Cropland taken from the 1994 Land Cover (from Landsat Imagery captured on May 14, 1994)
4. Figures are derived from the total area of annual cropland in 20062005 minus total annual cropland in 1994 in each Risk Class
5. Extent of Soils data is limited in size and does not encompass entire IWMP study area

Figure 26: Risk of Wind Erosion on 2005 Annual Cropland in the Swan Lake Watershed



iii. Water Erosion Risk Analysis

The overland flow of water can, under certain circumstances, carry particles of soil with it. Rain splash erosion, sheet erosion, rill erosion and gully erosion are all caused by water. Where this occurs, there is the potential to carry large quantities of sediment and contaminants to nearby waterways and waterbodies throughout the watershed. This section examines where in the watershed that there may be a greater potential for this to happen. The analysis focuses on annual cropland from land cover data (see ***Appendix C***) in conjunction with water erosion risk (see ***Appendix F***) and the proximity of these areas to water courses.

Water Erosion Risk

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

In the Swan Lake Watershed:

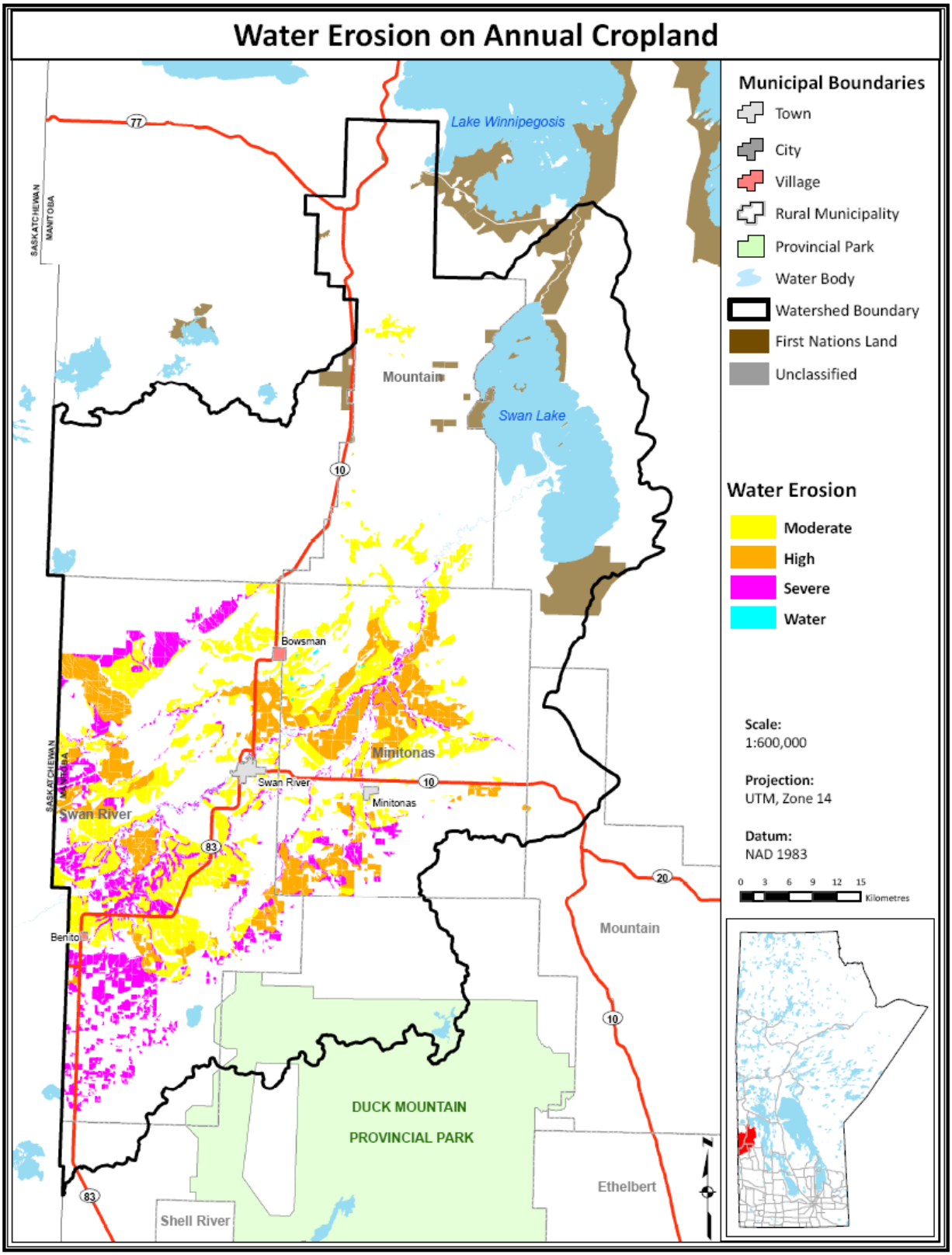
- **Approximately 31% of the study area (189,900 ha) has a moderate, high or severe risk to water erosion. 15% is identified as having severe water erosion risk areas alone in the watershed.**
- **A majority of the 2005 Annual Cropland was located on soils with a moderate soil erosion risk.**
- **The amount of annual cropland on soils with a moderate, high or severe water erosion risk dropped from 1994 (over 7,200 ha, see *Table 14, Figure 27*). Decreases in annual cropland were noted in all classes; however, this was likely attributed to change in the overall area of annual cropland from 173,700 ha in 1994 to 160,700 ha in 2005.**
- **Most of the annual cropland located on soils with moderate, high or the severe risk of water erosion was located in the southern half of the watershed (*see Figure 27)*.**

Table 14: Water Erosion Risk on Annual Cropland in the Swan Lake Watershed Study Area from 2005 Land Cover

Water Erosion[1]	Total Area in IWMP (ha)[5]	2005 Annual Cropland (ha)[2]	Distribution of Annual Cropland (%)	1994 Annual Cropland (ha)[3]	1994 to 2005 Change in Annual Cropland Area (ha)[4]
Negligible	155,089	40,006	25	43,998	-3,992
Low	44,582	26,977	17	28,742	-1,765
Moderate	61,625	42,640	27	45,128	-2,488
High	37,290	27,674	17	29,044	-1,370
Severe	90,986	23,107	14	26,450	-3,343
Water	3,469	246	0	313	-67
Unclassified	220,334	0	0	0	0
TOTAL[5]	**613,376**	**160,650**	**100**	**173,676**	**-13,025**

1. Water Erosion Risk is based on the weighted average USLE predicted soil loss within each soil polygon, assuming bare unprotected soil.
2. Annual Cropland taken from the 2005 Land Cover (from Landsat Imagery captured on July 14, 2005)
3. Annual Cropland taken from the 1994 Land Cover (from Landsat Imagery captured on May 14, 1994)
4. Figures are derived from the total area of annual cropland in 2005 minus total annual cropland in 1994 in each Risk Class
5. Extent of Soils data is limited in size and does not encompass entire IWMP study area

Figure 27: Risk of Water Erosion on 2005 Annual Cropland in the Swan Lake Watershed[1]



1. Water Erosion Risk is based on bare soil and does not take into account vegetative cover or management practices

iv. Soil Drainage Analysis

Soil drainage reflects the actual moisture content in excess of field capacity and the length of the saturation period within the plant root zone. Excess water content in the soil limits the free movement of oxygen and decreases the efficiency of nutrient uptake. Delays in spring tillage and planting are more likely to occur in depressional or imperfectly to poorly drained areas of individual fields. Surface drainage improvements and tile drainage are management practices that can potentially be used to manage excess moisture conditions in soils but should only be used if deemed appropriate for a site specific situation and only where regulations requirements can be met. Agriculture and Agri-Food Canada (AAFC) has classified soils for their drainage capacity using a five class system (see ***Appendix H***).

Improved drainage indicates areas where networks of surface drains can accelerate surface runoff that reduce the duration of surface ponding and provide greater flexibility to crop management. While these drains effectively move water off fields and decrease the amount of standing water in agricultural fields, other adverse effects need to be considered. The drains facilitate water moving off fields more quickly than under natural run off conditions resulting in river channels being filled to high water levels during heavy precipitation events. High water levels could lead to a flood or near-flood stage, thereby increasing the risk for water erosion or property damage. Unlike natural and undisturbed watercourses, man-made drainage systems tend not to have healthy riparian buffers associated with them. Insufficiently sized (or a complete absence of) riparian buffers may cause an increased risk of nutrient and sediment loading into watercourses. Riparian areas and perennial vegetation on adjacent lands are able to trap and store sediment and nutrients from field runoff during the growing season, reducing the risk of contaminating surface water.

- **Imperfectly drained soils make up the largest portion of the watershed at 23% or 142,100 ha (*see Table 15)*.**
- **Analysis of soil drainage shows that the majority (approximately 40% or 247,300 ha) of the watershed can be considered to be very poorly to imperfectly drained land.**
- **Most of the imperfectly drained soils are located in the eastern and central portions of the watershed.**

Soil Drainage of Annual Cropland

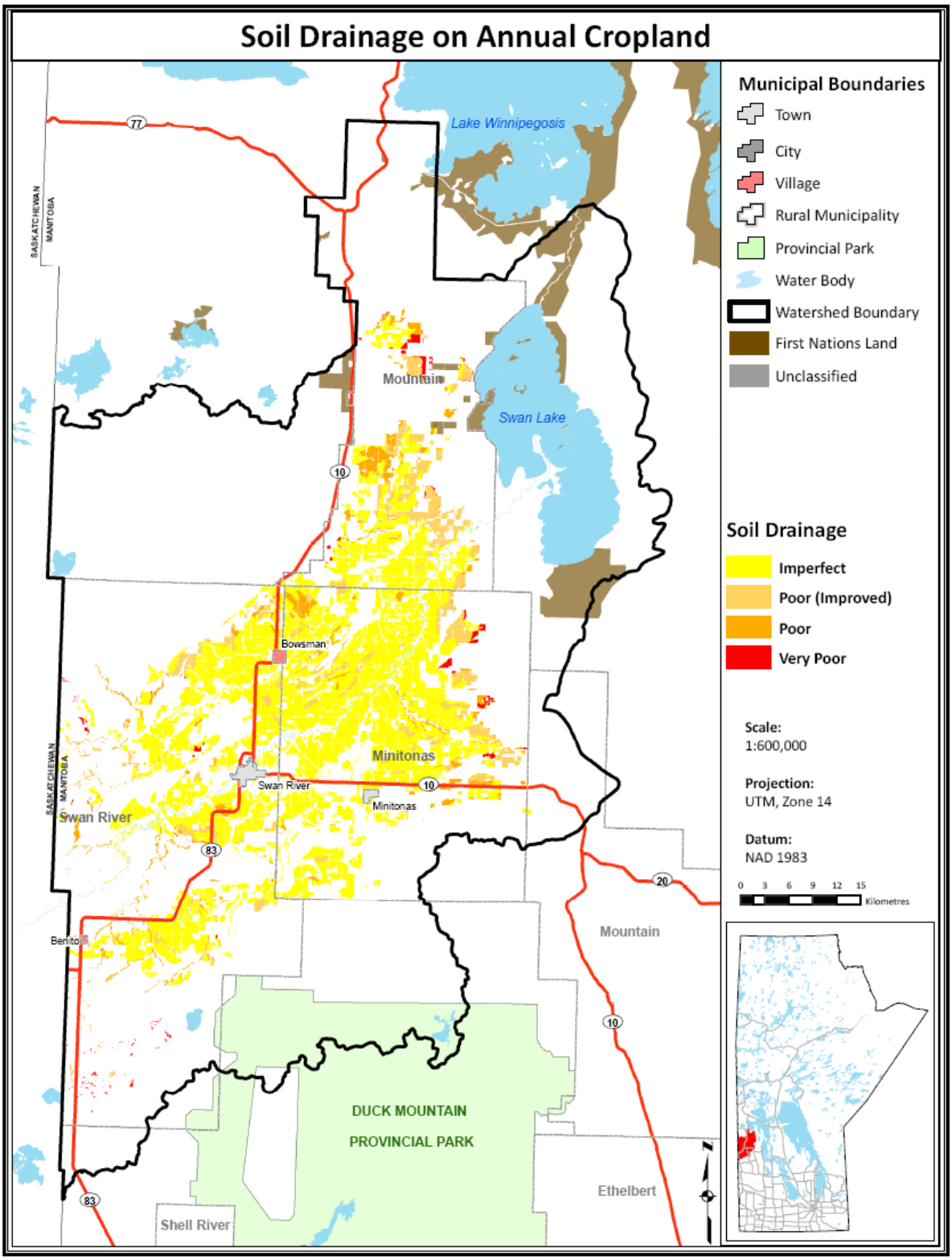
- **Most of the annual cropland in 2005 was located on imperfectly drained soils (51% or 82,700 ha).**
- **Approximately 64% (103,400 ha) of the 2005 annual cropland was located on very poorly to imperfectly drained land.**
- **This was located in the central lowlands portion of the watershed (refer to *Figure 28*).**
- **Annual Cropland decreased on all drainage classes in the watershed, most likely due to the reduction in the amount of Annual Cropland from 1993 to 2005 (173,700 ha in 1994 to 160,600 ha in 2005).**
- **The biggest decrease in annual cropland from 1994 to 2005 was noticed on lands classified as imperfectly drained soils.**
- **The percentage of annual cropland on very poor to imperfectly drained has remained the same from 1994 to 2005 despite the decrease of annual cropland area in 2005. (*See Table 15*).**

Table 15: Soil Drainage Classes in the Swan Lake Watershed

Drainage Class[1]	Total Area in IWMP (ha)[5]	2005 Annual Cropland (ha)[2]	Distribution of Annual Cropland (%)	1993 Annual Cropland (ha)[3]	1993 to 2005 Change in Annual Cropland Area (ha)[4]
Rapid	9,362	1,511	1	1,599	-88
Well	132,828	55,509	35	60,359	-4,850
Imperfect	142,066	82,665	51	88,438	-5,772
Poor (Improved)	18,840	11,945	7	12,848	-903
Poor	25,038	7,325	5	8,433	-1,108
Very Poor	61,359	1,446	1	1,674	-228
Unclassified	220,334	0	0	0	0
Water	3,469	246	0	313	-67
TOTAL[5]	**613,296**	**160,646**	**100**	**173,663**	**-13,016**

1. Drainage Class is based on the CLI Rating of the dominant soil series for each soil polygon
2. Annual Cropland taken from 2005 Land Cover (from Landsat Imagery captured on September 9, 2005)
3. Annual Cropland taken from the 1994 Land Cover (from Landsat Imagery captured on May 14, 1994)
4. Figures are derived from the total area of Annual cropland in 2005 minus total Annual cropland in 1994 in each class
5. Extent of Soils data is limited in size and does not encompass entire IWMP study area

Figure 28 - Soil Drainage with Respect to 2005 Annual Cropping in the Swan Lake Watershed Study Area[1]



1. Soil drainage class is based on the dominant soil series for each soil polygon

ii. Soil Texture Analysis

Soil surface texture strongly influences the soil's ability to retain moisture, its general level of fertility, and the ease or difficulty of cultivation. For example, water moves easily through coarse-textured (sandy) soils, with little moisture being retained resulting in these soils drying out more quickly than fine-textured (clayey) soils. Sandy soils are often characterized as having a loose or single-grained structure which is very susceptible to wind erosion whereas clay soils have a high proportion of very small pore spaces that are capable of retaining moisture. Clay soils are usually fertile because they have a greater capacity to retain nutrients than sandy soils. However, they transmit water very slowly and are therefore susceptible to saturation from excess moisture conditions (PFRA, 2005).

Soil texture in the Swan Lake watershed can have a bearing on groundwater management and potential contamination. Proper land management is important as soil textures can contribute to greater subsurface movement to the groundwater source, particularly where there is thin soil overburden to the aquifer. Furthermore, surface water movement into the bedrock material can increase contamination risks due to the chemical makeup of the surface water and by the physical properties of freezing and thawing.

