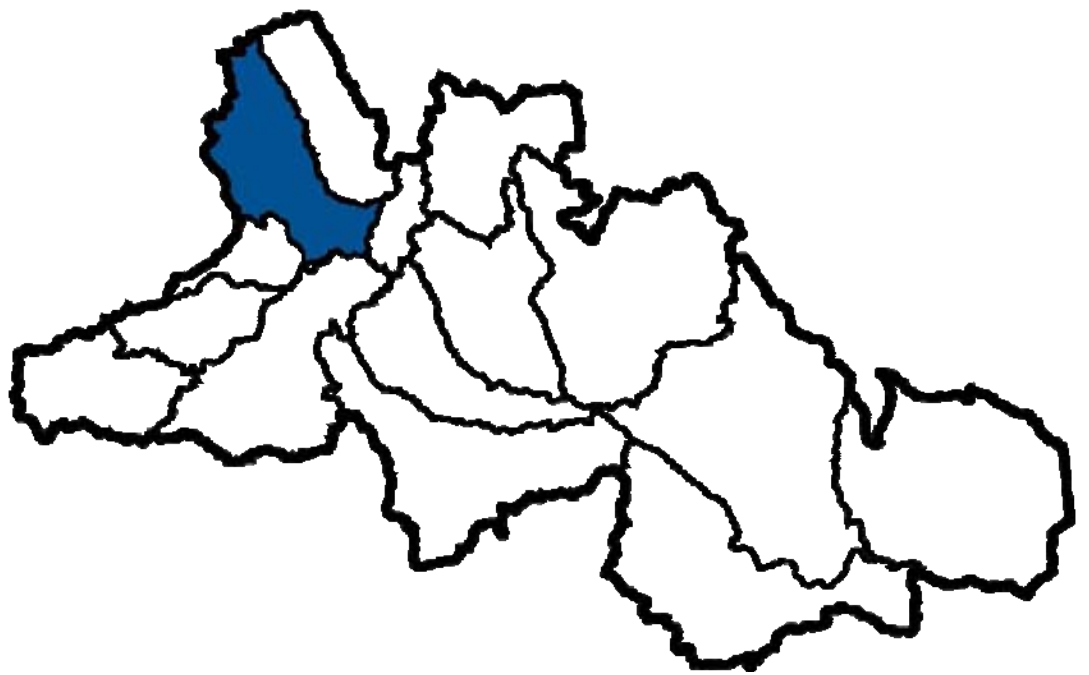


# Medicine Subwatershed



## **4.5 Medicine River Subwatershed**

### *4.5.1 Watershed Characteristics*

The Medicine River subwatershed encompasses about 289,943 ha and is located in the Counties of Clearwater, Lacombe, Ponoka and Red Deer (Figure 140).

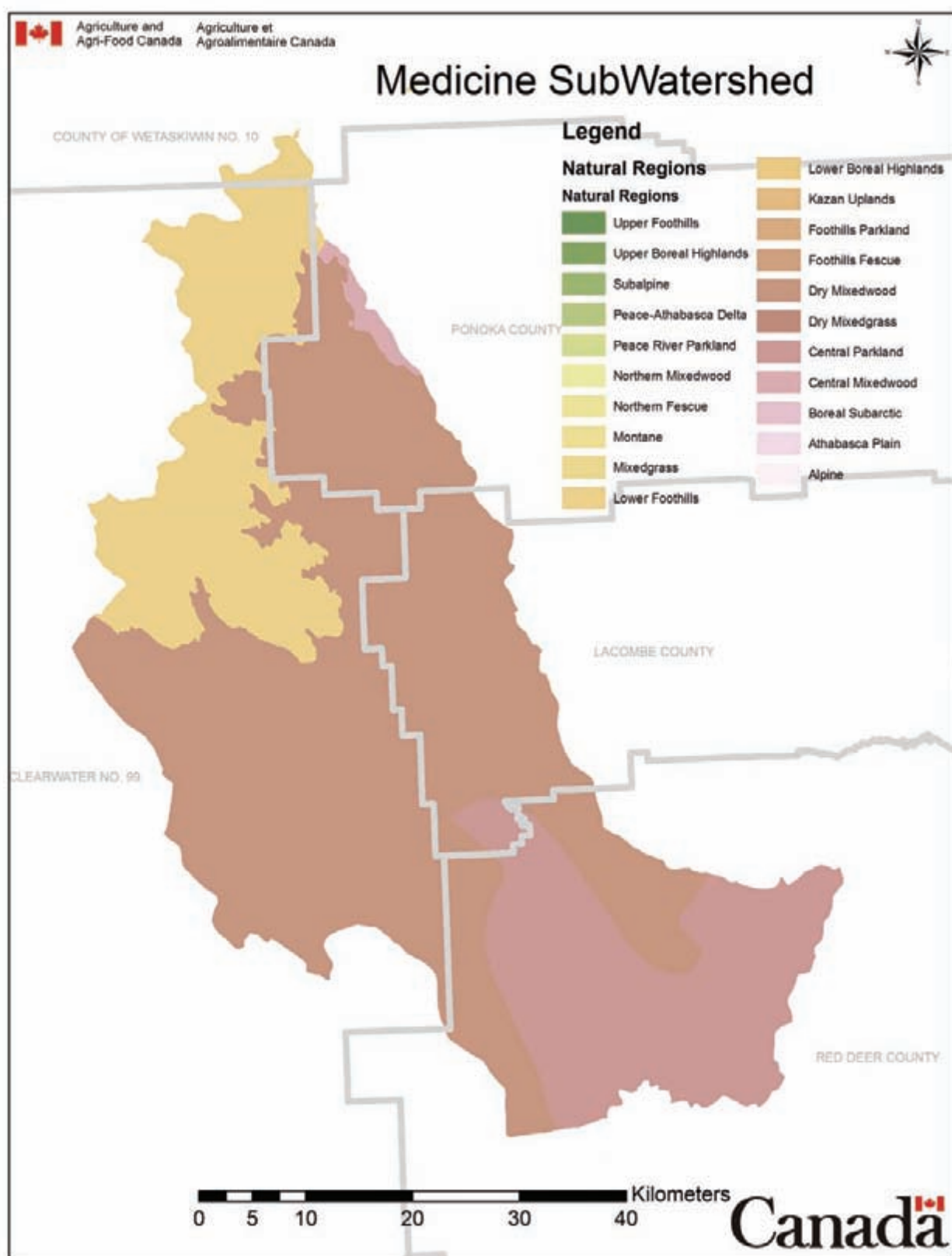
The Medicine River subwatershed is located in the northwest of the Red Deer River watershed. The subwatershed lies in the Lower Foothills, Dry Mixedwood and Central Parkland Subregions (Figure 141). The Lower Foothills Subregion lies at an elevations of about 1,250-1,450 m and is dominated by mixed forests of white spruce (*P. glauca*), black spruce (*P. mariana*), lodgepole pine (*P. contorta*), balsam fir (*A. balsamea*), aspen (*Populus* spp.), balsam poplar (*P. balsamifera*) and paper birch (*B. papyrifera*). Forests in the Dry Mixedwood Subregion are dominated by aspen (*Populus* spp.), balsam poplar (*P. balsamifera*), white spruce (*P. glauca*) and, in some areas, balsam fir (*A. balsamea*). Pure deciduous stands are common in the southern part of the Subregion, and dry, sandy sites are usually occupied by jack pine (*P. banksiana*). Peatlands are common and may be extensive. The Central Parkland Subregion is dominated by grassland with groves of aspen (*Populus* spp.), with the grassland vegetation being dominated by rough fescue (*F. campestris*) (Heritage Community Foundation, 2008).