Soil Texture in the Swan Lake IWMP

- **Loamy type texture makes up the largest portion of the watershed 31% or 189,700 ha (*see Table 16)*.**
- **Approximately 11% (69,700 ha) of the watershed has sandy textured soils, located in the central and eastern portions of the watershed (see *Figure 29*).**
- **Approximately 10% (59,600 ha) of the watershed is considered to be organic soils.**

Soil Drainage of Annual Cropland

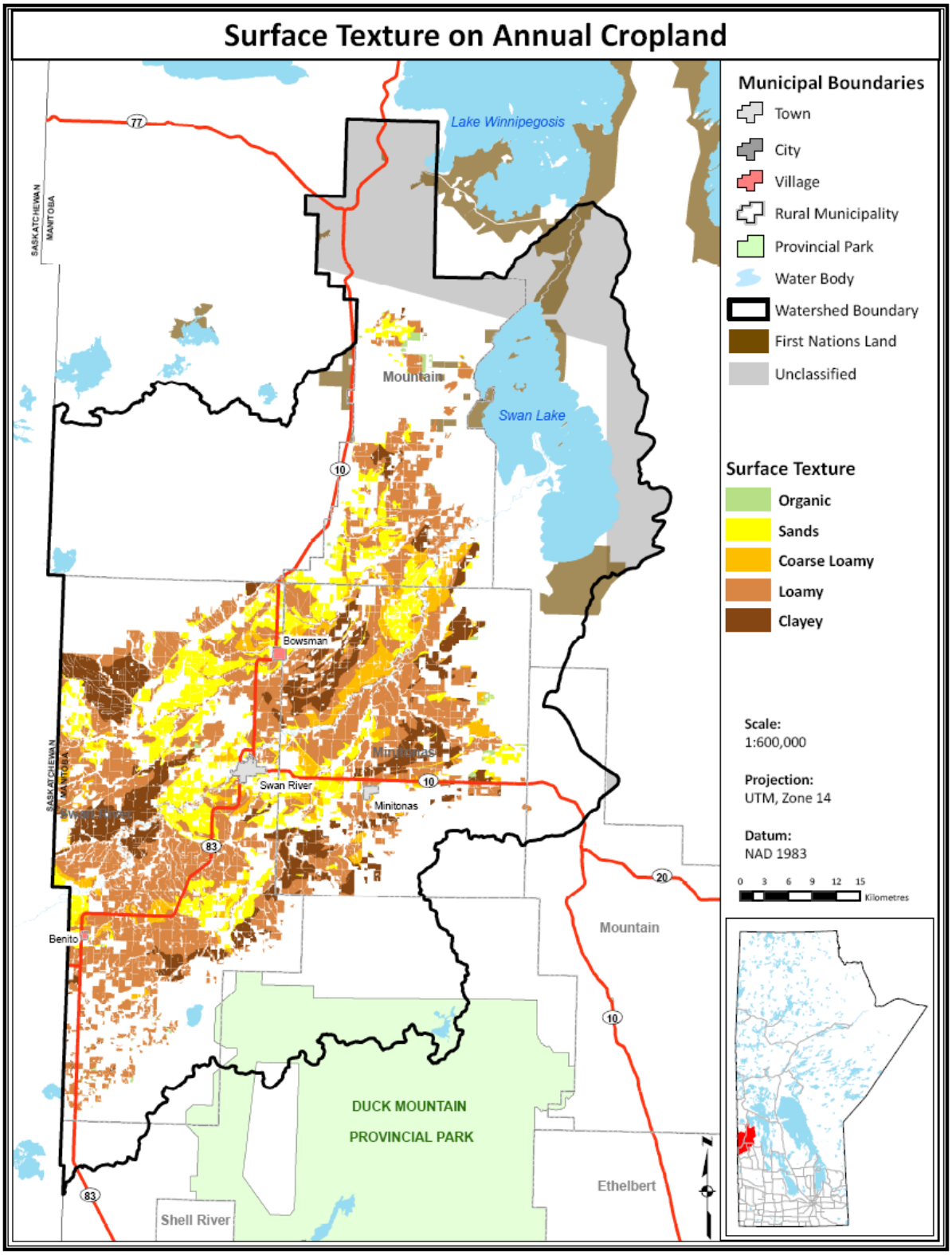
- **Approximately 24% (31,400 ha) of the 2005 annual cropland was located on sandy textured soils.**
- **Annual Cropland decreased on all soil texture classes in the watershed, probably as a result of the reduction in the amount of Annual Cropland from 1993 to 2005 (173,700 ha in 1994 to 160,700 ha in 2005).**
- **The biggest decrease in annual cropland from 1994 to 2005 was on lands classified as loamy textured soils.**
- **There was a 9% (3,000 ha) decrease in annual cropland from 1994 to 2005 on sandy textured soils.**
- **Approximately 1% of annual cropland in 2005 was located on organic soils.**

Table 16: Soil Texture in the Swan Lake Watershed Study Area

Surface Texture Class[1]	Total Area in IWMP Area (ha)[5]	2005 Annual Cropland area (ha)[2]	Distribution of Annual Cropland (%)	1994 Annual Cropland (ha)[3]	1994 to 2005 Change in Annual Cropland Area (ha)[4]
Organic	59,631	1,179	0.9	1,433	-254
Coarse Sands	0	0	-	-	0
Sands	69,665	31,443	23.9	34,401	-2,958
Coarse Loamy	24,224	13,186	10.0	13,960	-774
Loamy	189,675	85,926	65.2	93,031	-7,105
Clayey	42,167	0	0	0	0
Rock	0	0	0	0	0
Unclassified	220,334	392	0	441	-49
Water	3,961	246	0	313	-67
TOTAL[5]	**613,127**	**160,650**	**100**	**173,676**	**-13,025**

1. Soils Surface Texture is based on the textural rating of the dominant soil series for each soil polygon
2. Annual Cropland taken from 2005 Land Cover (from Landsat Imagery captured on September 9, 2005)
3. Annual Cropland taken from the 1994 Land Cover (from Landsat Imagery captured on May 14, 1994)
4. Figures are derived from the total area of Annual cropland in 2005 minus total Annual cropland in 1994 in each class
5. Extent of Soils data is limited in size and does not encompass entire IWMP study area

Figure 29: Areas Annually Cropped in 2005 on Surface Texture in the Swan Lake Watershed IWMP study area[1]



1. Soils Surface Texture is based on the textural rating of the dominant soil series for each soil polygon

G. Recent Federal and Provincial Policies and Programs Affecting Agricultural Land Use and Management

i. Crown Land Management in the Swan Lake Watershed

Crown Lands in the Swan Lake Management make up a significant portion of the watershed, approximately 46% of the landbase (see ***Figure 30***). These lands are generally associated with the Duck Mountain Provincial Park or the Porcupine Hills and are rich in natural resources. The management of these lands is protected through special interest from the Province and have designations based on their available resources, through Provincial Coding for Crown lands (see ***Table 17***).

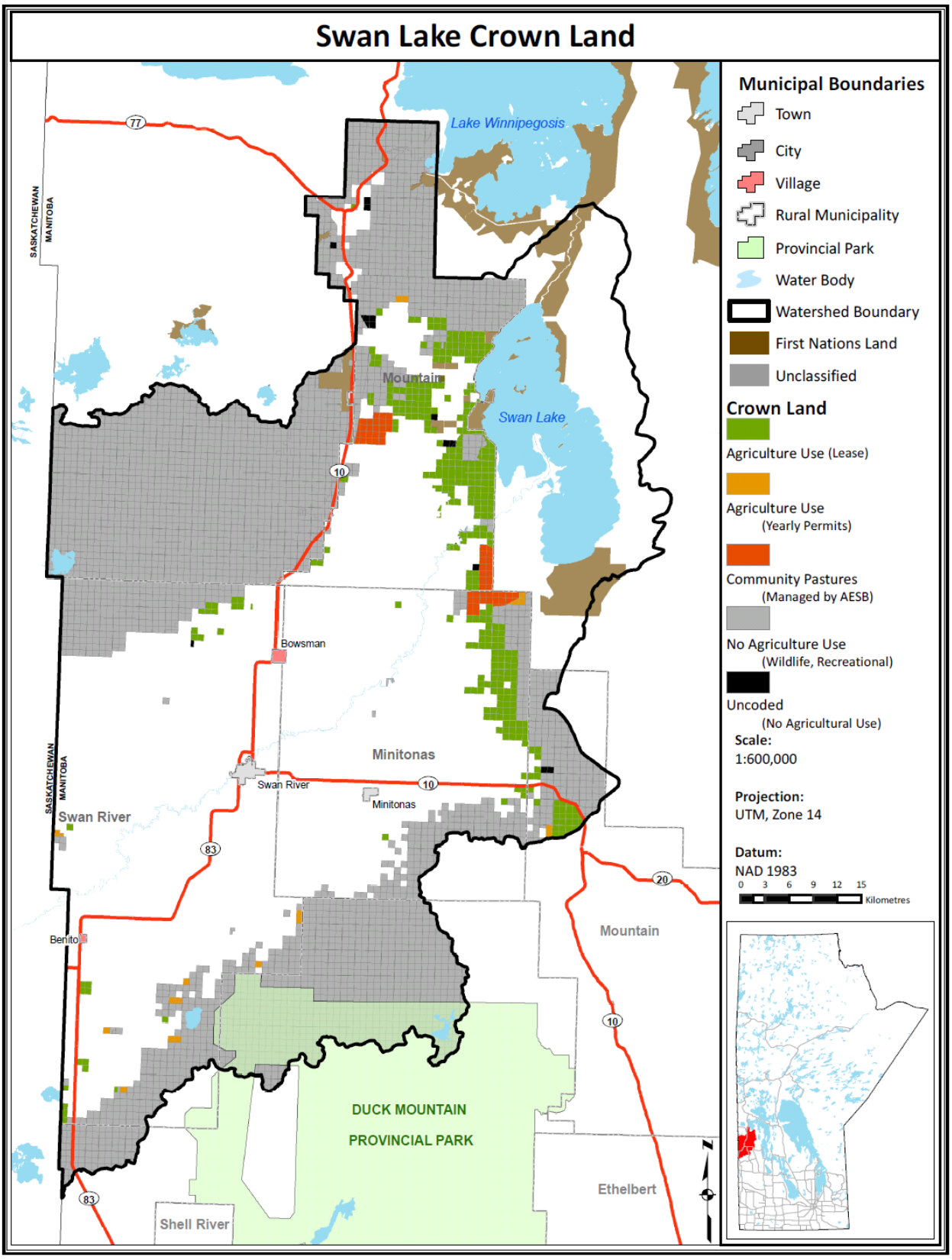
Table 17: Crown Lands in the Swan Lake Watershed Study Area- Hectares by MAFRI Crown Land Use Coding

Crown Land Use	Total Area (ha.)	Percentage
Agricultural Use (Lease)	23,444	9
Agricultural Use (Yearly Permits)	1,176	-
Community Pastures (Managed by AESB)	3,693	1
No Agricultural Use (Wildlife, Forestry)	240,098	89
Uncoded (No Agricultural Use)	873	0
TOTAL	**269,286**	**100**

- **There are approximately 269,200 hectares of Crown Land in the Swan Lake Watershed.**
- **Approximately 24,620 ha (9%) are available for agricultural use through the Agricultural Crown Land leasing and permitting program (See *Appendix M*).**
- **3,693 ha of land are managed by AESB's Community Pasture Program (see *Figure 30*).**
- **A majority of the Crown land is managed for other primary interests like Wildlife and Forestry (approximately 240,000 ha. – 89%).**

The information presented in ***Table 17*** is derived from a different dataset which results in minor discrepancy for the total amount of hectares of crown lands. The Rural Municipality of Mountain contains the majority of crown lands in the Swan Lake Watershed compared to the other municipalities (see ***Table 18***). A significant portion of the Crown Lands in the watershed is located in the Porcupine Provincial Forest.

Figure 30: Crown Land Characterization Coding in the Swan Lake Watershed Area



* Table does not include other categories and reflects a smaller area of Crown lands in the watershed.

Crown Land statistics are captured on a municipal boundary basis. As such, the statistics shown below are based on the total amount of crown land within only three municipalities that are in the watershed. The information provides a general indication of the use and management of crown lands within the Swan Lake portion of the watershed.

Table 18: Crown Lands by Rural Municipality within the Swan Lake Watershed Study Area

Rural Municipality	Total Area (ha.)	Percentage
Mountain	72,941	52
Swan River	36,474	26
Minitonas	29,875	21
TOTAL	**139,290**	**100**

Crown land is subject to specific land use and management based on government acts, regulations and policies. MAFRI is involved in the planning and regulatory management of approximately 648,500 Crown land leased hectares in Manitoba. More information regarding Crown Land Policy, Management, and regulation can be found in ***Appendix K***. This land base, which is primarily utilized for forage production and rangeland, provides the annual feed requirements for a percentage of the provincial beef herd. Given that agriculturally used crown land accounts for approximately 9% of the land base in the watershed, one could assume that continued agricultural use on these crown lands is extremely important in sustaining annual feed requirements for the cow calf herd in the Swan Lake Watershed.

ii. Management Considerations on Crown Lands

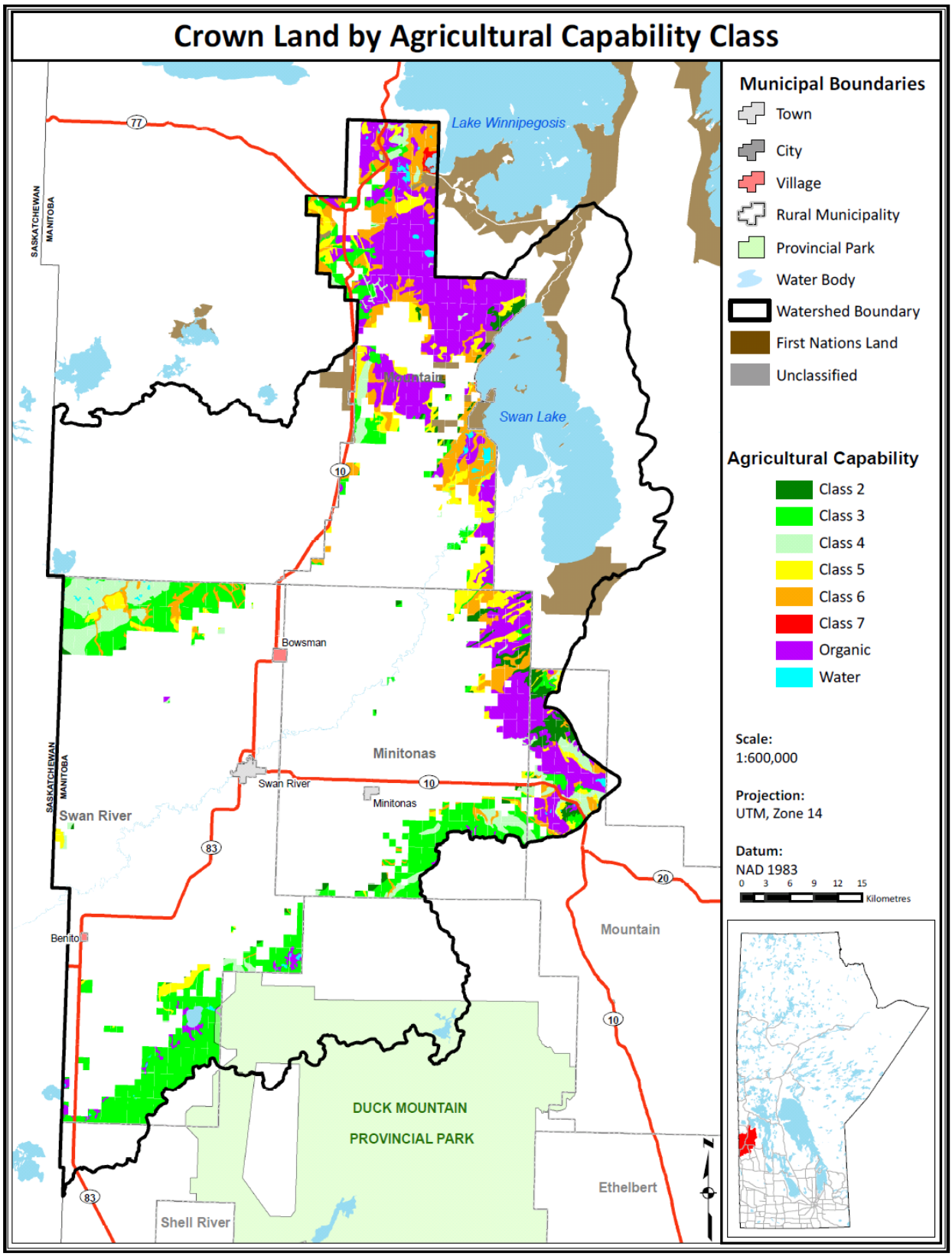
a) Land Capability Classification

Table* 19** illustrates the agricultural land use capability of crown land in the Swan Lake Watershed. Approximately 20% of the total crown lands within the watershed are either Class 4 or Class 5 (see ***Figure* 31, *Table 19). These viable lower class lands are suitable for supporting the existing cow calf enterprises within the watershed and should be maintained in agricultural production through the crown land leasing system.

Table 19: Agricultural Capability of Crown lands in the Swan Lake Watershed Study Area

Agricultural Capability	Total Area (ha)	Percentage of Study Area
Class 1-3	38,712	32
Class 4-5	23,931	20
Class 6-7	17,294	14
Organic	37,582	31
Water	2,013	2
Unclassified	1,473	1
TOTAL	**121,005**	100

Figure 31: Agricultural Capability of Crown Lands in the Swan Lake Watershed



b) Woody Species Encroachment on Crown Lands

As noted in Section E iii, there was an overall decrease of almost 3,700 ha of grassland between 1994 and 2005. This trend also occurs on crown lands with the watershed (see ***Table 20***).

Between 1994 and 2005, the largest increase took place on lands available for agriculture use (leased), while the lowest increase has taken place on lands identified for agriculture use (yearly permits).

It would seem to indicate that lands with wildlife or recreational use have reached equilibrium in terms of woody species encroachment, while lands available for long term agricultural use have had a small increase to woody species.

Woody species encroachment is a function of management (e.g. grazing), weather (rainfall), drainage, and by financial pressures in the industry. In general, the primary woody species encroaching on grassland tend to be poplar and willow.

A number of key factors have played a role in the reduction of productivity on both crown and private lands within the Swan Lake Watershed including reduced grazing pressure and lower cattle numbers, as well as excessive moisture and poor drainage. Extension activities focusing on range management and new farmers entering the cow calf sector can also assist with managing these lands for increased productivity.

Table 20: Tree Encroachment on Crown Lands (1994-2005)

Generalized Operation Land Use Code	Total Area (ha)	Total Area which changed from grassland in 1994 to trees in 2005	% Change	% Change/Yr
Agricultural Use (Lease)	23,444	629.7	3	0.5
Agricultural Use (Yearly Permits)	1,176	6.4	-	-
Community Pastures (Managed by AESB)	3,693	140	4	.4
No Agricultural Use (Wildlife, Recreational)	240,098	327.4	-	-
Uncoded (No Agricultural Use)	873	26.2	3	.3
TOTAL	**269,286**	**1,130**	**10**	**-**

ii. Recent Federal-Provincial Programs

Environmental Farm Planning and Canada-Manitoba Farm Stewardship Program - On-Farm Beneficial Management Practices Adoption

In 2003, the Agricultural Policy Framework (APF) was launched as a new national approach to support agricultural activities associated with Business Risk Management, food safety and quality, science and innovation, environment, and skill development. In support of priorities related to soil, air, water and biodiversity, various environmental initiatives were introduced across Canada including Environmental Farm Planning and the National Farm Stewardship Program. Environmental Farm Planning (EFP) is awareness and planning tool used to enhance producers' understanding of potential on-farm environmental risks and to develop action plans for how these risks can be addressed. Many producers in Manitoba, including those in the watershed, have participated in the EFP process to gain an improved understanding of the potential environmental risks associated with agriculture, as well as, those on their own farms. The EFP process also allowed producers to develop an action plan that outlines how potential risks on their farms can be addressed through the adoption of beneficial management practices (BMPs). Financial and technical support has been offered to producers wishing to adopt BMPs through the Canada Manitoba Farm Stewardship Program (CMFSP) between 2003 and 2009. This program offered 30 different BMPs to producers that had completed an EFP. (For a list and description of the BMPs see ***Appendix L***).

Participation in the Environmental Farm Plan Program is aggregated by municipalities in the study area (***Appendix M***). The information portrays the number of participants in the Environmental Farm Planning process based on where EFP workshops were held. Therefore it should be noted that participants may reside in the surrounding area and not necessarily in location of the workshop. Environmental Farm Planning Workshops were well attended, with a high degree of producers completing the process to receive a Statement of Completion for eligibility to BMP funding through the CMFSP. These numbers within the study area were at the Manitoba average as well, indicating that producers in the Swan Lake watershed are proactive and that environmental issues are high on their priorities.

In the Swan Lake Watershed study area there were a total of 310 BMP projects that were completed by producers (***Table 21***). All of these BMPs contribute to reducing risks to water quality. Of the 310 completed, 183 of the projects were categorized as Non-Point Source – Crop Related BMPs.

The top three BMPs adopted by producers in the study area through the CMFSP were Improved Cropping Systems, Product and Waste Management, and Winter Site Management.

Table 21: BMP Adoption through the Canada-Manitoba Farm Stewardship Program 2003-2008[8]

BMP Categories	Swan Lake IWMP
Point Source - Livestock Manure Related[1]	<5
Point Source - Other (Petroleum, Nutrients from Feed, Pesticides, etc.)[2]	49
Non Point Source - Livestock Related[3]	40
Non Point Source - Crop Related[4]	183
Non Point Source - Crop Related (Pesticides)[5]	24
Soil Erosion - Soils at Risk[6]	8
Biodiversity[7]	<5
Total	**310**

1. These include BMPs 1, 2, 4, 5, 6
2. These include BMPs 8, 9, 17
3. These include BMPs 3, 7, 10, 26, 30
4. These include BMPs 14, 18, 24, 29
5. These include BMPs 16, 20, 25
6. These include BMPs 11, 12, 13, 15, 19, 27
7. These include BMPs 21, 22, 23, 28
8. Refer to Appendix L for BMP descriptions

Growing Forward: Environmental Farm Action and Manitoba Sustainable Agriculture Practices Programs

The adoption of BMPs by producers is not limited to those funded through the CMFSP. Other agencies like Conservation Districts, Ducks Unlimited Canada, and Manitoba Habitat Heritage Corporation also support the adoption of various BMPs. In 2009, Manitoba Food and Rural Initiatives (MAFRI) began offering programs under the Growing Forward Agriculture Policy Framework, a provincial and federal commitment over five years (2008 – 2013), such as continued environmental farm planning and BMP support (see ***Appendix N***).

Financial and technical support is available through Growing Forward's suite called Environmental Action, directed to improve the environmental performance and sustainability of agricultural operations. Funding for eligible BMPs focuses on agriculture's capacity to reduce risk to water and air quality, improve soil productivity and enhance wildlife habitat. BMP support is available to producers upon completion of an environmental farm plan.

Once producers complete the EFP program, they receive a Statement of Completion which enables them to apply for financial assistance for specific beneficial management practices through the Environmental Farm Action Program (EFAP). In addition, the Manitoba Sustainable Agriculture Practices Program (MSAPP) is a provincial climate change program and has an objective to assist in implementing practices that reduce greenhouse gas emissions from agriculture. ***Table 22*** outlines the BMPs available through each respective program.

Table 22: BMPs available through the Environmental Farm Action Program (EFAP) and/or Manitoba Sustainable Agriculture Practices Program (MSAPP)

BMP Categories	BMP Suite
Increased Manure Storage Capacity	EFAP
Improved Manure Storage and Handling	EFAP
Solid-Liquid Separation of Manure	EFAP
Composting of Manure	EFAP
Farmyard Runoff Control	EFAP
Relocation of Livestock Confinement Facilities	EFAP
Wintering Site Management	EFAP
Riparian Area Management	EFAP
Improved Crop Residue Management	EFAP
Precision Agriculture Applications	EFAP
Nutrient Management Planning	EFAP
Reduced Greenhouse Gas (GHG) Emissions from Manure Storage	MSAPP
Manure Land Application	MSAPP
Reduced Tillage	MSAPP
Spring Fertilizer Application	MSAPP
Perennial Cover for Sensitive Land	MSAPP
Cover Crops	MSAPP
Improved Pasture and Forage Quality	MSAPP
Increased Perennial Legumes in Annual Crop Rotation	MSAPP
Grazing and Pasture Management Planning	MSAPP

Further information about the current Growing Forward Program in support of Environmental Farm Planning and BMPs can be found on the MAFRI website at: http://www.gov.mb.ca/agriculture//soilwater/farmplan/index.html

As indicated in the public consultation process for the IWMP, there have been many producers who have adopted BMPs on their own initiative, so it is difficult to determine precise adoption levels. However, considering the number of farms in the watershed, the CMFSP program data does suggest that producers in the watershed are progressive in terms of BMP adoption and that future agri-environmental programs that may stem from IWMP implementation are likely to have considerable levels of participation in this region.

H. Agricultural Land Use and Management Recommendations*

Watershed Issue	Analysis	Recommended Actions*	Target Areas*	Potential Indicators*
Groundwater	**Changing use and management of environmentally sensitive lands**, such as natural forests and wetlands that provide ecological benefits like clean water. The following influences refer to this issue: • **Tree Land Cover**- Treed areas dominated the watershed in the 2005 Land Cover (36%) **(Table 4, Page 21).** • **Agricultural influence on source water areas in watershed**- Activities on land may lead to the possibility of increased movement of potential contaminants into the subsurface and impacting the groundwater supply. Specific influences may include: • **Annual Cropping** – Trends noted include: (a) Annual Cropland accounts for 29% of the watershed (approximately 160, 150 ha) **(Table 4, Page 21)**. (b) Crop production is the main agricultural land use in the watershed with annual crops making up more than half of the farmland. In all three subwatersheds, over 80% of the cultivated land was seeded to cereals or oilseeds (mainly wheat and canola) **(Section E I, Page 19).** (c) Annual cropland has decreased by almost 3% (or approximately 13,000 hectares) between 2002 and 2005 **(Table11, Page 35).** (d) Analysis indicates that annual cropland was most often converted to forages – approximately, 17,500 ha. of annual cropland in 1994 converted to forages in 2005 **(Figure 19, Page 37).** Most of the land that was changed to annual cropland in 2005 came largely from forages (5,600 ha) and wetlands (5,317 ha) that were present in 1994 (**Figure 19, Page 37**). (e) **Marginal Land-** Approximately 13% (22,263 ha.) of the annual cropland was seeded on marginal lands in 2005 (Class 4 or lower)**.** The amount of marginal land being annually cropped has decreased since 1994, however, decreases were reflected on all Classes, with a majority of the decreases noted on Class 3 **(Table 12, Page 45**). (f) **Tillage Practices-** In the Central and Porcupine Subwatersheds, conservation and zero tillage practices were reported on 60% of the annually cropped lands while in the Ducks Subwatersheds it was about 50% **(Section E I, Page 19).** (g) **Fertilizer and Herbicide Practices-** In the Central and Porcupine Subwatersheds, 80% of the cropland had fertilizer applications while in the Ducks Subwatershed, it was 75% of the cropland. Similar trends were noted for herbicide application, though with slightly lower percentages. In Central and Porcupine Subwatersheds, about 75% of croplands were treated with herbicide, in the Ducks Subwatershed it was about two thirds of the cropland **(Section E I, Page 19).** • **Perennial Forages –** There has been a marginal decrease in the amount of forages but an overall increase in pasture in the watershed since 2001 reported by farmers in Census of Agriculture **(Figure 13, Page 25).** • **Grasslands -** There was an overall decrease of almost 3,700 ha of grassland in 2005, from 1994 **(Table 10, Page 31).** • **Soil Texture**- (**Table 16-Page 56, Figure 29-Page 57**) (a) Approximately 11% (69,700 ha) of the watershed has sandy textured soils, located in the central and eastern portions of the watershed (b) Approximately 24% (31,400 ha) of the 2005 annual cropland was located on sandy textured soils. There was a 9% (3,000 ha) decrease in annual cropland from 1994 to 2005 on Sandy Textured soils. Annual Cropland decreased on all soil texture classes in the watershed, probably as a result of the reduction in the amount of Annual Cropland from 1993 to 2005 (173,700 ha in 1994 to 160,700 ha in 2005). **Nutrient transport from agricultural land** due to fertilizers and manure application may lead to potential impacts on drinking water sources. The following trends (or influences) may affect this issue: (a) **Oilseeds, Spring Wheat** –Overall decrease in cereals and an increase in oilseeds in the watershed may be leading to increased levels of nutrient application on cropland **(Figure 14, Page 26).** (b) **Crop Inputs –** There was an increase in the use of fertilizer use for the Porcupine and Central Subwatersheds. Fungicide use had approximately doubled in both watersheds as well, while herbicide use increased only in the Central Subwatershed. Due to decrease in cropland, there was an overall decrease in the use of fertilizers as well as fungicides and insecticides while the use of herbicides decreased slightly. The use of insecticides and fungicides more than doubled in 2005 from 2001(**Figure, 15, Page 28**). • **Beef Production** - Total Cattle and Calves make up approximately 36,500 head in the watershed with average herd size being 124 cows/farm. Beef Cows make up approximately 17,400 head in the watershed, with average herd size being 60 beef cows per farm. (**Figure, 6, Page 16**). • **Livestock Changes (2001 – 2005) (Section Eii, Page 29)**. **–** (a) **Cattle**- Increases noted in total cattle numbers in the watershed, with decreases noted in number of farms reporting cattle and beef cattle. As such, average herd sizes increased per farm. (b) **Hogs**- Decreases as much as a third in the total number of pigs were noted across the watershed, particularly in the Porcupine and Central Subwatersheds. Significant decreases in the number of farms reporting pigs as well as sows reported for both watersheds as well. Small change was noted in the Duck Subwatershed. (c) **Poultry-** A large increase noted in the number of birds and average number of birds/farm throughout the watershed. (d) **Horses and Ponies**-Decreases were noted throughout the watershed for total horses and ponies. • **BMP Adoption -** Of the 310 completed under CMFSP, approximately 49 of the projects were categorized as Point Source BMPs. **(Table 21, Page 64).**	**Conduct Assessment of where vulnerabilities are with respect to groundwater (i.e. groundwater risk areas like recharge areas, high water table areas and contamination sources in or near these areas)** **Nutrient Losses from Agricultural Lands** –- Promote BMPs aimed at reducing nutrient transport to waterbodies (e.g. nutrient management plans, soil testing, manure testing, riparian area management and buffer strips) to address both point and non point **Education -** Encourage environmental educational initiatives that demonstrate the importance of wellhead and watershed protection to support improved or sustain current drinking water quality.	Groundwater risk areas, specifically those that are recharge areas, high water table areas and contamination sources in or near wellheads). Areas near source water or waterways and are: • In annual crop production with fertilizer or manure applied Entire Watershed	With respect to drinking source watersheds, specifically: • Percent change of landcover to perennial cover, • Percent change of wetland areas, • # of BMPs implemented in riparian areas. Change in the area of the watershed that: • are forested or wetland areas, • have grazing BMPs implemented for the riparian areas. Number of farmers implementing BMPs to reduce nutrient losses from cropland (e.g. nutrient management plans, buffer strips, soil and manure testing) Number of positive source water quality testing results Number of educational initiatives undertaken

* Specific approaches and opportunities related to recommended actions, including potential target areas and indicators; need to be explored further by the Project Management Team. Potential collaboration with partners and stakeholders should be considered Specific recommendations from the IWMP process must be forwarded to local councils for consideration within the Development Plan. These recommendations should take agricultural land management into consideration, for preservation of existing farm land and operations.

Watershed Issue	Analysis	Recommended Actions*	Target Areas*	Potential Indicators*
Surface Water Quality	**Agricultural influence on source water areas in watershed**- Activities on land may lead to the possibility of increased nutrient movement into the waterways. Specific influences may include: • **Annual Cropping** – Trends noted include: (a) Annual Cropland accounts for 29% of the watershed (approximately 160, 150 ha). (b) Crop production is the main agricultural land use in the watershed with annual crops making up more than half of the farmland. In all three subwatersheds, over 80% of the cultivated land was seeded to cereals or oilseeds (mainly wheat and canola) **(Section E I, Page 19).** (c) Annual cropland has decreased by almost 3% (or approximately 13,000 hectares) between 2002 and 2005 **(Table11, Page 35).** (d) Analysis indicates that annual cropland was most often converted to forages – approximately, 17,500 ha. of annual cropland in 1994 converted to forages in 2005 **(Figure 19, Page 37).** Most of the land that was changed to annual cropland in 2005 came largely from forages (5,600 ha) and wetlands (5,317 ha) that were present in 1994 (**Figure 19, Page 37**). (e) **Marginal Land-** Approximately 13% (22,263 ha.) of the annual cropland was seeded on marginal lands in 2005 (Class 4 or lower)**.** The amount of marginal land being annually cropped has decreased since 1994, however, decreases were reflected on all Classes, with a majority of the decreases noted on Class 3 **(Table 12, Page 45**). (f) **Tillage Practices-** In the Central and Porcupine Subwatersheds, conservation and zero tillage practices were reported on 60% of the annually cropped lands while in the Ducks Subwatersheds it was about 50% **(Section E I, Page 19).** (g) **Fertilizer and Herbicide Practices-** In the Central and Porcupine Subwatersheds, 80% of the cropland had fertilizer applications while in the Ducks Subwatershed, it was 75% of the cropland. Similar trends were noted for herbicide application, though with slightly lower percentages. In Central and Porcupine Subwatersheds, about 75% of croplands were treated with herbicide, in the Ducks Subwatershed it was about two thirds of the cropland **(Section E I, Page 19).** **Nutrient transport from agricultural land** due to fertilizers and manure application may lead to potential impacts on drinking water sources. The following trends (or influences) may affect this issue: (a) **Oilseeds, Spring Wheat** –Overall decrease in cereals and an increase in oilseeds in the watershed may be leading to increased levels of nutrient application on cropland **(Figure 14, Page 26).** (b) **Crop Inputs –** There was an increase in the use of fertilizer use for the Porcupine and Central Subwatersheds. Fungicide use had approximately doubled in both watersheds as well, while herbicide use increased only in the Central Watershed. Due to decrease in cropland, there was an overall decrease in the use of fertilizers as well as fungicides and insecticides while the use of herbicides decreased slightly. The use of insecticides and fungicides more than doubled in 2005 from 2001(**Figure, 15, Page 28**). • **Beef Production** - Total Cattle and Calves make up approximately 36,500 head in the watershed with average herd size being 124 cows/farm. Beef Cows make up approximately 17,400 head in the watershed, with average herd size being 60 beef cows per farm. (**Figure 6, Page 16**). • **Livestock Changes (2001 – 2005) (Section Eii, Page 29)**. **–** (a) **Cattle**- Increases noted in total cattle numbers in the watershed, with decreases noted in number of farms reporting cattle and beef cattle. As such, average herd sizes increased per farm increased. (b) **Hogs**- A decrease as much as a third in the total number of pigs were noted across the watershed, particularly in the Porcupine and Central Subwatersheds. Significant decreases in the number of farms reporting pigs as well as sows reported for both watersheds as well. Small change was noted in the Duck Subwatershed. (c) **Poultry-** A large increase noted in the number of birds and average number of birds/farm noted throughout the watershed. (d) **Horses and Ponies**-Decreases were noted throughout the watershed for total horses and ponies. • **BMP Adoption -** Of the 310 completed under CMFSP, approximately 49 of the projects were categorized as Point Source BMPs and 40 were categorized as Non Point Source – Livestock Related BMPs. **(Table 21, Page 64).** • **Crown Lands** - There are approximately 269,200 hectares of Crown Land in the Swan Lake Watershed. Approximately 24,620 ha (9%) are available for agricultural use through the Agricultural Crown Land leasing and permitting program (**Table 17 & 18, Figure 30, Pages 58-60**). • **Perennial Forages –** There has been a marginal decrease in the amount of forages but an overall increase in pasture l in the watershed since 2001 reported by farmers in Census of Agriculture **(Figure 13, Page 25).** • **Grasslands -** There was an overall decrease of almost 3,700 ha of grassland in 2005, from 1994 **(Table 10, Page 31).** • **Precipitation Levels**- All weather stations located in the watershed had recorded Total Annual Precipitation and Total Annual Rainfall corresponding to years of land cover imagery: (a) 50% of the observed periods for total annual precipitation were above the 30 year averages. 80% of the observed periods for Total annual rainfall levels were above the 30 year averages, and above normal readings were noted for the 2000/2001and 2005/2005 year records. (b) A majority of the Total Annual Precipitation comes in the form of Rainfall (approximately 71%)(**see Appendix O, Page 101**). • **Soil Drainage**- Analysis of the soil drainage shows that the majority, or approximately 62% or 254,500 ha of the watershed can be considered to very poorly to imperfectly drained land. Approximately 64% (103,400 ha) of the 2005 annual cropland was located on very poorly to imperfectly drained land. This was located in the central lowlands portion of the watershed (**Table 15-Page 53, Figure 28-Page 54**). • **Water Erosion Risk**- Approximately 49% of the study area (201,900 ha.) has a moderate, high or severe risk to water erosion. 25% is identified severe water erosion risk areas alone in the watershed. The amount of annual cropland on soils with a moderate, high or severe water erosion risk dropped from 1994 (over 7,200 ha **(Table 14-Page 50, Figure 27- Page 51)**. • **Wind Erosion Risk** - Approximately 9% of the Swan Lake Watershed is considered to have moderate, high or severe wind erosion risk, primarily in the eastern portion of the watershed. Approximately 21% of the annual cropland was located on soils with moderate, high, to severe risk for wind erosion. This is a decrease of approximately 3,100 ha from what was identified for 1994 on these types of soils. **(Table 13- Page 47, Figure 26-Page48).**	**Riparian Area Assessment –** Conduct a Riparian Area Assessment of select tributaries in the Swan Lake Watershed to determine where mitigation measures would be most effective. **Nutrient Losses from Agricultural Lands** –- i) Promote the adoption of BMPs that assist in the reduction of nutrient loading in surface water bodies. These include the adoption of riparian buffers, a management regime for healthy buffers, increase the size of buffers near specific streams, and nutrient management planning. ii) Promote the adoption of BMPs aimed at reducing nutrient transport to waterbodies (e.g. nutrient management plans, soil testing, and manure testing, feedlot relocation, winter site management, and farmyard runoff control). **Education –** Encourage environmental educational initiatives that demonstrate the benefits of implementing BMPS (as above) to support better surface water quality.	Specific tributaries in the Swan Lake Watershed Annual cropland located on soils with agricultural capabilities of Class 4 and lower, as well as, organic soils. Confined Livestock sites that are within the riparian area of sensitive streams. Agro-Woodlot stands that are primarily mature in age and are located near water source areas. Entire Watershed	The number of kilometers of riparian area that is healthy Change in area of watershed that: • are forested or wetland areas, • have grazing BMPs implemented for the riparian areas to reduce the impact on riparian zones. Number of farmers implementing BMPs to reduce nutrient losses from cropland (e.g. nutrient management plans, buffer strips, soil and manure testing) Changes that reflect positive source water quality testing results Number of workshops presented or amount of extension material provided