The geology of the Medicine River subwatershed consists of the Paskapoo Formation, which formed in the Paleocene epoch (56-65 million years ago). The formation consists of diverse sandstones and siltstones/mudstones and minor shale deposits (Alberta Geological Survey, 2006).

The climate of the Medicine River subwatershed is subhumid and continental. Mean May-September temperatures range from 11-13 °C, and the total annual precipitation ranges from 350-465 mm. Upwards of 2/3 of the total annual precipitation falls between May and September, with June and July being the wettest months (Environment Canada, 2006).



**Figure 140.** Location of the Medicine River subwatershed (AAFC-PFRA, 2008).



**Figure 141.** Natural subregions of the Medicine River subwatershed (AAFC-PFRA, 2008).

#### 4.5.2 Land Use Indicators

Changes in land use patterns reflect major development trends, such as forested lands converted to agriculture and agricultural lands developed and lost to urban sprawl. Land use changes and the subsequent changes in management practices impact both the quantity and quality of water within the Red Deer River watershed. Six metrics were used to indicate changes in land use and land use practices in the Red Deer River watershed and its 15 subwatersheds:

- Wetland Loss – Condition Indicator
- Riparian Health – Condition Indicator
- Livestock Manure Production – Risk Indicator
- Urban, Rural and Recreational Developments – Risk Indicator
- Linear Developments – Condition Indicator
- Oil and Gas Activities – Risk Indicator

These six land use change indicators also reflect socioeconomic growth in a region. Hence, while human activities in a region can have negative environmental impacts, it is important to strive for a balance between socioeconomic growth and the sustainable management of natural ecosystems to ensure their long-term health and enjoyment by future generations.

##### 4.5.2.1 Wetland Loss

Wetlands serve many functions in the natural landscape including water storage, flood attenuation, wildlife habitat, groundwater recharge and general water quality improvements (e.g., nutrient uptake, degradation of pesticides, sediment retention). Additionally, wetlands provide a cost effective and sustainable alternative to engineered treatment options. The loss of wetlands to development and/or agriculture can be deleterious to surface and groundwater quantity and quality.

Land cover data indicate the presence of 11,635 ha of wetlands (4.01% of the total subwatershed area) in the Medicine River subwatershed (AAFC-PFRA, 2008). Wooded and open, shrub-dominated fens occur near Medicine Lake (Twp. 44, Rge. 6, W 5) (Lamoureux et al., 1983; Geowest Environmental Consultants Ltd., 1995). There are no data on any other classes, forms and types of wetlands (*sensu* National Wetlands Working Group, 1997) within the subwatershed; however, given the presence of lentic (lakes) and lotic (streams and rivers) systems, marshes and shallow open water wetlands are likely also present in the subwatershed. In addition, ephemeral, temporary, seasonal and semi-permanent wetlands (*sensu* Stewart and Kantrud, 1971) are likely present in the subwatershed as well.

The Prairie Habitat Joint Venture program (a partnership between federal and provincial governments, organizations and conservation groups in Manitoba, Saskatchewan and Alberta) has assessed the loss of wetlands in the Parkland Natural Region (in the Central Parkland Subregion) from 1985-2001 (Watmough and Schmoll, 2007). In Alberta, this Subregion has lost 7% of its total wetland area and 8% of its total number of wetlands due to anthropogenic disturbances in that 16-year period. There appears to be no change in the rate of wetland loss in the Prairie Parkland Region over the past 50-70 years. Caution must be taken when extrapolating these data to the entire subwatershed, since only one transect from the Prairie Habitat Joint Venture program was located in the entire subwatershed (Watmough and Schmoll, 2007).

## 4.5.2.2 Riparian Health

Riparian areas are an important transition zone between uplands and water. They act as buffer zones, protecting water quality and attenuating floods. Contaminants are adsorbed onto sediments, assimilated by vegetation and transformed by soil microbes into less harmful forms. They have long been proven effective in reducing nutrients, sediments and other anthropogenic pollutants that enter surface waters via overland and subsurface flow.

Three riparian health assessments have been conducted in the Medicine River subwatershed. In 2002, 16 study sites were assessed along 17.4 km of the Medicine River from Highway 11 to the confluence of the Medicine River with the Red Deer River (Cows and Fish, 2003a). In 2003, a second assessment was completed along the Medicine River from the northwest border of Ponoka County to the southern border of Lacombe County (Cows and Fish, 2004). A third riparian health assessment was completed on tributaries of the Medicine River in 2004. These tributaries were within Clearwater County and included Blueberry, Horseguard, Lasthill, Lobstick and Welch Creeks (Cows and Fish, 2005c) (Table 65).

**Table 65.** Riparian health assessment of waterbodies in the Medicine River subwatershed.

<b>Waterbody</b>	<b>Location</b>	<b>Primary health issues</b>	<b>Ranking</b>
Medicine River <sup>1</sup>	Highway 11 to the confluence of the Medicine River with the Red Deer River, 17.4 km	Invasive plant species, disturbance-caused plants, low number of preferred woody species	16 sites, 6 healthy, 5 healthy but with problems, 5 unhealthy
Medicine River, Horseguard Creek, Stauffer Creek <sup>2</sup>	Selected locations along the river and creeks, 18.6 km	Invasive plant species, disturbance-caused plants, low number of preferred woody species	20 sites, 3 healthy, 9 healthy but with problems, 8 unhealthy
Blueberry Creek, Horseguard Creek, Lasthill Creek, Lobstick Creek, Welch Creek <sup>3</sup>	Selected locations along the creeks, 25.6 km	Noxious and disturbance-caused weeds, heavy grazing of woody plants, streambank structurally altered, pugging and/or hummocking	25 sites, 7 healthy, 8 healthy but with problems, 10 unhealthy

Note: 1 = Cows and Fish (2003a), 2 = Cows and Fish (2004), 3 = Cows and Fish (2005c).