* Specific approaches and opportunities related to recommended actions, including potential target areas and indicators; need to be explored further by the Project Management Team. Potential collaboration with partners and stakeholders should be considered Specific recommendations from the IWMP process must be forwarded to local councils for consideration within the Development Plan. These recommendations should take agricultural land management into consideration, for preservation of existing farm land and operations.

Watershed Issue	Analysis	Recommended Actions*	Target Areas*	Potential Indicators*
Soil Erosion	The following trends may influence this issue: • **Annual Cropping** – Trends noted include: (a) Annual Cropland accounts for 29% of the watershed (approximately 160, 150 ha). (b) Crop production is the main agricultural land use in the watershed with annual crops making up more than half of the farmland. In all three subwatersheds, over 80% of the cultivated land was seeded to cereals or oilseeds (mainly wheat and canola) **(Section E I, Page 19).** (c) Annual cropland has decreased by almost 3% (or approximately 13,000 hectares) between 2002 and 2005 **(Table11, Page 35).** (d) Analysis indicates that annual cropland was most often converted to forages – approximately, 17,500 ha. of annual cropland in 1994 converted to forages in 2005 **(Figure 19, Page 37).** Most of the land that was changed to annual cropland in 2005 came largely from forages (5,600 ha) and wetlands (5,317 ha) that were present in 1994 (**Figure 19, Page 37**). (e) **Marginal Land-** Approximately 13% (22,263 ha.) of the annual cropland was seeded on marginal lands in 2005 (Class 4 or lower)**.** The amount of marginal land being annually cropped has decreased since 1994, however, decreases were reflected on all Classes, with a majority of the decreases noted on Class 3 **(Table 12, Page 45**). (f) **Tillage Practices-** In the Central and Porcupine Subwatersheds, conservation and zero tillage practices were reported on 60% of the annually cropped lands while in the Ducks Subwatersheds it was about 50% **(Section E I, Page 19).** (g) **Fertilizer and Herbicide Practices-** In the Central and Porcupine Subwatersheds, 80% of the cropland had fertilizer applications while in the Ducks Subwatershed, it was 75% of the cropland. Similar trends were noted for herbicide application, though with slightly lower percentages. In Central and Porcupine Subwatersheds, about 75% of croplands were treated with herbicide, in the Ducks Subwatershed it was about two thirds of the cropland **(Section E I, Page 19).** • **Water Erosion Risk**- Approximately 49% of the study area (201,900 ha.) has a moderate, high or severe risk to water erosion, approximately 25% is identified severe water erosion risk areas alone in the watershed. The amount of annual cropland on soils with a moderate, high or severe water erosion risk has been reduced from 1994 (over 7,200 ha **(Table 14-Page50, Figure 27- Page 51)**. • **Wind Erosion Risk** - Approximately 9% of the Swan Lake Watershed is considered to have moderate, high or severe wind erosion risk, primarily in the eastern portion of the watershed. Approximately 21% of the annual cropland was located on soils with moderate, high, to severe risk for wind erosion. This is a decrease of approximately 3,100 ha from what was identified for 1994 on these types of soils. **(Table 13, Page 47).** • **Soil Texture**- Approximately 24% (31,400 ha) of the 2005 annual cropland was located on sandy textured soils. • Annual Cropland decreased on all soil texture classes in the watershed, probably as a result of the reduction in the amount of Annual Cropland from 1993 to 2005 (173,700 ha in 1994 to 160,700 ha in 2005). There was a 9% (3,000 ha) decrease in annual cropland from 1994 to 2005 on Sandy Textured soils. (**Table 16-Page 56, Figure 29-Page 57**). • **Soil Drainage-** Approximately 64% (103,400 ha) of the 2005 annual cropland was located on very poorly to imperfectly drained land. The percentage of annual cropland on very poor to imperfectly drained has remained the same from 1994 to 2005 despite the decrease in annual cropland hectares for 2005. This was located in the central lowlands portion of the watershed (**Table 15-Page 53, Figure 28-Page 54**). • **Perennial Forages –** There has been a marginal decrease in the amount of forages but an overall increase in pasture in the watershed since 2001 reported by farmers in Census of Agriculture **(Figure 13, Page 25).** • **Grasslands -** There was an overall decrease of almost 3,700 ha of grassland in 2005, from 1994 **(Table 11, Page 35).** • **Tree Land Cover**- Treed areas dominated the watershed in the 2005 Land Cover (36%) **(Table 4, Page 21).** Changes in land cover between 1994 and 2005 show an increase of 6,400 ha in forested areas, primarily in the southern portions of the watershed. Forestry showed a significant change in land cover from 1994 to 2005 a decrease of approximately 27,500 hectares (from 226,000 to 202,000 ha.). A majority of the forested areas land cover came at the expense of what was previously noted as grassland land cover in 1994 (approximately 22,000 hectares) **(Table 11- Page 35, Figure 24-Page 43).** • **Farm Size-** The average size of farms, in terms of area per farm, has increased steadily from approximately 335 ha to almost 390ha in the Swan Lake IWMP area, an increase of approximately 17%. The amount of total farmland increased in the Central Subwatershed while the Ducks and Porcupine Subwatershed areas decreased. The increase in the Central Subwatershed could be attributed to increases noted in leased or rented lands, probably associated with total cropland. **(Figure 13, Table 5 & 6 Page 24-25).** • **BMP Adoption -** Of the 310 completed under CMFSP, 8 of the projects were categorized as Soil Erosion - Soils at Risk Erosion Protection BMPs. **(Table 21, Page 64).** • **Woody River Headwater Storage Study-** Report listed in Literature Review identifies soil erosion issues in the Birch River Watershed **Appendix P, 102)** • **Precipitation Levels**- All weather stations located in the watershed had recorded Total Annual Precipitation and Total Annual Rainfall corresponding to years of land cover imagery: (a) 50% of the observed periods for total annual precipitation were above the 30 year averages. 80% of the observed periods for Total annual rainfall levels were above the 30 year averages, and above normal readings were noted for the 2000/2001and 2005/2005 year records. (b) A majority of the Total Annual Precipitation comes in the form of Rainfall (approximately 71%)(**see Appendix O, Page 101**). • Due to data limitations, further attention to these areas such as site assessments would be required if action (BMP implementation) is indeed warranted.	**Water Erosion Mitigation** - Promote BMPs in areas with potential risk for water erosion (e.g. riparian buffer, and perennial cover establishment for the lower class of lands in severe or highly erosive areas). **Wind Erosion Mitigation** - Promote BMPs, such as the use of cover crops and residue management techniques, and shelterbelt establishment in select areas where wind erosion has been lowered **Education –** Encourage environmental educational initiatives that demonstrate the benefits of implementing BMPs (as above) to support improved straw residue and soil management.	Areas in the watershed that are: • in close proximity to waterways and in annual crop production with a high risk of water erosion • Annual cropped lands of class 4 and lower Entire Watershed	Proportion of the watershed: • where annual cropland hectares within 50 m of a water course have been converted to perennial cover • that has water erosion mitigation BMPs (e.g. cover crops, buffer strips, etc.) implemented • where BMPs have been adopted in critical areas or targeted areas • water quality results or report card larger waterways Number of educational initiatives undertaken

* Specific approaches and opportunities related to recommended actions, including potential target areas and indicators; need to be explored further by the Project Management Team. Potential collaboration with partners and stakeholders should be considered Specific recommendations from the IWMP process must be forwarded to local councils for consideration within the Development Plan. These recommendations should take agricultural land management into consideration, for preservation of existing farm land and operations.

Watershed Issue	Analysis	Recommended Actions*	Target Areas*	Potential Indicators*
Flooding and Drainage	**Influences on Water Management** – Parts of the watershed that have been identified as vulnerable to flooding due to excess moisture and/or increased drainage. The following trends have been noted in the watershed and influence this issue: • **Farm Size-** The average size of farms, in terms of area per farm, has increased steadily from approximately 335 ha to almost 390ha in the Swan Lake IWMP area, an increase of approximately 17%. The amount of total farmland increased in the Central Subwatershed while the Ducks and Porcupine Subwatershed areas decreased. The increase in the Central Subwatershed could be attributed to increases noted in leased or rented lands, probably associated with annual cropland. **(Figure 13, Table 5 & 6 Page 24-25).** • **Annual Cropping** – Trends noted include: (a) Annual Cropland accounts for 29% of the watershed (approximately 160, 150 ha). (b) Crop production is the main agricultural land use in the watershed with annual crops making up more than half of the farmland. In all three subwatersheds, over 80% of the cultivated land was seeded to cereals or oilseeds (mainly wheat and canola) **(Section E I, Page 19).** (c) Annual cropland has decreased by almost 3% (or approximately 13,000 hectares) between 2002 and 2005 **(Table11, Page 35).** (d) Analysis indicates that annual cropland was most often converted to forages – approximately, 17,500 ha. of annual cropland in 1994 converted to forages in 2005 **(Figure 19, Page 37).** Most of the remaining land that was changed to annual cropland in 2005 came largely from forages (5,600 ha) and wetlands (5,317 ha) that were present in 1994 (**Figure 19, Page 37**). (e) **Marginal Land-** Approximately 13% (22,263 ha.) of the annual cropland was seeded on marginal lands in 2005 (Class 4 or lower)**.** The amount of marginal land being annually cropped has decreased since 1994, however, decreases were reflected on all Classes, with a majority of the decreases noted on Class 3 (**Table 12, Page 45**). (f) **Tillage Practices-** In the Central and Porcupine Subwatersheds, conservation and zero tillage practices were reported on 60% of the annually cropped lands while in the Ducks Subwatersheds it was about 50% **(Section E I, Page 19).** (g) **Fertilizer and Herbicide Practices-** In the Central and Porcupine Subwatersheds, 80% of the cropland had fertilizer applications while in the Ducks Subwatershed, it was 75% of the cropland. Similar trends were noted for herbicide application, though with slightly lower percentages. In Central and Porcupine Subwatersheds, about 75% of croplands were treated with herbicide, in the Ducks Subwatershed it was about two thirds of the cropland **(Section E I, Page 19).** • **Soil Drainage**- Approximately 64% (103,400 ha) of the 2005 annual cropland was located on very poorly to imperfectly drained land. The percentage of annual cropland on very poor to imperfectly drained has remained the same from 1994 to 2005 despite the decrease in annual cropland hectares for 2005. This was located in the central lowlands portion of the watershed (**Table 15-Page 53, Figure 28-Page 54**). • **Class 4 and Poorer Agricultural Lands** - Within the Swan Lake Watershed, approximately 89% of the land is classified as Class 4 and poorer. The 2005 land cover data indicates that over 53% of annual cropland is located on land rated as Class 4 or poorer**(Table 12, Page 45)**. There has also been a steady increase in forages **(Table 11, Page 35).** • **Tree Land Cover**- Treed areas dominated the watershed in the 2005 Land Cover (36%) **(Table 4, Page 21).** Changes in land cover between 1994 and 2005 show an increase of 6,400 ha in forested areas, primarily in the southern portions of the watershed. Forestry showed a significant change in land cover from 1994 to 2005 a decrease of approximately 27,500 hectares (from 226,000 to 202,000 ha.). A majority of the forested areas land cover came at the expense of what was previously noted as grassland land cover in 1994 (approximately 22,000 hectares) **(Table 11, Page 35, Figure 19,20-Page 37-38).** • **Perennial Forages –** There has been a marginal decrease in the amount of forages but an increase in pasture overall in the watershed since 2001 reported by farmers in Census of Agriculture **(Figure 13, Page 25).** • **Grasslands -** There was an overall decrease of almost 3,700 ha of grassland in 2005, from 1994 **(Table 11, Page 35).** • **Wetlands** – Trends noted include: (a) Wetlands make up 13% of the watershed **(Figure 11 & 12 - Page 22 & 23, Table 11, Page 35).** (b) The area covered by wetlands increased by approximately 27,500 hectares from 1994-2005**(Table 11, Page 35)**. • **Precipitation Levels**- All weather stations located in the watershed had recorded Total Annual Precipitation and Total Annual Rainfall corresponding to years of land cover imagery: (a) 50% of the observed periods for total annual precipitation were above the 30 year averages. 80% of the observed periods for Total annual rainfall levels were above the 30 year averages, and above normal readings were noted for the 2000/2001and 2005/2005 year records. (b) A majority of the Total Annual Precipitation comes in the form of Rainfall (approximately 71%)(**see Appendix O, Page 101**). • **BMP Adoption -** Of the 310 completed under CMFSP, approximately 55 of the projects were categorized as Point Source BMPs. **(Table 21, Page 64).** • **Manitoba Escarpment Headwater Storage Study -** Report identified in Literature Review identifies the potential effectiveness of several small headwater storage dams (**Appendix P, 102)** • **Manitoba Escarpment Headwater Storage Study -** Report identified in Literature Review identifies the potential effectiveness of several small headwater storage dams (**Appendix P, 102)** • **Flooding Reports 1955-1994- Flooding Reports for the Swan Lake First Nation and Duck Mountain Region identified in the Literature Review indicate the extent of previous flooding events** (**Appendix P, 102).** • **Timing of Land cover Imagery** -Timing of Imagery and classification definitions may affect the number (i.e. a decrease or increase) of wetlands identified and should be verified with site specific analysis (ground truthing)	Examine the effectiveness of headwater storage dams for water management similar to South Tobacco Creek area. **Site Specific BMP Implementation for Water Management** - Promote and provide technical assistance for water management BMPs (e.g. riparian buffers, riffle structures, headwater storage options, and erosion control in key priority areas of the watershed. **Watershed Approach to Water Management BMP Implementation** - Promote and provide technical assistance for water management BMPs using whole watershed approach with consideration of upstream opportunities and downstream effects (e.g. perennial forage establishment, sustainable woodlot management, sustainable rotational grazing, riparian area management). Examine other **Land Management Opportunities** that provide value to landowners and contribute environmental benefits (e.g. wetlands or riparian buffers). **Education -** Encourage environmental educational initiatives that demonstrate the benefits of implementing BMPs (as above) to support better surface water management.	Escarpment zones of the watershed. Areas in the watershed that are: • Imperfectly drained soils and annual cropland • Class 4 or higher lands that are suitable for wetland retention Entire Watershed	Reduced frequency of downstream flooding. Proportion of watershed where: • wetlands have changed (e.g. increase in sizes and/or numbers), • the change of annual cropland hectares decreases on imperfectly drained soils • wetland, tree, grassland/pasture and forage land cover classes have increased • BMPs have been implemented to manage flooding and/or restore wetlands Changes in surface water flows as identified through stream flow measurements Number of educational initiatives undertaken

* Specific approaches and opportunities related to recommended actions, including potential target areas and indicators; need to be explored further by the Project Management Team. Potential collaboration with partners and stakeholders should be considered Specific recommendations from the IWMP process must be forwarded to local councils for consideration within the Development Plan. These recommendations should take agricultural land management into consideration, for preservation of existing farm land and operations.

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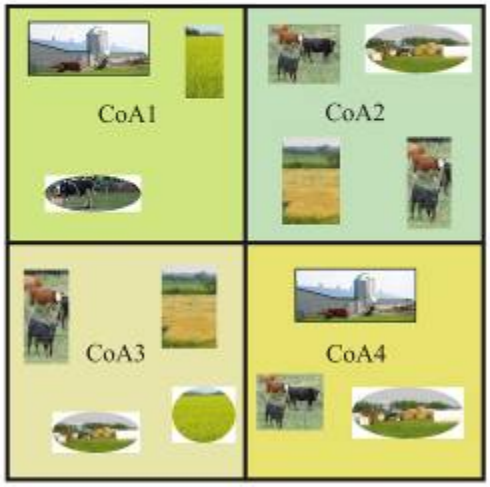
J. Appendices

Appendix A: Diagram for Interpolating Census of Agriculture Data (Area Weighting Method)

Basic concept of interpolating Census of Agriculture (CoA) using the area weighting method*

Census of Agriculture (CoA) from Statistics Canada's geographic boundaries



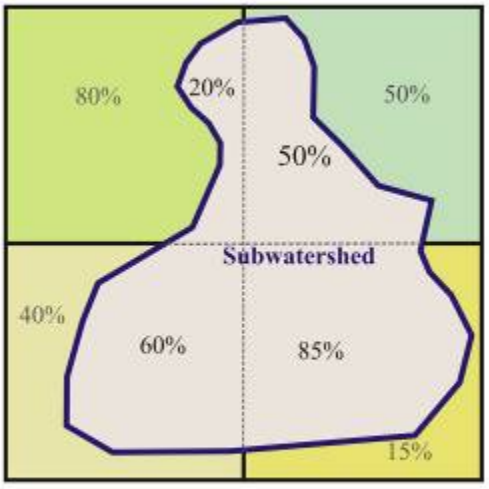
CoA is the sum of all survey forms of farms with farm headquarters located in the specific boundary

For Example - Total cattle and calves

CoA1 = 540 total cattle
CoA2 = 300 total cattle
CoA3 = 125 total cattle
CoA4 = 1200 total cattle

CoA from Statistics Canada's geographic boundary

CoA interpolated to subwatershed boundary



Interpolated CoA for Subwatershed =
(CoA1: 540 cattle x 20%) +
(CoA2: 300 cattle x 50%) +
(CoA3: 125 cattle x 60%) +
(CoA4: 1200 cattle x 85%) = 1353.6 total cattle and calves**

** due to the methodology of interpolating data, final census numbers are estimates.

*This is a simplified explanation of the methodology used to interpolated Census of Agricultural data from Statistic Canada's geographic boundaries into other specified boundaries such as watersheds. There are other factors not explained here that are taken into account during the process.

Appendix B: Animal Unit Calculations

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

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

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

Summary of assumptions made in calculating Animal Units1 from 2001 Agricultural Census Data

Livestock	Manitoba Animal Unit Category	Census Category	Assumptions Used for Animal Unit Calculations with census data
Dairy	Milking cows (including associated livestock)	Dairy cows	Assumed categories are equal.
Beef	Beef cows	Beef cows	Assumed number of beef cows reported in 2001 Census equal cow/calf pairs
	Backgrounder Summer pasture Feedlot cattle	Heifers and steers for slaughter or feeding 1 yr and older (combined categories)	Assumed steers and heifers reported in these census categories are split into the three categories (communication with MAFRI). Animal unit coefficient determined using this ratio.
Pigs	Sows, farrow–to-weanling	Sows	Assumed there are no farrow-to-finish operations and no weanling operations in Manitoba – only farrow-to-weanling and grower/finisher operations.
	Grower/finishers	Grower and finisher pigs	
	Boars (artificial insemination operations)	Boars	Assumed all boars reported in the 2001Census are from artificial inseminations.
Chickens	Broilers	Broilers and roasters	Assumed all birds reported in the census category are broilers (communication with MAFRI).
	Layers	Laying hens (19 weeks and older)	Assumed categories are equal.
	Pullets	Pullets (under 19 weeks)	Assumed categories are equal.
	Broiler breeding hens	Laying hens in hatcheries	Assumed all laying hens in hatchery supply flocks reported in Manitoba are broiler breeder hens.
Turkeys	Broiler, Heavy Toms, Heavy Hens	Turkeys	Assumed "turkeys" represents 20% boilers, 40% heavy toms, 40% heavy hens (communication with MAFRI). Animal unit coefficient is determined using this ratio.
Sheep	Ewes, including associated livestock	Ewes	Assumed ewe/lamb pairs (communication with MAFRI).
	Feeder lambs	Lambs	Assumed no feeder lambs in province since numbers are very small and cannot be determined from census data (communication with MAFRI).
Horses	Horses	Total horses and ponies	Assumed each animal produces 1 Animal Unit – PMU farms not identified in Census (communication with MAFRI).
Bison	Bison	Bison	Assumed adults represent 85% and calves represent 15% of bison population in Manitoba (communication with MAFRI). Animal unit coefficient is determined using this ratio.
Elk	Elk	Elk	Number of calves and sex of animals not identified in Census – assumed 45% cows, 35% bulls and 20% calves (communication with MAFRI). Animal unit coefficient is determined using this ratio.
Goats	Goats	Goats	Number of kids and sex of animals not identified in Census – assumed 7 goats make up one Animal Unit, irregardless of age and sex.

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

Appendix C: Land Cover Time Frame, Classifications, and Constraints

For the IWMP study area, imagery was available for the years of 1994, 2000, and most recently, 2005. Imagery was classified by the Manitoba Conservation - Manitoba Remote Sensing Centre into 16 unique land cover classes. To simplify the analysis, the 16 classes were aggregated into 7 basic land cover classes: annual cropland, forages, grasslands/pasture, trees, wetlands, water, and urban/transportation.

The 1994 land cover used satellite imagery that was captured on May 14, 1994. Imagery for the 2002 land cover data was taken May 31, 2002. The 2005 land cover data utilized satellite imagery that was captured on September 9, 2005.

Data Constraints

It should be noted that the use of land cover data has limitations from a couple of perspectives. Weather patterns in years leading up to the imagery will impact the cover analysis and may be short term as opposed to a long term trend. Further, past image classifications were undertaken for specific purposes with standardization occurring between 2000-2001 and 2005-2005 as detailed below:

- Classification effort - the 1994 image classification concentrated specifically on annual cropland to aid in delivery of the Western Grains Transportation Payment Program. Greater attention was paid to all classification categories on the 2002 image classification.
- The classification of forages and forages/grasslands - As the land cover classifications could be difficult to interpret given the age of the forage stand and the reflectance of the satellite imagery for classification.
- With respect to the increased level of forages, some of the forage conversion trends may be explained through the adoption of Permanent Cover Program offered by Agriculture Canada in the early 1990s. A program summary for the Swan Lake Watershed study area could provide more insight toward understanding the forage trends and if they were indeed related to the Permanent Cover Program, however, the data could not be made available in time for this report. There is some indication from local contacts that the program uptake by producers was low for this watershed, however, without an actual program summary, it cannot be quantified. This information will be available for future reports or for this watershed at a later date.

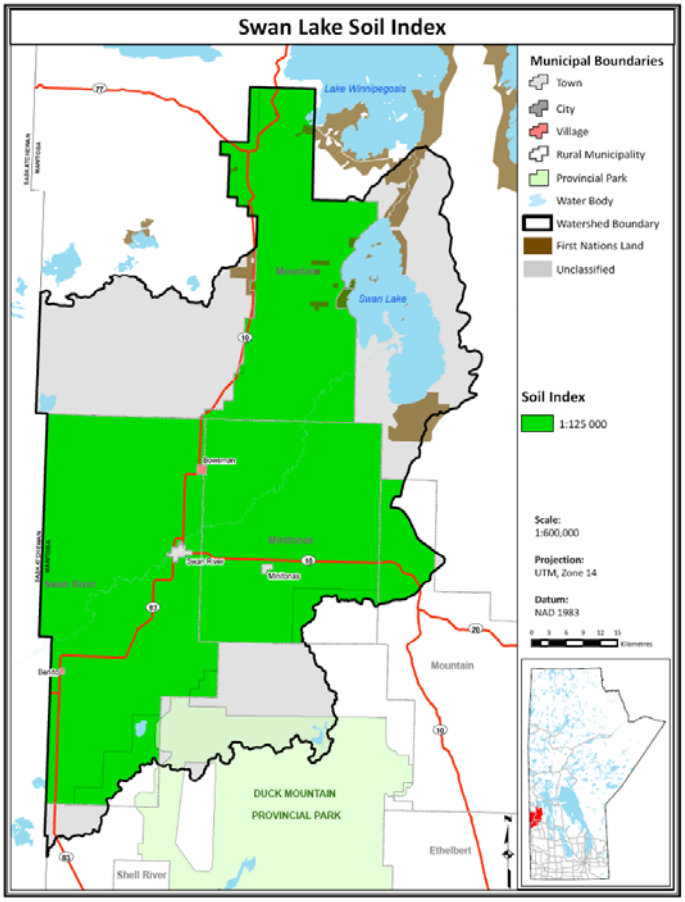
Classification Scheme: Land Cover Mapping of Manitoba	
1. Annual crop land:	Land that is normally cultivated on an annual basis.
2. Forage:	Perennial forages, generally alfalfa or clover with blends of tame grasses.
3. Grassland:	Areas of native or tame grasses, may contain scattered stands of trees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

Appendix D: Soil Information and Background

Soils data within the watershed can be used to provide information on various soil characteristics as well as interpretative ratings such as agriculture capability, water and wind erosion risk. Used in conjunction with the land cover data from 1994-2005, observations about temporal land use trends can be made and used to explain any changes in land management practices.

Soils data within Manitoba have been mapped at different scales of accuracy. In the Swan Lake study area, soils were surveyed at more reconnaissance scale of 1:125,000 (green area) (see figure below).

Reconnaissance soils data is more suitable for broader landscape based analysis and regional planning purposes. This information is not suitable for the development of municipal development plans/zoning by-laws, agronomic assessment for irrigation and other site specific land use activities. Analysis of this nature requires more detailed soils information for assessments and management considerations. Soil information provided in this report is based on the characteristics of the dominant soil series within the various soils polygons.



Appendix E: Canada Land Inventory System Land Classes

Agricultural Capability for Manitoba

Agriculture capability is a 7 class rating of mineral soils based on the severity of limitations for dryland farming. This system does not rate the productivity of the soil, but rather its capability to sustain agricultural crops based on limitations due to soil properties and landscape features and climate. This system is usually applied on a soil polygon basis and the individual soil series are assessed and maps portray the condition represented by the dominant soil in the polygon. Class 1 soils have no limitations, whereas Class 7 soils have such severe limitations that they are not suitable for agricultural purposes. In general, it takes about 2 acres (0.8 hectares) of Class 4 land to equal production from 1 acre (0.4 hectares) of prime (Class 1) land. (From *Land: The Threatened Resource*).

Class 1: Soils in this class have no important limitations for crop use. The soils have level to nearly level topography; they are deep, well to imperfectly drained and have moderate water holding capacity. The soils are naturally well supplied with plant nutrients, easily maintained in good tilth and fertility; soils are moderately high to high in productivity for a wide range of cereal and special crops (field crops).

Class 2: Soils in this class have moderate limitations that reduce the choice of crops or require moderate conservation practices. The soils have good water holding capacity and are either naturally well supplied with plant nutrients or are highly responsive to inputs of fertilizer. They are moderate to high in productivity for a fairly wide range of field crops. The limitations are not severe and good soil management and cropping practices can be applied without serious difficulty.

Class 3: Soils in this class have moderate limitations that restrict the range of crops or require moderate conservation practices. The limitations in Class 3 are more severe than those in Class 2 and conservation practices are more difficult to apply and maintain. The limitations affect the timing and ease of tillage, planting and harvesting, the choice of crops and maintenance of conservation practices. Under good management, these soils are fair to moderate in productivity for a fairly wide range of field crops.

Class 4: Soils in this class have significant limitations that restrict the choice of crops or require special conservation practices or both. These soils have such limitations that they are only suited for a few field crops, the yield for a range of crops may be low or the risk of crop failure is high. These soils are low to moderate in productivity for a narrow range of field crops but may have higher productivity for a specially adapted crop or perennial forage.

Class 5: Soils in this class have severe limitations that restrict their capability to producing perennial forage crops and improvement practices are feasible. These soils have such serious

soil, climatic or other limitations that they are not capable of use for sustained production of annual field crops. However, they may be improved by the use of farm machinery for the production of native or tame species of perennial forage plants.

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

Class 7: Soils in this class have no capability for arable culture or permanent pasture because of extremely severe limitations. Bodies of water too small to delineate on the map are included in this class. These soils may or may not have a high capability for forestry, wildlife and recreation.

Agriculture capability subclasses identify the soil properties or landscape conditions that may limit use. A capital letter immediately following the class number identifies the limitation (eg. 2W, 3N, etc.).

Subclasses:
C - adverse climate (outside the boundaries of agro-Manitoba)
D - undesirable soil structure and/or low permeability
E - erosion damage
I - inundation (flooding) by streams and lakes
M - moisture (droughtiness) or low water holding capacity
N - salinity
P - stoniness
R - consolidated bedrock
T - topography (slopes)
W - excess water other than flooding (inadequate soil drainage or high water table)
X - two or more minor limitations

Appendix F: Water Erosion Risk

Water erosion information is available as part of the provincial soil survey data that has been compiled from reconnaissance (1:126,720 scale) and detailed (1:40,000 & 1:20,000 scale) soil survey reports. The Universal Soil Loss Equation (USLE) that was developed by Wischmeier and Smith (1965) was used to provide information on water erosion as part of the provincial soils data. The USLE provides a quantitative estimate on the amount of soil that is displaced due to water erosion (either tonne/ha or ton/ac) on an annual basis due to soil, climatic, landscape and management factors that influence the rate of erosion. The USLE can be written as:

A = RKLSCP

Where:

A = Predicted water erosion rate
R = Erosivity of rainfall and snowmelt factor
K = Soil erodibility factor
L = Slope length factor
S = Slope steepness factor
C = Crop cover and management factor (set at 1.0 - assuming bare, unprotected soil)
P = Conservation practice factor (set at 1.0 - assuming no conservation practices)

Due to limitations that are inherent in the model, the lack of the inclusion of conservation management practices and crop cover factors, the numbers that are generated from the USLE should not be used as a value for actual soil loss due to water erosion. However, the USLE is useful in comparing water erosion risk between soils based on their soil/landscape properties and climatic conditions. To accomplish this, the computed USLE values have been compiled into the following 5 group risk classes:

N = Negligible	< 2.7 ton/ac/yr (< 6 tonne/ha)
L = Low	2.7 – 4.9 ton/ac/yr (6 – 11 tonne/ha)
M = Moderate	4.9 – 9.8 ton/ac/yr (11 – 22 tonne/ha)
H = High	9.8 – 14.7 ton/ac/yr (22 – 33 tonne/ha)
S = Severe	> 14.7 ton/ac/yr (> 33 tonne/ha)

By using the risk class groupings, soils can be compared on the basis of their soil physical properties, landscape and climate for resource analysis and targeting of soil conservation programming.

Appendix G: Wind Erosion Risk

Wind erosion information in Manitoba has been developed from the provincial soil survey data and the Soil Landscapes of Canada (SLC Ver 1.0). A geographic information system (GIS) was used to combine both spatial datasets, creating a derived product upon which wind erosion was calculated.

The wind erosion model that is used for the Agriculture Canada Wind Erosion Risk Maps (1989) was applied to the derived dataset. The model was developed from the works of Chepil (1945, 1956) and Chepil and Woodruff (1963) and derives an index value *E* for wind erosion risk (Coote, Eilers & Langman, 1989). The model is stated as:

$$E = kC(V_*^2 - \gamma W^2)^{1.5}$$

Where:

E = maximum instantaneous soil movement by wind (dimensionless)
k = surface roughness and aggregation factor (dimensionless)
C = factor representing soil; resistance to movement by wind (dimensionless)
V_* = drag velocity of wind at soil surface ($cm \cdot s^{-1}$)
γ = soil moisture shear resistance (dimensionless), a value of 5000 was used
W = available moisture of the surface soil ($m^3 water \cdot m^{-3} soil$)

For the analysis, the V_* and *W* values were used from the Soil Landscapes of Canada series. These values are listed for each polygon in the Wind Erosion Risk publication. A listing of *k* and *C* values are also listed in the report and are based on soil surface texture. The values were entered into the database based on soil surface texture types taken from the provincial soil survey data.