Overall, the health assessments showed that 27% of all sites assessed received a rating of healthy, 35% received a rating of healthy but with problems and 38% received a rating of unhealthy. The primary causes for impaired riparian health were the presence of invasive and/or disturbance-caused plants, grazing of preferred woody plant species and altered streambanks and pugging and/or hummocking (Table 65).

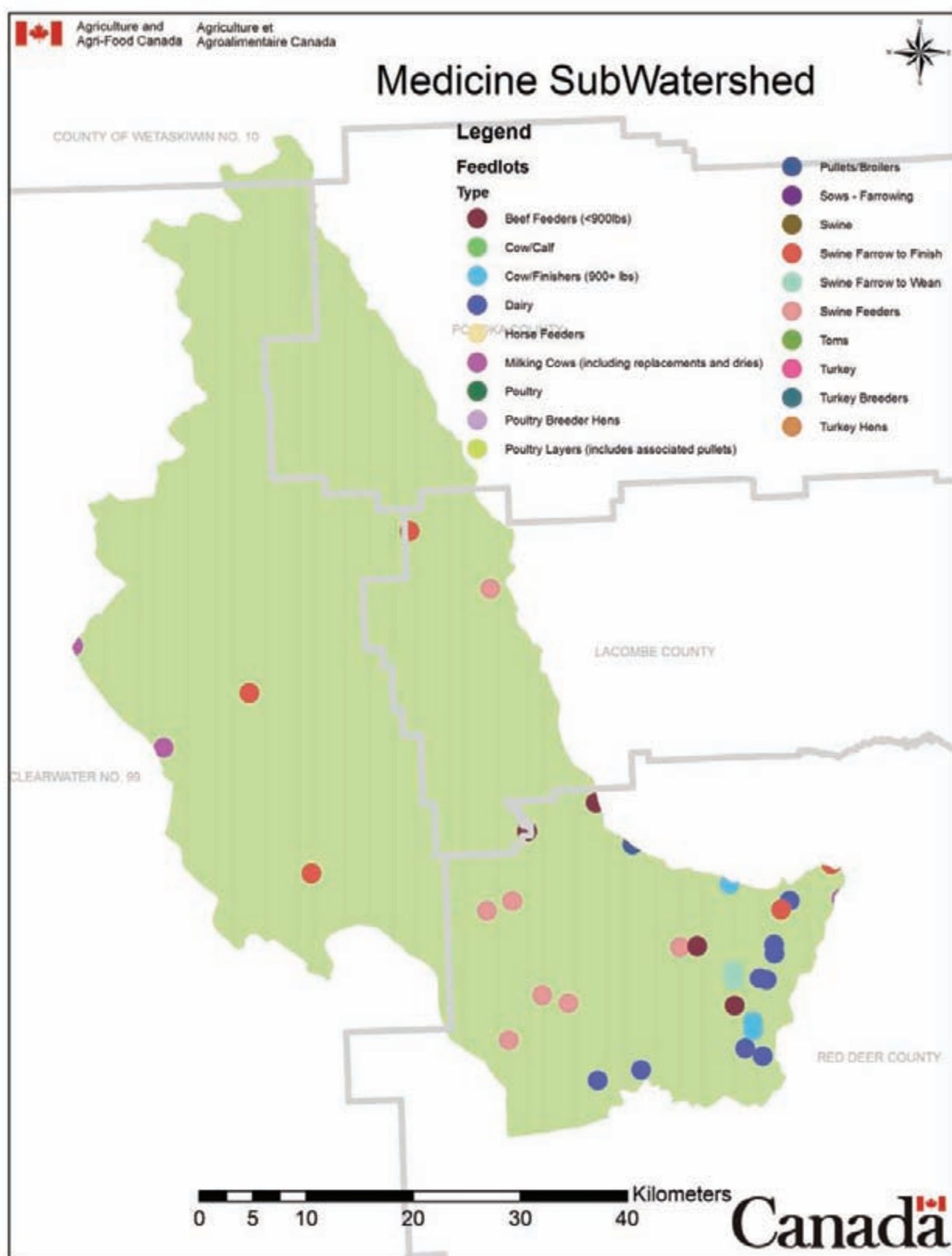
#### 4.5.2.3 Livestock Manure Production

Areas of higher livestock density within a subwatershed, and their associated higher manure production, are expected to have greater impacts on downstream water quality. Streams that drain land with high intensity livestock operations have higher nutrient concentrations, dissolved nutrients, mass loads, fecal bacteria and exports of total dissolved phosphorus than streams with medium or low intensity livestock operations and manure production.

There are more than 30 feedlots/intensive livestock operations in the Medicine River subwatershed, located mostly in the south-eastern area of the subwatershed in the vicinity of Red Deer River (Figure 142) (AAFC-PFRA, 2008). Most of these feedlots finish cattle/cows and swine. Cattle density ranges from 0-0.20 cattle/ha in the northern area of the subwatershed, to 0.21-0.40 cattle/ha in the north-central area of the subwatershed and to 0.41-0.60 cattle/ha throughout the remainder of the subwatershed (Figure 143) (AAFC-PFRA, 2008). Manure production ranges from 2.6-5.0 tonnes manure/ha in the north-central area of the subwatershed and from 5.1-7.5 tonnes manure/ha throughout the southern area of the subwatershed (Figure 144) (AAFC-PFRA, 2008). These manure production quantities are considered low relative to the remainder of the Red Deer River watershed.