Following entering of values for *K*, *C*, *W* and calculating values for V_*, the dimensionless wind erosion index values (*E)* were calculated for each polygon. These values were rated as per the rating system in the Wind Erosion Risk publication.

Class	**E Value**
Negligible	< 100
Low	101 - 250
Moderate	251 - 400
High	401 - 700
Severe	> 700

The ratings are for bare soil and do not consider land use and crop management factors. *E* values were calculated only for those soils within the seamless soil layer that had a mineral soil surface texture rating. Polygons that were rated as being organic soils, bare rock and water in either the seamless soil data or the SLC data did not have *E* values calculated.

For those polygons that have secondary and/or tertiary soils listed within the map unit, a weighted calculation was done based on the percent of occurrence. If organic soils existed in any combination (primary, secondary, tertiary) with mineral soils, weightings were based on mineral soils only.

Appendix H: Soil Drainage Classes

Soil Drainage Class	Description
Very Poor	Water is removed from the soil so slowly that the water table remains at or on the soil surface for the greater part of the time the soil is not frozen. Excess water is present in the soil throughout most of the year
Poor	Water is removed so slowly in relation to supply that the soil remains wet for a large part of the time the soil is not frozen. Excess water is available within the soil for a large part of the time.
Imperfect	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Excess water moves slowly down the profile if precipitation is the major source
Well	Water is removed from the soil readily but not rapidly. Excess water flows downward readily into underlying materials or laterally as subsurface flow
Rapid	Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep slopes during heavy rainfall.
Source: *System of Soil Classification of Canada – Canada-Manitoba Soil Survey Reports*	

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

Appendix I: 2006 Census of Agriculture data

Table 1: Agricultural Land Use types reported in the 2006 Census of Agriculture (hectares)

Subwatershed	Total Farmland	Total Cropland**	Summerfallow	Pasture***	Other*
Porcupine	84,425	55,896	1,689	17,243	9,598
Central	106,764	76,717	1,863	17,540	10,645
Ducks	65,755	2,471	1,175	14,456	7,653

*Other category includes all other land uses including farmyard, woodlots, Christmas trees, wetlands, etc.
** Total cropland includes all field crops, forages, vegetables, fruit and nuts and sod
*** Pasture includes tame pasture and natural areas used for pasture.

Table 2: Distribution of crop types as reported in the 2006 Census of Agriculture (hectares)

Subwatershed	Total Cropland*	Cereals	Oilseeds	Pulse	Forage for hay	Forage for seed
Porcupine	55,896	24,685	21,045	x	8,462	0
Central	76,717	35,903	28,821	x	10,121	0
Ducks	42,471	19,105	14,408	x	7,748	0

x – data has been suppressed by Statistics Canada to preserve confidentiality of the data
* Total Cropland includes all field crops, forages, vegetables, fruits and nuts, and sod

Table 3: Total area treated with crop inputs for the 2005 cropping year, as reported in the 2006 Census of Agriculture (hectares)

Subwatershed	Use of commercial Fertilizers	Use of Herbicides	Use of Insecticides	Use of Fungicides
Porcupine	45,202	43,578	10,064	14,269
Central	61,663	56,854	9,963	17,706
Ducks	32,413	27,534	4,260	6,465

Table 4: Total dollars spent on crop inputs for the 2005 cropping year, as reported in the 2006 Census of Agriculture

Subwatershed	Total crop expenses	Total fertilizer and lime	Total herbicides, insecticides & fungicides	Total seed
Porcupine	$10,094,712	$4,998,077	$3,528,059	$1,568,576
Central	$14,211,237	$7,189,067	$5,007,600	$2,014,570
Ducks	$7,279,091	$3,851,924	$2,467,522	$959,645

Table 5: Tillage practices on areas prepared for seeding as reporting as a percentage of total cultivated land, as reported in the 2006 Census of Agriculture

Subwatershed	Tillage incorporating most crop residue into the soil	Tillage retaining most crop residue on the surface	No-till or zero-till seeding
Porcupine	38%	46%	16%
Central	40%	39%	20%
Ducks	50%	38%	12%

Table 6: Total number of livestock and poultry on Census Day in 2006, as reported in the 2006 Census of Agriculture

Subwatershed	Total Cattle	Beef Cows	Dairy Cows	Horses & Ponies	Total Pigs*	Sows**	Total Poultry***
Porcupine	11,131	5,307	x	778	4,576	162	5,472
Central	14,401	6,884	x	1,358	7,951	1,071	26,672
Ducks	10,971	5,162	x	2,376	2,111	x	3,168

* Totals were estimated for the Porcupine Subwatershed due to some data suppression
** Data for the Ducks Subwatershed has been suppressed and could not be estimated.
*** Totals were estimated for the Porcupine and Central Subwatershed due to some data suppression

Table 7: Total number farms reporting livestock and poultry on Census Day in 2006, as reported in the 2006 Census of Agriculture

Subwatershed	Total Cattle	Beef Cows	Dairy Cows	Horses & Ponies	Total Pigs	Sows	Total Poultry
Porcupine	100	97	0	0	14	6	11
Central	128	119	1	1	12	5	14
Ducks	86	81	3	3	6	3	11

Table 8: Average number of livestock animals or poultry birds per farm on Census Day in 2006, as reported in the 2006 Census of Agriculture

Subwatershed	Total Cattle	Beef Cows	Dairy Cows	Horses & Ponies	Total Pigs*	Sows**	Total Poultry***
Porcupine	112	55	x	2,161	322	26	493
Central	112	58	x	984	686	195	1,897
Ducks	127	64	x	822	356	x	300

* Totals were estimated for the Porcupine Subwatershed due to some data suppression
** Data for the Ducks Subwatershed has been suppressed and could not be estimated.
*** Totals were estimated for the Porcupine and Central Subwatershed due to some data suppression

Table 9: Summary of farm financial characteristics in 2005, as reported in the 2006 Census of Agriculture

Subwatershed	Number of Farms	Average farm size (ha)	Average Capital investment ($/farm)	Average livestock-related expenses ($/ha farmland)*	Average crop-related expenses ($/ha cropland and summerfallow)*	Estimated profit ($/farm)
Porcupine	210	402	691,199	27	175	16,522
Central	283	378	739,904	31	181	14,918
Ducks	170	386	739,633	40	167	20,707

* Calculations are based on the expenses for the 2005 calendar year, as reported in the 2005 Census of Agriculture

Table 10: Summary of farm financial activity in 2005, as reported in the 2006 Census of Agriculture

Subwatershed	Number of Farms	Total farm business operating expenses	Total gross farm receipts	Total income and expenses*
Porcupine	210	$25,943,886	$29,418,126	$55,362,012
Central	283	$37,702,511	$41,918,675	$79,621,186
Ducks	170	$21,279,457	$24,805,797	$46,085,254

* Total income and expenses are calculated as total gross farm receipts plus total farm operating expenses

Appendix J: 2001 Census of Agriculture data

Table 1: Agricultural Land Use types reported in the 2001 Census of Agriculture (hectares)

Subwatershed	Total Farmland	Total Cropland**	Summerfallow	Pasture***	Other*
Porcupine	86,720	58,161	2,679	19,018	6,863
Central	99,282	72,570	3,282	15,305	8,125
Ducks	65,900	44,944	1,537	13,283	6,136

*Other category includes all other land uses including farmyard, woodlots, Christmas trees, wetlands, etc.
** Total cropland includes all field crops, forages, vegetables, fruit and nuts and sod
*** Pasture includes tame pasture and natural areas used for pasture.

Table 2: Distribution of crop types as reported in the 2001 Census of Agriculture (hectares)

Subwatershed	Total Cropland*	Cereals	Oilseeds	Pulse	Forage for hay	Forage for seed
Porcupine	58,161	30,374	17,391	x	8,640	x
Central	72,570	38,998	20,229	x	11,817	795
Ducks	44,944	22,795	11,660	x	8,960	x

x – data has been suppressed by Statistics Canada to preserve confidentiality of the data
* Total Cropland includes all field crops, forages, vegetables, fruits and nuts, and sod

Table 3: Total area treated with crop inputs for the 2000 cropping year, as reported in the 2001 Census of Agriculture (hectares)

Subwatershed	Use of commercial Fertilizers	Use of Herbicides	Use of Insecticides	Use of Fungicides
Porcupine	42,083	45,065	x	7,596
Central	56,364	58,439	3,731	7,440
Ducks	34,665	34,650	x	2,860

x – data has been suppressed by Statistics Canada to preserve confidentiality of the data

Table 4: Total dollars spent on crop inputs for the 2000 cropping year, as reported in the 2001 Census of Agriculture

Subwatershed	Total crop expenses	Total fertilizer and lime	Total herbicides, insecticides & fungicides	Total seed
Porcupine	$7,935,194	$4,102,196	$2,919,720	$913,278
Central	$9,874,206	$5,211,631	$3,408,954	$1,253,622
Ducks	$5,841,356	$3,051,311	$2,089,217	$700,827

Table 5: Tillage practices on areas prepared for seeding as reporting as a percentage of total cultivated land, as reported in the 2001 Census of Agriculture

Subwatershed	Tillage incorporating most crop residue into the soil	Tillage retaining most crop residue on the surface	No-till or zero-till seeding
Porcupine	76%	22%	2%
Central	62%	33%	6%
Ducks	64%	x	x

x – data has been suppressed by Statistics Canada to preserve confidentiality

Table 6: Total number of livestock and poultry on Census Day in 2001, as reported in the 2001 Census of Agriculture

Subwatershed	Total cattle	Beef cows	Dairy Cows	Horses & Ponies	Total Pigs*	Sows**	Total Poultry*
Porcupine	10,531	4,848	x	1,142	6,626	385	2,285
Central	12,635	5,402	x	1,651	10,606	905	1,810
Ducks	11,013	4,581	x	2,082	2,385	x	872

x – data has been suppressed by Statistics Canada to preserve confidentiality
* Totals were estimated for the Porcupine Subwatershed due to some data suppression
** Data for the Ducks Subwatershed has been suppressed and could not be estimated.
*** Totals were estimated for the Porcupine and Central Subwatershed due to some data suppression

Table 7: Total number farms reporting livestock and poultry on Census Day in 2001, as reported in the 2001 Census of Agriculture

Subwatershed	Total cattle	Beef cows	Dairy Cows	Horses & Ponies	Total Pigs	Sows	Total Poultry
Porcupine	110	106	3	57	26	17	17
Central	145	133	3	63	17	11	16
Ducks	106	99	3	43	8	5	9

Table 8: Average number of livestock animals or poultry birds per farm on Census Day in 2001, as reported in the 2001 Census of Agriculture

Subwatershed	Total cattle	Beef cows	Dairy Cows	Horses & Ponies	Total Pigs*	Sows**	Total Poultry***
Porcupine	96	46	x	20	255	23	138
Central	87	41	x	26	639	82	117
Ducks	104	46	x	48	302	x	97

x – data has been suppressed by Statistics Canada to preserve confidentiality
* Totals were estimated for the Porcupine Subwatershed due to some data suppression
** Data for the Ducks Subwatershed has been suppressed and could not be estimated.
*** Totals were estimated for the Porcupine and Central Subwatershed due to some data suppression

Table 9: Summary of farm financial characteristics for the 2000, as reported in the 2001 Census of Agriculture

Subwatershed	Number of Farms	Average farm size (ha)	Average Capital investment ($/farm)	Average livestock-related expenses ($/ha farmland)*	Average crop-related expenses ($/ha cropland and summerfallow)*	Estimated profit ($/farm)*
Porcupine	239	363	$566,416	$42	$130	$12,140
Central	308	322	$572,663	$41	$130	$14,900
Ducks	205	321	$577,565	$47	$126	$11,374

* Calculations are based on the expenses for the 2000 calendar year, as reported in the 2001 Census of Agriculture

Table 10: Summary of farm financial activity in 2005, as reported in the 2006 Census of Agriculture

Subwatershed	Number of Farms	Total farm business operating expenses	Total gross farm receipts	Total income and expenses*
Porcupine	239	$26,095,031	$28,995,336	$55,090,367
Central	308	$30,782,850	$35,373,621	$66,156,471
Ducks	205	$20,223,473	$22,556,267	$42,779,740

* Total income and expenses are calculated as total gross farm receipts plus total farm operating expenses

Appendix K: Private and Crown Land Planning in the Swan Lake Watershed

Overview

The Provincial Land Use Policies (PLUPs) outline Agriculture's interests of both private and crown land that is used for agriculture by maintaining this land as viable agricultural land, minimizing subdivision, and protecting farms from encroachment by other uses which may be incompatible with normal farming operations.

Policy #1 of the Provincial Land Use Policies Regulation guides General Development while Policy #2 guides Agriculture. The objectives of policy #2 are to maintain a viable base of agricultural lands for present and future food and fibre production and agricultural diversification, and to protect agricultural operations.

Provincial Land Use Policies

These policies guide local and provincial authorities in preparing Development Plans and in making land use decisions. The PLUPS cover nine broad policy areas, of which Agriculture is one component; each policy area is given equal precedence. The other areas, besides agriculture, are General Development, Renewable Resources, Water and Shoreline, Recreational Resources, Natural Features and Heritage Resources, Flooding and Erosion, Provincial Highways, and Mineral Resources. The various government departments have an interest in "their" policies and are involved in establishing them.

Development Plans

The Provincial Land Use Policies are applied at the local level through the Development Plan which is initiated by a municipality or planning district (group of municipalities). The Development Plan is the agreement between the local and provincial governments on matters concerning land use and future development and it should be generally consistent with the PLUPs.

This is where the policies governing the protection of prime agricultural land and agricultural operations are set out. The Plan sets out land use objectives and patterns or characteristics of development for an area. Through the Development Plan, lands are designated for certain uses such as agriculture, agriculture restricted, residential, industrial or commercial. Once adopted, all proposed development and land use changes must be evaluated under the policies of the development plan.

Zoning By-Laws

Regulating the Use of the Land: Following the approval of a development plan, a municipality must enact a zoning by-law that is consistent with their development plan. A municipal zoning by-law contains the rules and regulations that control development as it occurs. A zoning by-law further divides a municipality into various zones such as rural residential, highway-commercial and general agricultural. For example, an area that is designated as Agricultural in a development plan may be further zoned as Agricultural General and Agricultural Restricted, with both zones having separate criteria for agricultural development. The zoning by-law sets out requirements and criteria under which development may occur, including property site size, dimensions, separation distances and other siting criteria. It also specifies permitted and conditional uses within each zone.

Planning -General

Integrated watershed planning is a community based focused planning process around issues that affect water management. This planning needs to support the existing community

framework for economic development and land use planning. In most cases, this means, integration of the IWMP into the existing Development Plan. The Development Plan is the local legal framework under *The Planning Act.*

All of the municipalities included in the Swan Lake IWMP area have Development Plans which govern land use decisions including the protection and use of agricultural lands.

Development of rural lands for non-agricultural use can impact watershed health, and may result in enhanced drainage above agricultural requirements. Because of this, the ability of the landscape to provide ecological goods and services such as the retention and filtering of water is impacted with development. Within a Development Plan, protecting agricultural land from non agricultural use may also mean protecting wetlands and tree cover, especially if the farmland is maintained for grazing purposes. For these reasons, having agricultural lands protected in a Development Plan will have benefits for the five issues (groundwater, soil erosion, surface water, and flooding and drainage) identified in the public consultations.

The planning district within the Swan Lake IWMP area is Swan Valley Planning District.

The following sections describe the framework for land use planning from a legal perspective, set out by the Provincial Government.

Crown Land Management and Planning in the Swan Lake Watershed.

Overview

In ***1930***, responsibility for ***Crown Lands*** was transferred to the provincial government of ***Manitoba.*** Virtually all of Northern ***Manitoba***, beyond the Department of Aboriginal and Northern Affairs boundary, is what they called “unorganized territory" and is also ***Crown land*****.** Today, Manitoba’s Crown Lands are used for varying purposes, including agriculture, mining, and cottages. Other areas are set aside for research, environmental protection, public recreation, and resource management. Approximately 95% of the province's forests sit within provincial Crown land.

Operations

The planning and classification of Crown land in agro-Manitoba is the ultimate responsibility of the Crown Lands Assistant Deputy Minister’s Committee (CLADMC), previously known as the Crown Land Classification Committee (CLCC). The CLCC was created in 1975 by the Premier of Manitoba for the specific purpose of Crown land use planning and resolution of land and resource use conflicts between departments of government. It is an interdepartmental committee with representation from Manitoba Agriculture, Food and Rural Initiatives (MAFRI), Conservation, Water Stewardship, Aboriginal and Northern Affairs, Science Technology Energy & Mines (STEM) and Intergovernmental Affairs (IAF). The committee reports to cabinet.
The CLCC determined that to achieve its objectives, there was a need for on-the-ground planning and resource management expertise. This was obtained by creating local Block Planning Committees (BPC’s), comprised of regional specialists from those departments on CLADMC. Eight BPCs were created in 1976. The BPC’s meet every two months or as needed to discuss issues related to crown lands in their respective regions. Minutes are then forwarded to CLADMC for final approval.

Multi-Use Concept

The Provincial Crown Land Planning Process is strongly guided by the concept of multiple resource use whereby Crown Lands may be used by both competing and complementary users.

Complementary use of Crown land requires special consideration be given to management in order to ensure that one resource use does not compromise the other. One such example is timber harvesting/livestock grazing, where a project initiated by MAFRI (Garland Project) is showing that proper management (of livestock grazing and forestry practices) can result in long term benefits to both resource users. The science and research from this project will be very beneficial in resolving a longstanding land use issue, and ultimately make more land available for complementary use. The information from this project will also assist private landowners in terms of managing their resources (e.g.; in instances where the land management objective is to enhance both forestry potential and livestock grazing).

Management and Administration

Management and administration of Crown land is shared by Manitoba Conservation, Manitoba Agriculture, Food and Rural Initiatives (MAFRI), Aboriginal and Northern Affairs and Manitoba Infrastructure and Transportation (MIT). The Crown Lands and Property Agency of MIT is responsible for the administration of Crown land, issues leases and permits upon the direction of MAFRI with regard to Crown lands classified for agricultural uses and issues leases and permits for all other Crown lands as directed by Manitoba Conservation. Manitoba Aboriginal and Northern Affairs maintain authority equivalent to that of local government for Crown land dispositions in the Northern Affairs area.

Manitoba Agricultural Crown Lands

Agricultural Crown Lands in Manitoba are managed and regulated by the Agriculture Crown Lands section of the Land Use Branch of Manitoba Agriculture, Food and Rural Initiatives. MAFRI issues agricultural leases and permits on those lands which are designated as primarily agricultural as well as multi-use lands which may be used for agricultural purposes on a secondary or interim use-basis, subject to specific conditions and covenants required by other resource users. The section also advertises available agricultural Crown lands for lease and ensures equitable allocation.

Community Pastures

Community pastures support not only the livestock industry, but also maintenance of large tracts of native habitat. The managed grazing of these lands is compatible with natural grassland species, and associated wildlife, and are recognized for their value in providing ecological goods and services, just as other areas of managed rangelands. Community pastures are unique, in that the parcels of land within them can be a combination of provincial agricultural Crown Land, municipal lands, some federal agricultural land, and occasionally, some private parcels. MAFRI is responsible for the administration of Crown land within these Community pastures via Federal-provincial agreements and acts a liason for AESB on all land and land use related issues within the pastures. This includes securing non-crown land for community pasture use. AESB is responsible for the grazing management of these pastures.

Appendix L: Beneficial Management Practices offered under the Canada Manitoba Farm Stewardship Program 2003-2008

NFSP System Development
BMP Category Code/Practice Code Assignment

NOTE 1: The units of measurement are: distance = kilometers (km), area = acres, volume = cubic meters (m3)

NOTE 2: Funding is expressed as thousands of $ = K (eg. $4K = $4,000)

BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
01	Improved Manure Storage and Handling	0101	increased storage to meet winter spreading restrictions (including satellite storage)	volume (m^3)	30%	$30K
		0102	improved features to prevent risks of water contamination (leaks, spills)	N/A		
		0103	slurry storage covers to reduce odours and GHG emissions	N/A		
		0104	containment systems for solid manure (includes covers)	N/A		
		0105	assessment and monitoring of existing manure storage infrastructure	N/A		
		0106	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)	N/A		
02	Manure Treatment	0201	dewatering systems, nutrient recovery systems	N/A	30%	$30K
		0202	composting of manure			
		0203	anaerobic biodigestors			
		0204	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
03	Manure Land Application	0301	specialized/modification to equipment for improved manure application	N/A	30%	$10K
04	In Barn Improvements	0401	more efficient livestock watering devices and cleanout systems to reduce water use and decrease manure volumes	N/A	30%	$20K
		0402	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			

BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
05	Farmyard Runoff Control	0501	upstream diversion around farmyards ;downstream protection (eg. catch basins, retention ponds, constructed wetlands)	N/A	50%	$20K
		0502	construction of impermeable base and roof for minimizing runoff from livestock pen areas and confinement areas (feed bunks, water infrastructure, walls and electrical costs are not eligible)			
		0503	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
06	Relocation of Livestock Confinement and Horticultural Facilities	0601	relocation of livestock facilities such as corrals, paddocks and wintering sites away from riparian areas	N/A	50%	$30K
		0602	relocation of horticultural facilities such as greenhouses and container nurseries from riparian areas			
		0603	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
07	Wintering Site Management	0701	shelterbelt establishment	# kms	50%	$15K
		0702	portable shelters and windbreaks	# kms		
		0703	alternative watering systems (ie: solar, wind or grid power)	N/A		
		0704	field access improvements: alleyway/access lane upgrades	# kms		
		0705	fence modifications	# kms		
08	Product and Waste Management	0801	improved on-farm storage and handling of agricultural products (eg. fertilizer, silage, petroleum products, and pesticides)	N/A	30%	$15K
		0802	improved on-farm storage, handling, and disposal of agricultural waste (eg. livestock mortalities, fruit and vegetable cull piles, wood waste)			
		0803	composting of agricultural waste (eg. Livestock mortalities fruit, vegetable, wood, straw residue)			
		0804	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			

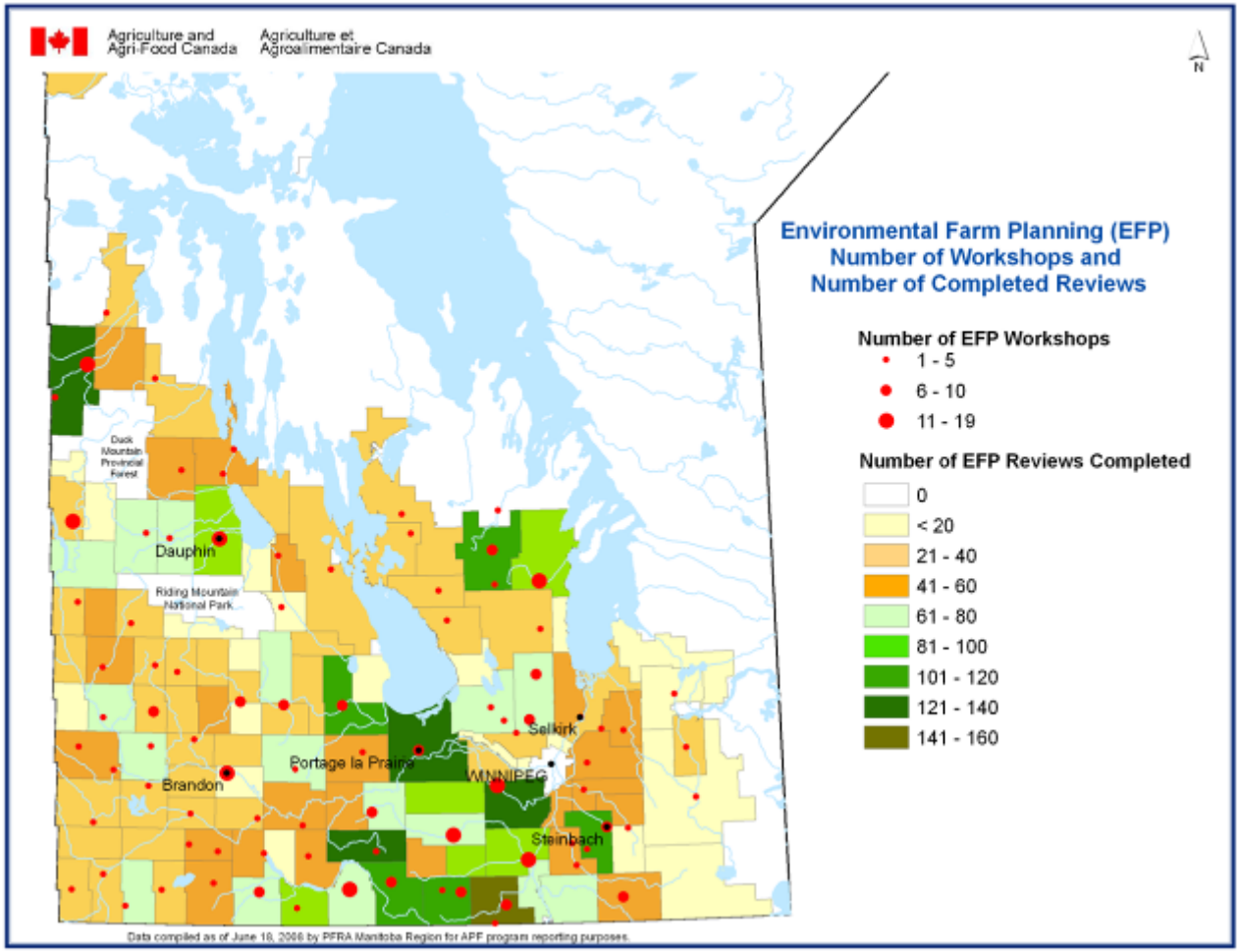
BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
09	Water Well Management	0901	sealing & capping old water wells	N/A	50%	$6K
		0902	protecting existing water wells from surface contamination			
10	Riparian Area Management (GREENCOVER)	1001	alternative watering systems (ie: solar, wind or grid power)to manage livestock:	N/A	50%	$20K
		1002	buffer establishment and planting of forages (planting and establishment costs for trees and shrubs for the year of planting and one year after the planting year, or the termination of the NFSP funding, whichever comes first)	# acres		
		1003	fencing to manage grazing and improve riparian condition/function	# kms		
10	Riparian Area Management (GREENCOVER)	1004	native rangeland restoration or establishment: native species of forages, shrubs, and trees	# acres		
		1005	grazing management in surrounding uplands: alternative watering systems (ie: solar, wind or grid power) and cross fencing	# kms offence		
		1006	improved stream crossings	N/A		
11	Erosion Control Structures(Riparian) (GREENCOVER)	1101	constructed works in riparian areas: contour terraces, gully stabilization, bank stabilization, erosion control matting, silt fencing, drop inlet and enhanced infiltration systems, in-channel control, retention ponds and erosion control dams	N/A	50%	$20K
		1102	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
12	Erosion Control Structures(Non Riparian)	1201	constructed works in non riparian areas: contour terraces, gully stabilization, bank stabilization, erosion control matting, silt fencing, drop inlet systems and enhanced infiltration systems, in-channel control, retention ponds and erosion control dams, mechanical wind screens	N/A	50%	$20K
		1202	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
13	Land Management for Soils at Risk	1301	forage or annual barrier establishment for soils at risk (eg. stripcropping, grassed waterways, perennial forages on severely erodible or saline soils)	# acres	50%	$5K
		1302	straw mulching	# acres		

BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
		1303	grazing management in critical erosion areas not associated with riparian zones: alternative watering systems (ie: solar, wind or grid power), crossfencing	# kms offence		
14	Improved Cropping Systems	1401	equipment modification on pre-seeding implements for restricted zone tillage for row crops, seeding and post seeding implements for low disturbance placement of seed and fertilizer	N/A	30%	$15K
		1402	chaff collectors and chaff spreaders installed on combines			
		1403	precision farming applications: GPS information collection, GPS guidance (ie: autosteer, lightbars, software) , manual and variable rate controllers for variable fertilizer application			
15	Cover Crops	1501	establishment of non-economic cover crop	# acres	30%	$5K
		1502	equipment modification for inter row seeding of cover crops (eg. relay crops)	N/A		
16	Improved Pest Management	1601	equipment modification for improved application	N/A	30%	$5K
		1602	information collection and monitoring			
		1603	biological control agents			
		1604	cultural control practices			
		1605	mobile water tanks			
17	Nutrient Recovery from Waste Water	1701	recycling of waste water streams from milkhouses, fruit and vegetable washing facilities, and greenhouses in order to recover nutrients	N/A	30%	$20K
		1702	engineering design work (this practice code will stand alone if project does not proceed for economic, technical or environmental reasons (CEAA)			
18	Irrigation Management	1801	irrigation equipment modification/improvement to increase water or nutrient use efficiency	N/A	30%	$10K
		1802	equipment to prevent backflow of altered irrigation water into water sources			
		1803	improved infiltration galleries and irrigation intake systems			

BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
19	Shelterbelt Establishment (GREENCOVER)	1901	establishment of shelterbelts for farmyard, live stock facilities, dugout snowtrap, wildlife habitat enhancement, field (planting and establishment costs for trees and shrubs for the year of planting and one year after the planting year, or the termination of the NFSP funding, whichever comes first)	# kms	50%	$10K
		1902	tree materials required for shelterbelt establishment	N/A		
20	Invasive Alien Plant Species Control	2001	integrated approaches (cultural, mechanical, and biological) for control of invasive plant species (eg. leafy spurge, purple loosestrife, scentless chamomile)	N/A	50%	$5K
21	Enhancing Wildlife Habitat and Biodiversity	2101	buffer strips: native vegetation	# acres	50%	$10K
		2102	alternative watering systems (ie: solar, wind or grid power)	N/A		
		2103	improved grazing systems: crossfencing	# kms		
		2104	wildlife shelterbelt establishment	# kms		
21	Enhancing Wildlife Habitat and Biodiversity	2105	improved stream crossings	N/A		
		2106	hayland management to enhance wildlife survival	N/A		
		2107	wetland restoration	acres		
22	Species at Risk	2201	alternative watering systems (ie: solar, wind or grid power)	N/A	50%	$10K
		2202	improved grazing systems: crossfencing	# kms		
		2203	plant species establishment	# acres		
		2204	infrastructure development and relocation	N/A		
23	Preventing Wildlife Damage	2301	forage buffer strips	# acres	30%	$10K
		2302	fencing or netting to protect stored feed, concentrated livestock, high value crops, drip irrigation systems, and other ag. activities	# km offence		
		2303	scaring and repellant systems and devices	N/A		

BMP Category Code	BMP Category Description	BMP Practice Code	BMP Practice Description	BMP Practice Unit Type	Cost Share	Caps
24	Nutrient Management Planning	2401	consultative services to develop nutrient management plans, planning and decision support tools	# acres	50%	$4K
25	Integrated Pest Management Planning	2501	consultative services to develop integrated pest management plans, planning and decision support tools	# acres	50%	$2K
26	Grazing Management Planning (GREENCOVER)	2601	consultative services to develop range and grazing management plans, planning and decision support tools	# acres	50%	$2K
27	Soil Erosion and Salinity Control Planning	2701	consultative services to develop soil erosion and salinity control plans, planning and decision support tools	# acres	50%	$2K
28	Biodiversity Enhancement Planning	2801	consultative services to plan habitat enhancement, wetland restoration, stewardship for species at risk and/or wildlife damage prevention within agricultural land base; planning and decision support tools	# acres	50%	$2K
29	Irrigation Management Planning	2901	consultative services for planning improved water use efficiency and reduced environmental risk of existing irrigation systems, planning and decision support tools	# acres	50%	$2K
30	Riparian Health Assessment (GREENCOVER)	3001	consultative services for assessing riparian health, planning and decision support tools	# acres	50%	$2K

Appendix M: Environmental Farm Plan Workshops and EFP Statement of Completions in Manitoba under APF



Appendix N: Growing Forward Program

Growing Forward is the foundation for coordinated federal-provincial-territorial government action to help the agriculture and agri-food sectors become more profitable, competitive and innovative. Governments are investing $1.3 billion over five years (2008 – 2013) toward *Growing Forward* programs. The funding represents $330 million more than the Agricultural Policy Framework (APF) and will be cost-shared between the Government of Canada, as well as provincial and territorial governments on a 60:40 basis.

The **Environment Suite** supports two funding avenues: Environmental Action and Environmental Information.

I. Environmental Action improves the environmental performance and sustainability of agricultural operations.

To do this, the program will provide funding for eligible Beneficial Management Practices that enhance agriculture's capacity to reduce risk to water and air quality, improve soil productivity and enhance wildlife habitat.

Programs included in Environmental Action are:

Environmental Farm Plan

The Environmental Farm Plan (EFP) Program has created opportunities for farmers to take part in a confidential self-assessment of the environmental risks and assets existing on their operations. Once producers complete the EFP program, they receive a Statement of Completion which enables them to apply for financial assistance for specific beneficial management practices through EFAP and MSAPP.

Environmental Farm Action The Environmental Farm Action Program (EFAP) is part of the federal-provincial Growing Forward suite of agricultural programs designed to support agricultural producers in reducing environmental risks specifically through beneficial management practices (BMPs). This program provides technical and financial assistance to producers to accelerate the adoption of BMPs in Manitoba to improve the environmental performance and sustainability of agricultural operations.

The EFAP provides cost-shared funding to producers to implement eligible beneficial management practices (BMPs) identified in their action plans, under such categories as:

- Increased Manure Storage Capacity;
- Improved Manure Storage and Handling;
- Solid-Liquid Separation of Manure;
- Composting of Manure;
- Farmyard Runoff Control;
- Relocation of Livestock Confinement Facilities;
- Wintering Site Management;
- Riparian Area Management;
- Improved Crop Residue Management;
- Precision Agriculture Applications; and
- Nutrient Management Planning

Additional BMP categories are available to Manitoba producers through the Manitoba Sustainable Agriculture Practices Program (MSAPP). MSAPP is the provincial climate change program for agro-Manitoba. Its main objective is to provide incentives to producers to implement practices that reduce greenhouse gas emissions from agriculture.