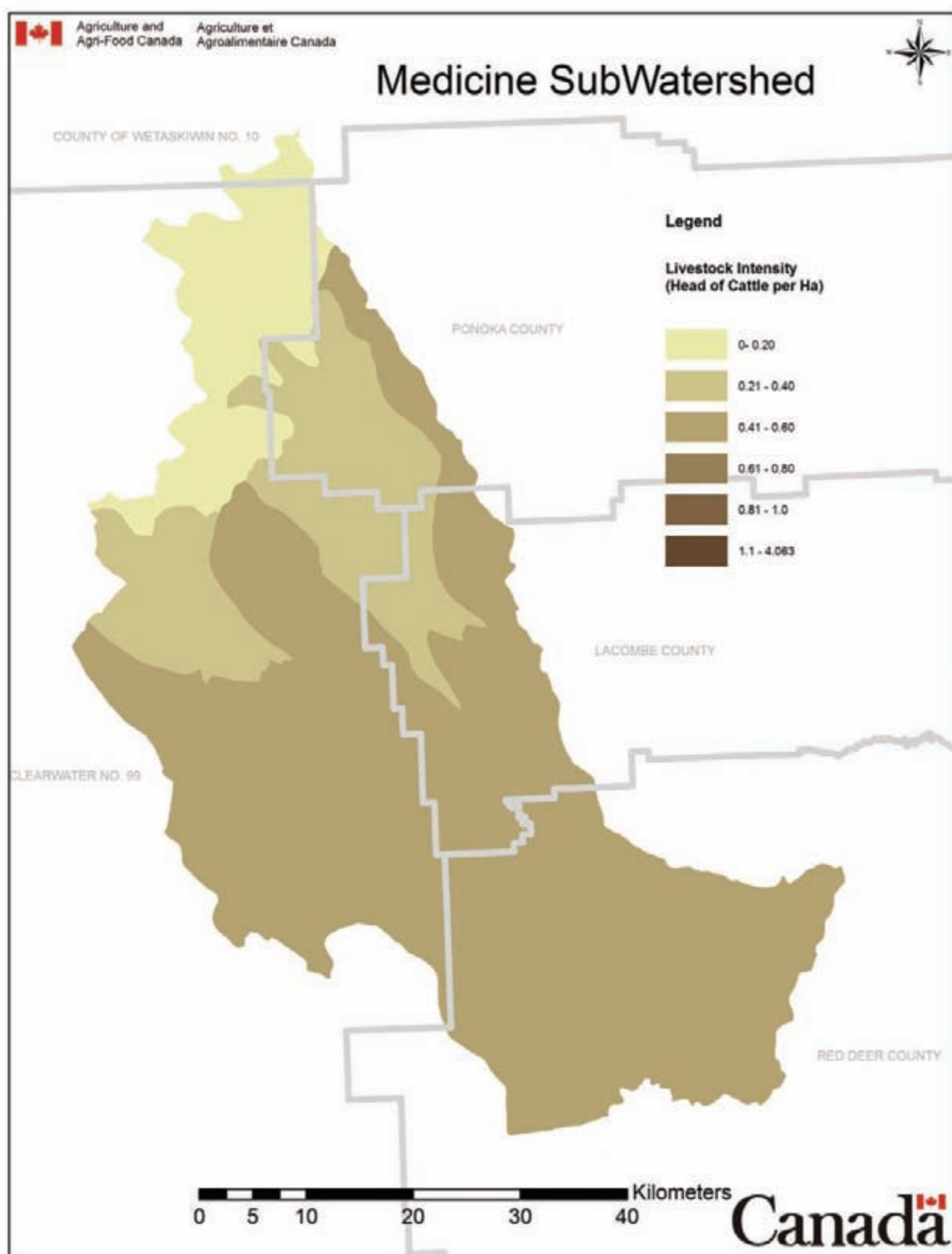
Agricultural intensity, expressed as the percent land cover used as croplands, ranges from 0-40% in the northwestern area to primarily 40-60% intensity in the remainder of the Medicine River subwatershed. Agricultural intensity peaks near the Red Deer River (60-80%) (Figure 145) (AAFC-PFRA, 2008).

The Rocky Mountain House Provincial Grazing Reserve is located north of Highway 53 and east of Highway 22 near Medicine Lake. It covers an area of 6,411 ha and can accommodate about 1,300 head of mature livestock. It has been in operation since 1984 and is open for livestock grazing from May-November. As a result of this unique design and geophysical characteristics, the reserve offers a variety of recreational opportunities, including hunting for elk, moose, white-tailed and mule deer and bears, fishing on the Medicine River and its tributaries and snowmobiling and trail riding on numerous old logging trails. Recently, oil and gas exploration has occurred throughout the reserve (Alberta Sustainable Resource Development, 2008b).

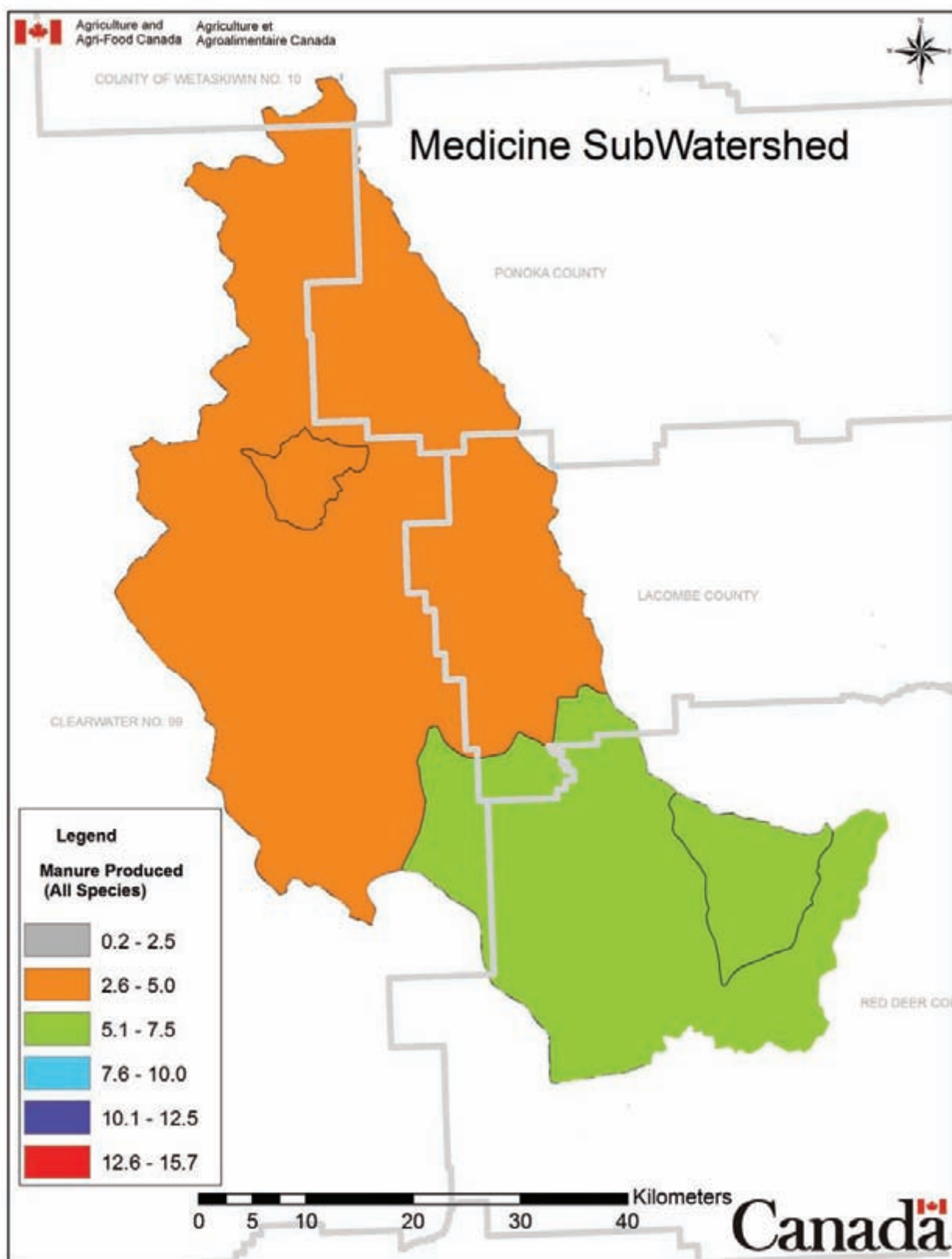


**Figure 142.** Feedlots and intensive livestock operations in the Medicine River subwatershed (AAFC-PFRA, 2008).

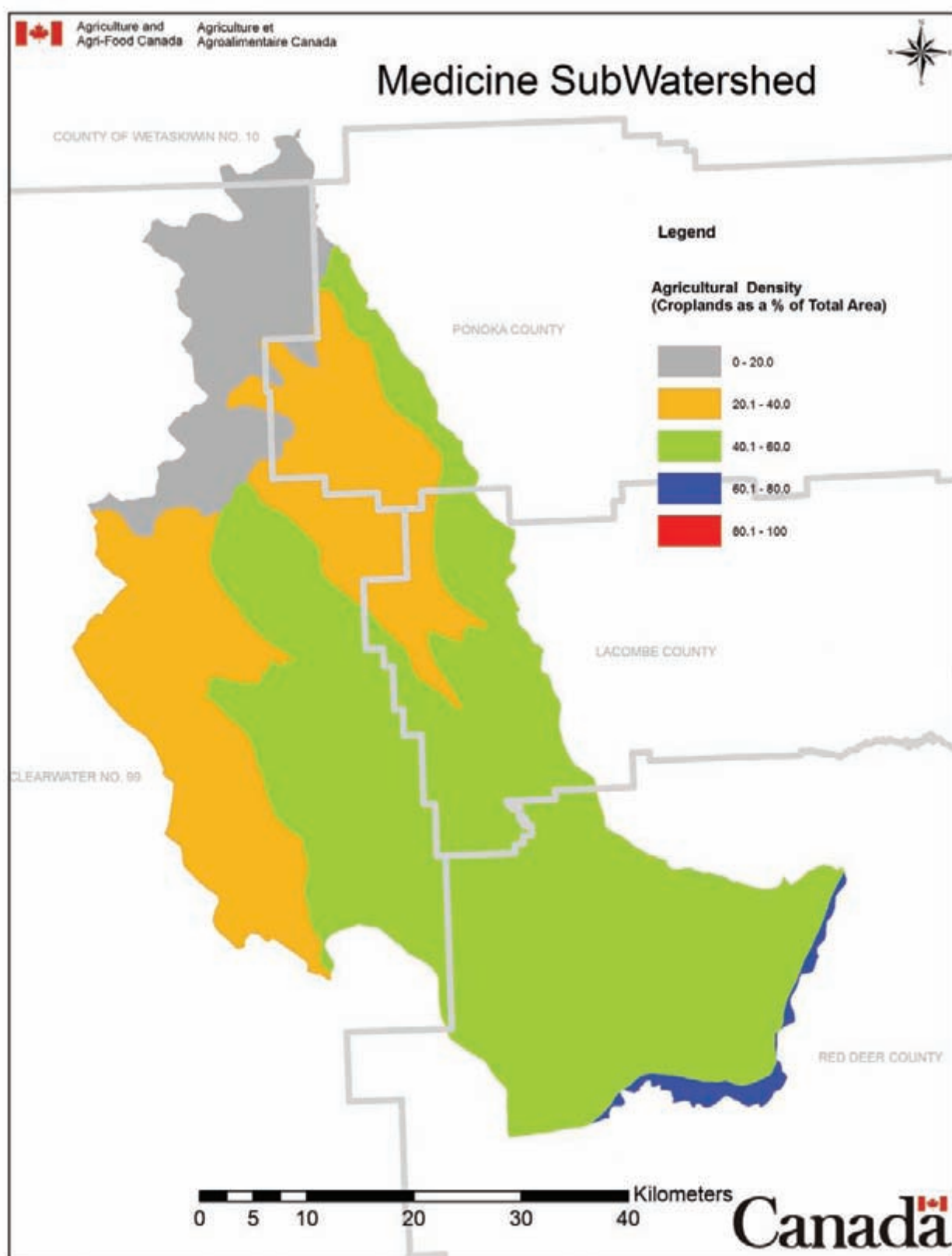




**Figure 143.** Cattle density (cattle/ha) in the Medicine River subwatershed (AAFC-PFRA, 2008).



**Figure 144.** Manure production (tonnes/ha) in the Medicine River subwatershed (AAFC-PFRA, 2008).



**Figure 145.** Agricultural intensity (% cropland) in the Medicine River subwatershed (AAFC-PFRA, 2008).

#### 4.5.2.4 Urban, Rural, Agricultural and Recreational Developments

Urban sprawl, rural and recreational development is the expansion of urban areas, rural subdivisions and recreational areas into surrounding landscape. This expansion can have many negative effects on the environment, including the loss of wetlands, riparian areas, intermittent streams and wildlife habitat, as well as increased surface runoff into neighboring creeks, rivers and lakes.