- Reduced Greenhouse Gas (GHG) Emissions from Manure Storage
- Manure Land Application
- Reduced Tillage
- Spring Fertilizer Application
- Perennial Cover for Sensitive Land
- Cover Crops
- Improved Pasture and Forage Quality
- Increased Perennial Legumes in Annual Crop Rotation
- Grazing and Pasture Management Planning

II. Environmental Information supports the provision of environmental information to help decision-making and improve the sustainability of agriculture.

Programs include:
Agri-Extension Environment

Activities include:
Soil Survey Program: Provide operational support (equipment, staff, etc) to create an inventory of soil properties such as pH, salinity or erosion and to map the distribution of these soil types in Manitoba to direct agricultural management practices. Farmers, government, conservation groups and commodity groups will be able to use the information to guide environmental farm planning, land-use planning, watershed management and nutrient management planning purposes.

Ecological Goods and Services Pilot Projects: The program will support research, modeling and evaluation of Environmental Goods and Services (EG&S) policy options to determine the most effective EG&S policy instrument for agro Manitoba. Different models for this program will be developed and tested on the Manitoba agro-landscape using agricultural landowners in selected pilot study areas.

Environmental Sustainability: Provides funding and technical assistance to a max of $50,000 per proponent to local producer groups and commodity organizations with an interest in agricultural sustainability to carry out applied investigation projects. The Agricultural Sustainability Initiative will support projects aimed to improve sustainable agriculture farming practices, transfer or sharing of technology and information, workshops and fact sheets. Capital items are not covered under this initiative.

Agro-Meteorology Information System: Monitors meteorology patterns throughout agro-Manitoba and develops decision-support systems through the use of real-time data dissemination that enhances risk mitigation and input efficiency tools for producers. The information uses include, but are not limited to: pest forecasting, stubble-burning authorizations and risk mitigation of weather-related threats to crop and livestock production.

Appendix O: Annual Precipitation for weather stations located in the Swan Lake IWMP for selected years.*

Weather Station	Total Annual Precipitation (mm)						
	1992	**1994**	**1999**	**2000**	**2005**	**2005**	**30-year average (1971 - 2000)**
Swan Lake	516.6	559.2	585.9	506.0	M	M	530.3
Cowan(1)	576.6	706.2	590.6	541	598.	809.4	600.3

Weather Station	Total Annual Rainfall (mm)						
	1992	**1994**	**1999**	**2000**	**2005**	**2005**	**30-year average (1971 - 2000)**
Swan Lake	405.5	452.2	474.2	342.2	M	M	394.1
Cowan(1)	435.9	570	462.2	374.2	474.4	544.4	427.5

*Annual precipitation and rainfall data was obtained from the Environment Canada website at:
http://www.climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html

(1) Data was gathered from a community located outside the IWMP study area.

Appendix P: SWAN LAKE BASIN LITERATURE REVIEW

Submitted by Jeff Thiele, PFRA - Dauphin

Report on Proposed Scheme for Lowering the Level of Swan Lake, Water Resources Branch, Dept of Mines and Resources, Province of Manitoba, 1952.

Lowering the mean lake level from 848.55 to 844.77 through channel improvement at the outlet of Swan Lake would benefit 40-50,000 acres.

Report on Riding Mountain - Duck Mountain 1953 Flood Damage, PFRA, 1955

Heavy floods have been noted to occur in this area in 1903, 1912, 1921, 1923, 1925, 1935, 1944, 1947, 1953 and a flood of lesser magnitude in 1948. In parts of the area, 1950 and 1954 would also be included.

In 1953, flooding in the western section of the Swan - Sinclair River Watershed (498,000 acres outside of Duck Mountain Forest) is almost wholly confined to the river valley bottoms, and some local inundation from the smaller creeks is apparent. Flooding is, however, most severe in the eastern section, and especially so, close into the escarpment in the vicinity of Renwer and Minitonas where most watercourses have an abrupt change in hydraulic gradient and cross-sectional area. The flooding potential of the watercourses diminishes as they flow to the north and northwest to join the Swan Lake. Overflow water from the east out of the Unorganized Territory swamps, also causes concern to farmers in the northern part of Minitonas Municipality. The presence of beach ridges in this area hinders the disposal of floodwater to a certain extent. However, drainage ditches constructed by the province and the Municipality are doing much to alleviate flooding in a difficult situation where spring water apart from formed stream overflow, contributes quite substantially to field inundation, along the mountain escarpment.

Agricultural damages in the Swan - Sinclair River Watershed in 1953 amounted to $197,202. Cultivated acres affected by the flood total 11,060 acres of Class 1-3 land, with slight erosion on 118 acres, moderate erosion on 154 acres, and severe erosion on 59 acres. As well 20 acres is deemed to have been totally lost to future agricultural purposes by extreme water erosion.

Second Report on Proposed Scheme for Lowering the Level of Swan Lake by Means of Channel Improvement on Shoal River, J.Clark, Water Resources Branch, Dept. of Mines and Natural Resources, Province of Manitoba, 1955.

Two schemes were proposed for consideration, both of which involve increasing the capacity of the outlet by: (1) construction of an auxiliary channel; and (2) channel improvement on the Shoal River.

The cost of the auxiliary channel was considered to be too excessive based on the benefits. Two alternatives were considered for the Shoal River channel improvement; (1) a reduction of 3.4 feet below the highest recorded stage of 852.97 feet: and (2) a reduction of 3.9 feet below the highest recorded stage of 852.97 feet. Included in the cost estimates of both alternatives is a dam located at the outlet of Swan Lake to maintain water levels during drought periods. The cost of the scheme, based on 1954 prices, was placed at $312,000 and $360,000 respectively.

An Investigation of Flood Control Proposals Lower Woody River - Preliminary Engineering Report, PFRA, 1959.

This study is part of the investigation of the entire Woody River watershed as requested by the Province of Manitoba in 1957, and is concerned with dyking as a solution to the flooding problem. The drainage basin of the Woody River above Sec.36-39-25 W1 covers an area of 899 sq.miles. The Birch River Land Settlement Project is located on the delta of the Woody River where gradients are flat and drainage is very poor. Although some lands are affected directly by fluctuation of water levels in Swan Lake, the most damaging flooding is caused by overflow from the Woody and Swan Lakes. No economic appraisal is possible as no estimate of average annual damages exists. Surveys have indicated that the problem area is not affected by lake levels below 851 ft. Topographic surveys were conducted by PFRA along the lower Woody River during the fall and winter of 1957.

If flood control in this area is to be achieved by dyking, this report recommends the adoption of Scheme 2 (double-diking of 5 miles of the Woody River from a point near SW 22-39-25 W1 to the north boundary of Sec.6-40-24W1, and following adjacent roads to higher ground). The proposed works were estimated to cost $274,000, $30 per protected acre. It would provide protection to about 9,000 acres of cultivated and hay land from a flood occurring on the average of once in 25 years (design flow of 8,000 c.f.s).

There are few hydrometric records in the area. Hydrometric data between 1915 and 1920 were taken from a road bridge one mile south of Bowsman. Since 1954, stream flow records have been gathered from a bridge north of Bowsman on Lenswood road, four miles downstream from the one used during 1915-20. These two gauging stations could not be correlated due to the Bowsman River, and the Smith, Maple, and Mullen Creeks which enter the Woody River between the two stations. Stream flow records were supplemented with a comparison of the Swan Lake, and were complicated by the fact that some of the flooding in the problem area is caused by overflow from the Swan Lake. Some diking on the north and west bank of the Swan Lake will be required (2 foot dike 25,000 feet in length between Sec.18 and 29-39-24W1. Three-quarters of a mile of double-diking is required along the Birch River, west of its junction with the Woody River, to allow for backwater effects.

An Investigation of Flood Control Proposals Lower Woody River - Summary Engineering Report, PFRA, 1959.

A summary of the previously prepared “Preliminary Engineering Report”.

Agricultural and Flood Damage Report on the Lower Woody River, PFRA, 1959.

Overflow from the Woody River in 1954 and the Swan Lake in 1957 flooded 7,300 acres within the Birch River Land Settlement project, and in Twps.39 and 40, Rges, 24 and 25 WPM. From opinions expressed by farm operators in the area, it is quite evident that a much larger area than this was inundated in 1948, when both rivers flooded out at the same period. As far as the investigator could ascertain, this was the only year in which the Woody and Swan Lakes coincided in bank overflow. It is the opinion of most of the farm operators that such a severe flood would not be liable to occur again for, since this period, an extensive amount of drainage has been done to take care of at least a good part of Swan Lake and Indian Birch River overflow.

With respect to Woody River overflow, it was found to be aggravated to a large extent on the west side of the Woody River by overflow from the Birch River. Since the 1954 Woody River flood, when the Indian Birch River also contributed to flooding, a channel clean-out and re-alignment has been done on the latter watercourse and now does not flood until it reaches the low area to the northeast and more or less clear of the settlement area.

Mixed farming is carried out in the area with approx. 15 head of livestock carried per farm and with farms averaging a half-section. Land values range between $7-1500 on unimproved land and between $5-9000 on land 60-70% broken. Land taxes average $39 per quarter section, with wheat yields averaging 31 bu/ac and barley averaging 37 bu/ac. Agricultural damages from the 1954 Woody River flood are estimated at $32,967 and from the 1957 Swan Lake flood at $36,651.

The Birch River overflow at Sec.29 should be investigated before any system of diking occurs on the Woody River, as it is probable that flooding would occur behind these dikes on the west side of the Woody River. Similarly, investigation should be directed towards the possible effects that a dike may have on increased flooding on the south and east side of the Swan Lake, where serious flooding, but of a localized nature, at present takes place. It is felt that any increase in bank overflow will very readily spread to the south on account of the flat topography and the fall away from the river. The area which would receive protection from Scheme 2 of the diking is, as far as can be ascertained, comprised of the better soils found in the district.

Woody River Watershed Headwater Storage Study - Preliminary Engineering Report, PFRA, 1960.

The possibility of constructing headwater storage reservoirs to control flooding along the lower Woody River was investigated. In the Birch River Land Settlement and near Swan Lake, the gradient is only 0.4 ft per mile. It is here that much of the sediment load from the steep gradients upstream are deposited. This delta area is poorly-drained and swampy, with many aggraded and abandoned channels. The capacity of the river is small, causing floodwaters to overflow onto the land and into the marshes and abandoned channels. This flooding is further aggravated by recurrent high water levels in Swan Lake.

The reduction in flood peak discharges, due to various combinations of three storage reservoirs (dams up to 70 ft. in height) in the upper Woody River basin was determined. The optimum combination of reservoirs would give a maximum reduction in design peak flow of 12% at a cost of $1,012,000. Flooding would not be eliminated however and would reduce the cost of the diking proposed in the first report by only $23,000. The effectiveness of the headwater reservoirs are diminished for two reasons, firstly the distance the flood wave travels, and secondly due to the great quantity of uncontrolled local inflow that enters the river below the reservoirs.

Report of Detailed-Reconnaissance Soil Survey of Swan Lake Map Sheet Area, Manitoba Soil Survey, 1962.

The Canadian Northern Railway reached Cowan in 1899 and in the ensuing rush of settlers 1350 acres of land was prepared for seeding in the Swan Lake Valley for the spring of 1900.

Census information from 1956 indicated that improved land is 54.8%, 55.7%, and 15.7% of the total area in the municipalities of Swan Lake, Minitonas and Mountain respectively.

Average farm size increased between 1941 and 1956 in RM of Swan Lake from 270 acres to 317 acres, with farm operators peaking at 1018 in 1951, and a total of 2423 farm operators in all three RM's.

The major crop in the Swan Lake Valley in 1956 was barley, followed by oats, wheat and then cultivated hay. The general cropping practice on cultivated land is summerfallow followed by 2 or 3 years of grain crops. Wheat yields between 1939 and 1960 averaged 26.9 bu/ac, barley 30.0 bu/ac, oats 40.8 bu/ac, and flax 11.4 bu/ac. Average farm livestock in 1956 in the RM of Swan Lake are as follows; Horses-2.1, Milk Cows-5.9, Other Cattle-13.0, Sheep-2.8, Swine-25.1, Hens and Chickens, 47.1, Other Poultry, 92.3.

Approximately 40 % of the land in the municipalities of Minitonas and Swan Lake and about 75% of the land in the LGD of Mountain is not suitable for grain farming. This land occurs mainly along the eastern portion of the map area and in the hilly sections of Thunder Hill, Porcupine and Duck Mountains. These soils are rough, stony, gravelly, sandy or wet. Peat areas, which are wet most of the year, and soils with rugged topography cover the largest acreage unsuitable for grain production. In these areas livestock production appears to be the best use of the land. Limited grain production on small areas of better soils within these districts provide the necessary feed concentrate.

Natural Flow : Woody River at Saskatchewan - Manitoba Boundary, Prairie Provinces Water Board, 1985.

The average natural flow of the Woody River at the Saskatchewan - Manitoba boundary every year from 1912-1983 was approximately 49,680 dam^3. All estimates are based on data from the hydrometric gauging station at the Woody River near Bowsman, and are not considered adequate for calculating natural flow at the provincial boundary. There is only one licensed minor water use project in Saskatchewan, a stockwatering project constructed in 1965 with estimated average annual depletion (including evaporation) of 5 dam^3. Based on this level of development, monitoring of apportionment should not be implemented.

Natural Flow : Swan Lake at Saskatchewan - Manitoba Boundary, Prairie Provinces Water Board, 1985.

The average annual natural flow of Swan Lake at the Saskatchewan-Manitoba boundary in the 71 year period between 1912 and 1983 was 184,100 dam^3. Average annual consumptive water use in the Saskatchewan portion of the basin now amounts to approx. 117 dam^3, 0.06% of the average annual natural flow. The present (1983) level of use in the Saskatchewan side does not exceed Saskatchewan's 50% share of the natural flow at the border. The existing hydrometric network does not provide adequate information for calculating the natural flow at the border. However, it is not required based on the present water use.

Several water use projects, both licensed and unauthorized have been identified in the Saskatchewan side of the basin. Ducks Unlimited also has a large project on the Bear Head Creek. In addition, effluent from the Town of Swan Lake sewage system is discharged into the Swan Lake.

The first hydrometric gauging station in the basin was located at the Town of Swan Lake and operated between 1912 and 1936. It was reactivated between 1950-60. In 1960 it was moved to the Swan Lake near Minitonas. Another hydrometric station was established near Norquay, SK in 1965.

Manitoba Escarpment Headwater Storage Study, PFRA and Man. Natural Resources, 1988.

The entire Manitoba escarpment was studied to determine potential sites for headwater storage dams to reduce flooding and erosion. Several locations in the Swan Lake Basin were studied. The following sites were initially identified
a) Draining into Indian Birch River - Fishtown Cr. (2 sites), Swede Cr.
b) Draining into Woody River - Birch R., Kemulch Cr., Bowsman R., Smith Cr. Hubbell Cr., Trout Cr. (2), Whitefish Cr., McVey Cr., Mink Cr., Whitebeech Cr. (2), and 3 sites on the Woody River main channel.
c) Draining into the Swan Lake - Lobstick Cr., Roaring R. (2), Minitonas Cr. (2), East Favel R. and West Favel R.

Of these sites, preliminary hydrologic evaluations were done to identify those sites which do not have sufficient storage capacity to appreciably reduce downstream flood flows. After this, two sites were selected for detailed investigations, one on the Minitonas Creek at NE 3-35-26 W1, and one on the West Favel River at NW 30-35-25 W1. A damage-causing event on these two creeks was determined to occur every five years on average, likely in the summer. The costs of these two large dams (up to 52 feet in height) outweighed the potential benefits of the project and were ruled out as unfeasible.

One of the recommendations of the report is that a pilot project be undertaken to study the effectiveness of several dozen small headwater storage dams for water control in South Tobacco Creek area.

Flood Risk Study for Swan Lake I.R. 65C Manitoba, Environment Canada, 1994.

This report studies the flood risk from the combined effects of the mean annual (1:2) wind and the 1:100 calm lake levels of Swan Lake under a Memorandum of Understanding between Environment Canada and the Dept. of Indian and Northern Affairs. Swan Lake I.R. 65C has an area of 785 ha (1940 ac) and a population of 175 on-reserve and 121 off-reserve members, and has two large rivers passing through the reserve, the Woody (drainage area 2500km^2). and the Indian Birch (drainage area 300 km^2) Rivers. In addition, the Wawayanagan River (drainage area 35km^2) joins the Indian Birch River inside the reserve.

Heavy rains in July of 1993 have indicated that the 1:100 design flood elevation for Swan Lake, including wind effects, exceeds the 1:100 flood levels for either of the rivers on the reserve. In July 1993 the Woody River reached 1:50 levels and peak flows were mitigated by discharge spilling into Swan Lake through the marsh area immediately upstream of the Swan Lake reserve. Thus, the necessity for a flood risk study of the rivers was negated.

Manitoba Natural Resources has estimated the 1:100 calm lake level as 260.73m (855.41 ft) through 36 years of annual maximum mean daily lake levels monitored at Swan lake near Novra. The terms of reference for this flood risk study require the determination of 1% annual flood level including wind effects, and 1:100 flood lake levels taking into account the effect of an inshore wind on the water levels. The flood risk areas have been mapped to establish flood risk shoreline zones of the reserve. The resulting 1:100 design flood levels for Swan lake along the shoreline of Swan lake Reserve were 261.29m (857.25 ft) on the East Shore and 261.28m (857.19) ft on the North Shore.