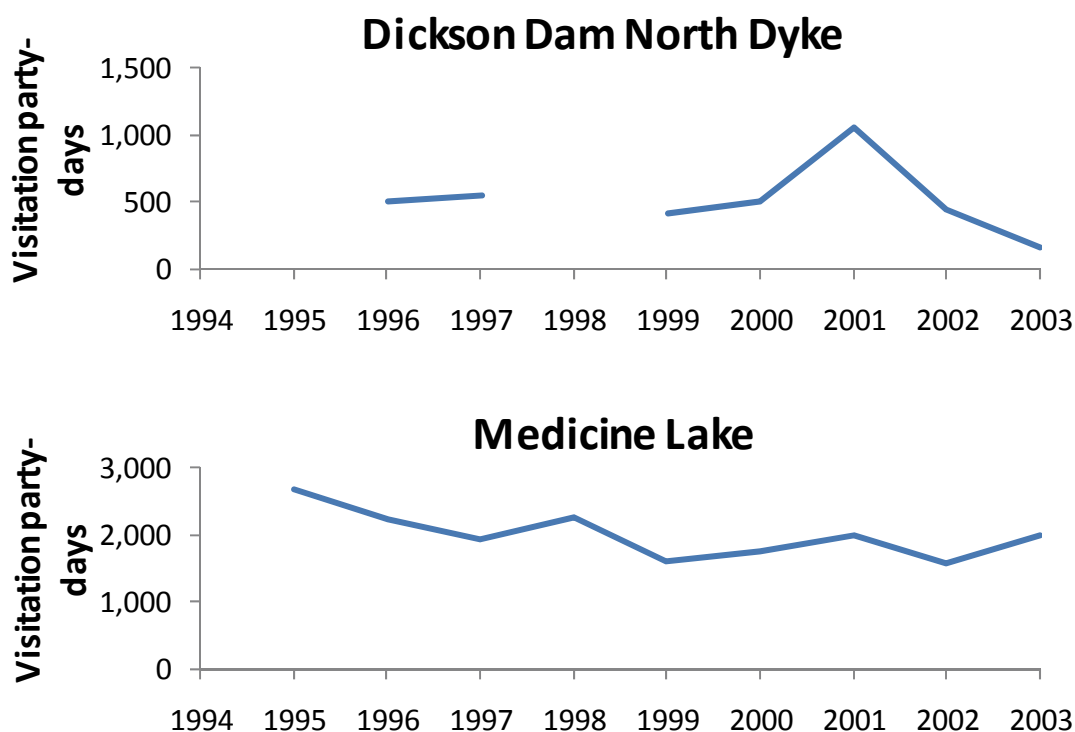
Communities in the Medicine River subwatershed include the Town of Eckville as well as numerous hamlets, including Alhambra, Benalto, Bingley, Carlos, Codner, Condor, Dickson, Elspeth, Evarts, Evergreen, Gilby, Hespero, Leedale, Leslieville, Markerville, Spruce View, Willesden Green and Withrow (Government of Canada, 2006). There are six recreational facilities in the subwatershed, including Provincial Natural Areas (PNA), one Provincial Forest Recreation Area (PFRA), one Provincial Grazing Reserve (PGR) and one Provincial Recreation Area (PRA) (Table 66) (Alberta Tourism, Parks and Recreation, 2008b).

**Table 66.** Recreational facilities in the Medicine River subwatershed (Alberta Tourism, Parks and Recreation, 2008b).

Facility	Characteristics
Chedderville PNA	<ul style="list-style-type: none"> <li>• 229.34 ha</li> </ul>
Dickson Dam-North Dyke PRA	<ul style="list-style-type: none"> <li>• 19.95 ha on Gleniffer Lake Reservoir</li> <li>• 30 unit campgrounds</li> </ul>
Medicine Lake PFRA	<ul style="list-style-type: none"> <li>• 40.38 ha</li> <li>• 49 unit campgrounds, 10 unit group campgrounds</li> </ul>
Open Creek PNA	<ul style="list-style-type: none"> <li>• 64.75 ha on Open Creek</li> <li>• day use sites</li> </ul>
Rocky Mountain House PGR	<ul style="list-style-type: none"> <li>• 6,411 ha on the Medicine River</li> <li>• can accommodate about 1,300 head of cattle, grazing season is from May-November</li> <li>• wilderness camping, hunting, fishing, trail riding and snowmobiling</li> </ul>
Welch Creek PNA	<ul style="list-style-type: none"> <li>• 64.53 ha on Medicine Lake</li> <li>• day use site on Welch Creek</li> </ul>

Note: PFRA = provincial forest recreation area, PGR = provincial grazing reserve, PNA = provincial natural area, PRA = provincial recreation area.

Visitation statistics for two recreation facilities in the subwatershed indicate that the number of visitors to these facilities varies considerably on an annual basis (Figure 146). For those years with available data, the average number of visitors per year was 520 in Dickson Dam North Dyke PRA and 2,006 in Medicine Lake PFRA. An average 2,411 visitors have used these two recreation facilities annually from 1994-2003 (Alberta Tourism, Parks and Recreation, 2008b).



**Figure 146.** Visitation statistics for two recreation facilities in the Medicine River subwatershed (Alberta Tourism, Parks and Recreation, 2008b).

Recreation activities, including the use of off-highway motor vehicles (OHVs), monster trucks, mudder trucks, boats, jet-boats, etc., and the improper disposal of garbage have had substantial and increasing impacts on the ecological integrity of aquatic and terrestrial habitats in the subwatershed, particularly in Clearwater County, where an increasing number of violation tickets have been issued since 2004 (Alberta Sustainable Resource Development, 2008a). Increased enforcement and clean-up activities have resulted in escalating costs to the enforcement agencies, including the RCMP, Clearwater County Highway Patrol, Sustainable Resources (Lands Division, Fish & Wildlife and Forestry), Tourism, Parks, Recreation, Commercial Vehicle Enforcement and Alberta Sheriff's Department (Edmonton, Calgary and Red Deer) (Alberta Sustainable Resource Development, 2008a).

#### 4.5.2.5 Linear Developments

Linear developments include seismic lines, pipelines, roads, railways and utility right of ways. Quantifying linear development will help us understand potential changes in water quality and fish and wildlife populations, e.g., wildlife corridors can be interrupted by roads, and watersheds can have their drainage patterns permanently altered by increases in impervious or compacted surfaces.

The most prominent linear developments in the Medicine River subwatershed are urban and rural roads, which have a total length of 3,900 km and cover 62.4 km<sup>2</sup> of the subwatershed's landbase. Other major linear developments include cutlines/trails and pipelines (Table 67). In total, all linear

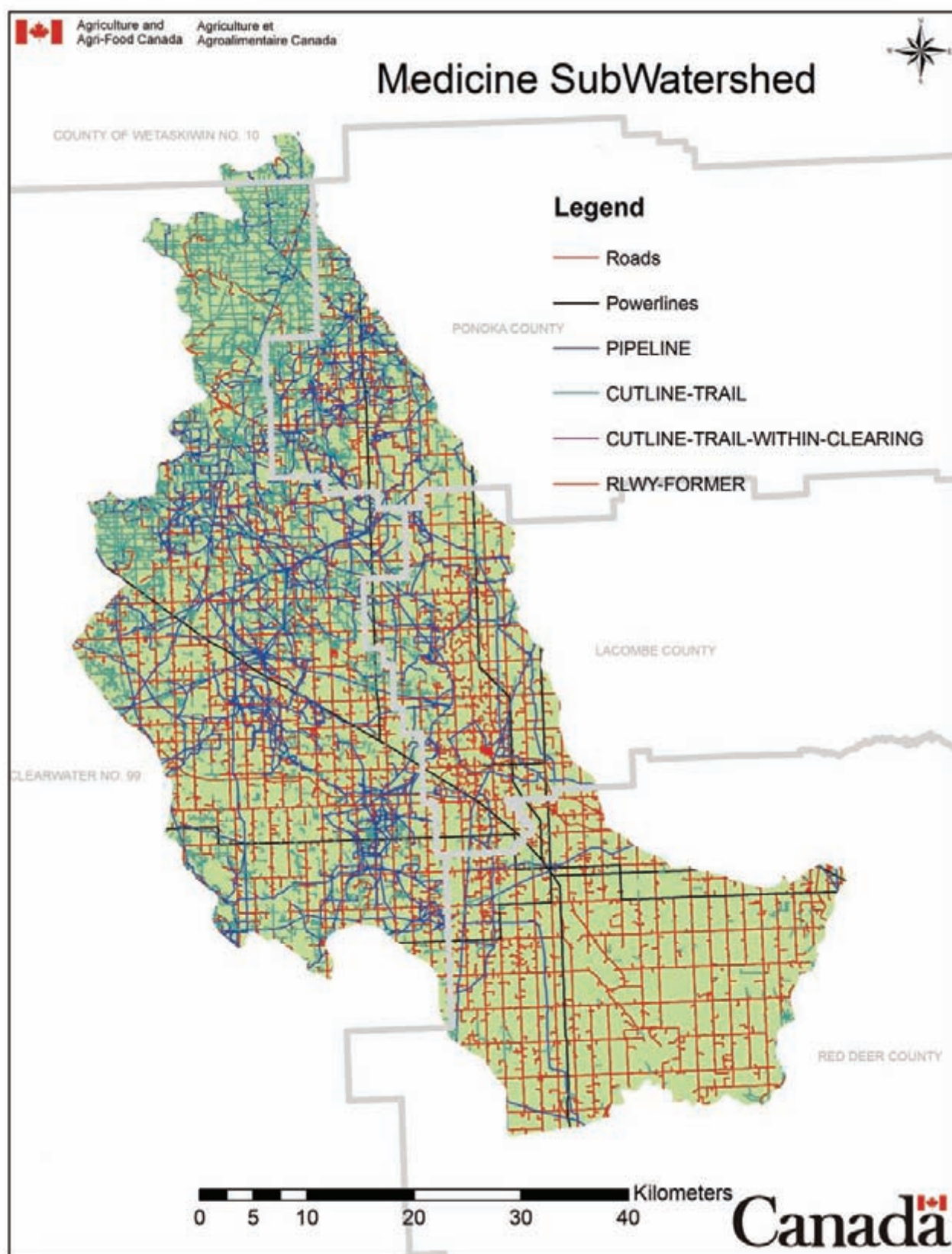
developments cover an area of 123.7 km<sup>2</sup>, or 4.3% of the total area of the subwatershed (Figure 147) (AAFC-PFRA, 2008).

**Table 67.** Linear developments in the Medicine River subwatershed (AAFC-PFRA, 2008). The dominant linear development is highlighted.

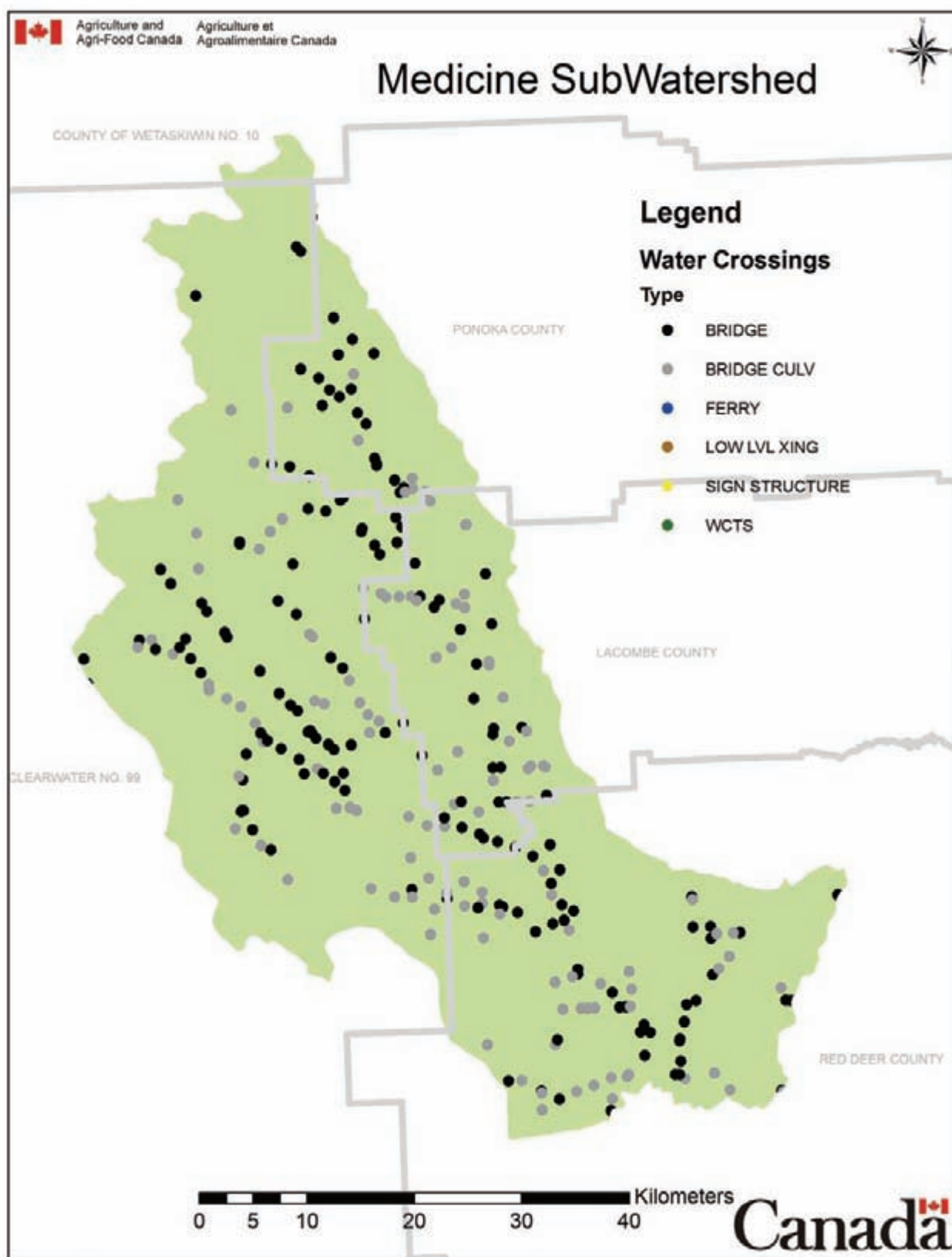
Linear Development	Length (km)	Width (m)	Area (km <sup>2</sup> )	Proportion of total linear disturbances (%)
All roads	3,900	16	62.40	50.5
Cutlines/trails	2,600	6	15.60	12.6
Pipelines	2,300	15	34.50	27.9
Powerlines	330	30	9.90	8.0
Railways	85	15	1.27	1.0
<b>Total</b>	<b>9,215</b>		<b>123.67</b>	

In addition to linear developments, the Medicine River subwatershed has 293 bridges that cross waterbodies, mostly streams and creeks, or culverts that connect waterbodies (Figure 148) (AAFC-PFRA, 2008). These are primarily associated with the Medicine River and Lobstick Creek. The majority of pipeline crossings in the Medicine River subwatershed are located in the north-central area of the subwatershed near Lobstick and Welch Creeks. There are no pipeline crossings near Medicine Lake in the north-west of the subwatershed and south of Sylvan Lake and east of Medicine River in the south-east of the subwatershed (Figure 149) (AAFC-PFRA, 2008).



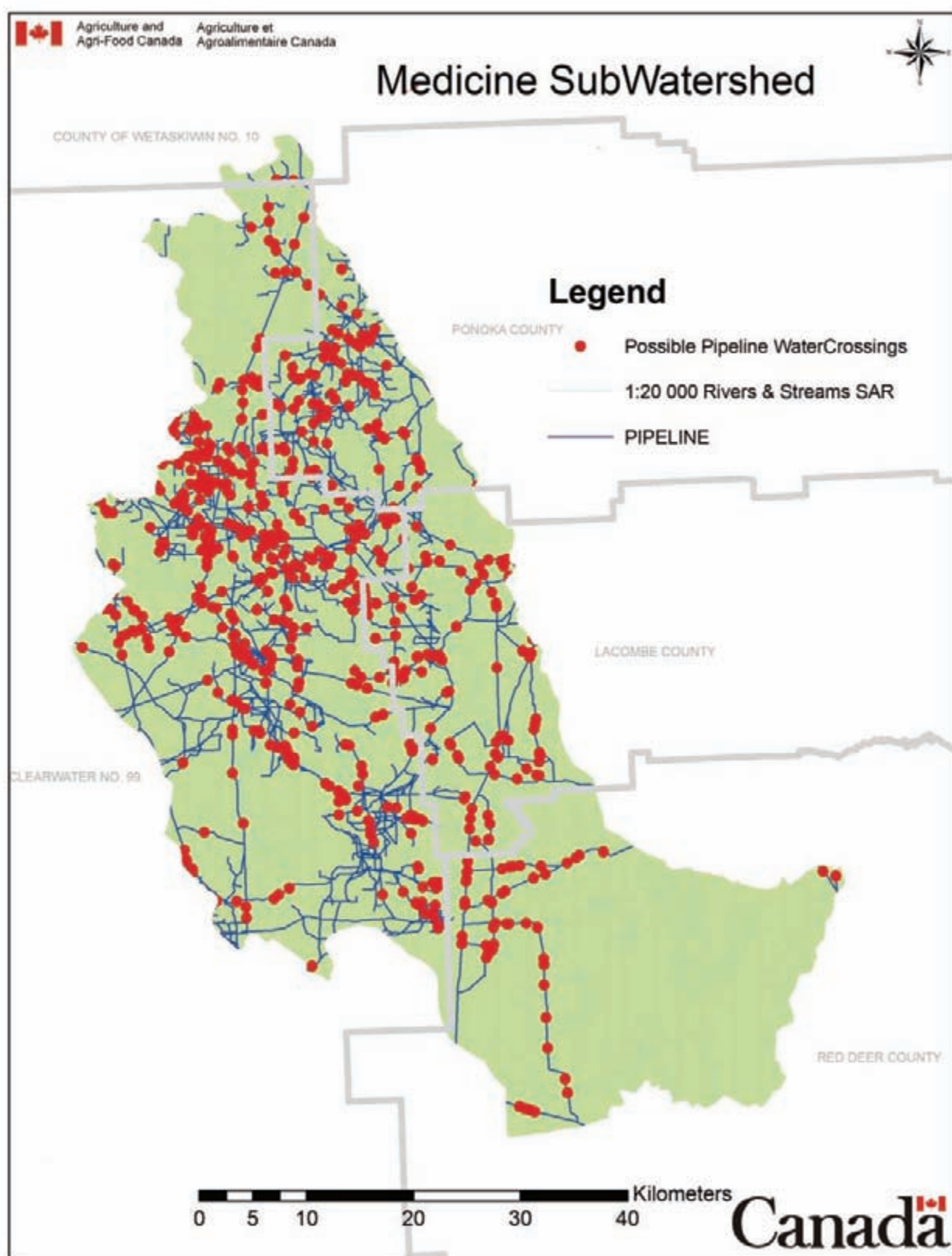


**Figure 147.** Linear developments in the Medicine River subwatershed (AAFC-PFRA, 2008).



**Figure 148.** Waterbody crossings in the Medicine River subwatershed (AAFC-PFRA, 2008).





**Figure 149.** Pipeline crossings over waterbodies in the Medicine River subwatershed (AAFC-PFRA, 2008).

## 4.5.2.6 Oil and Gas Activities

Oil and gas activity is very common throughout the province of Alberta. With oil and gas development there can be a number of associated impacts, including loss of wetlands, habitat fragmentation, increased water use and surface water and groundwater contamination (Alberta Centre for Boreal Studies, 2001).

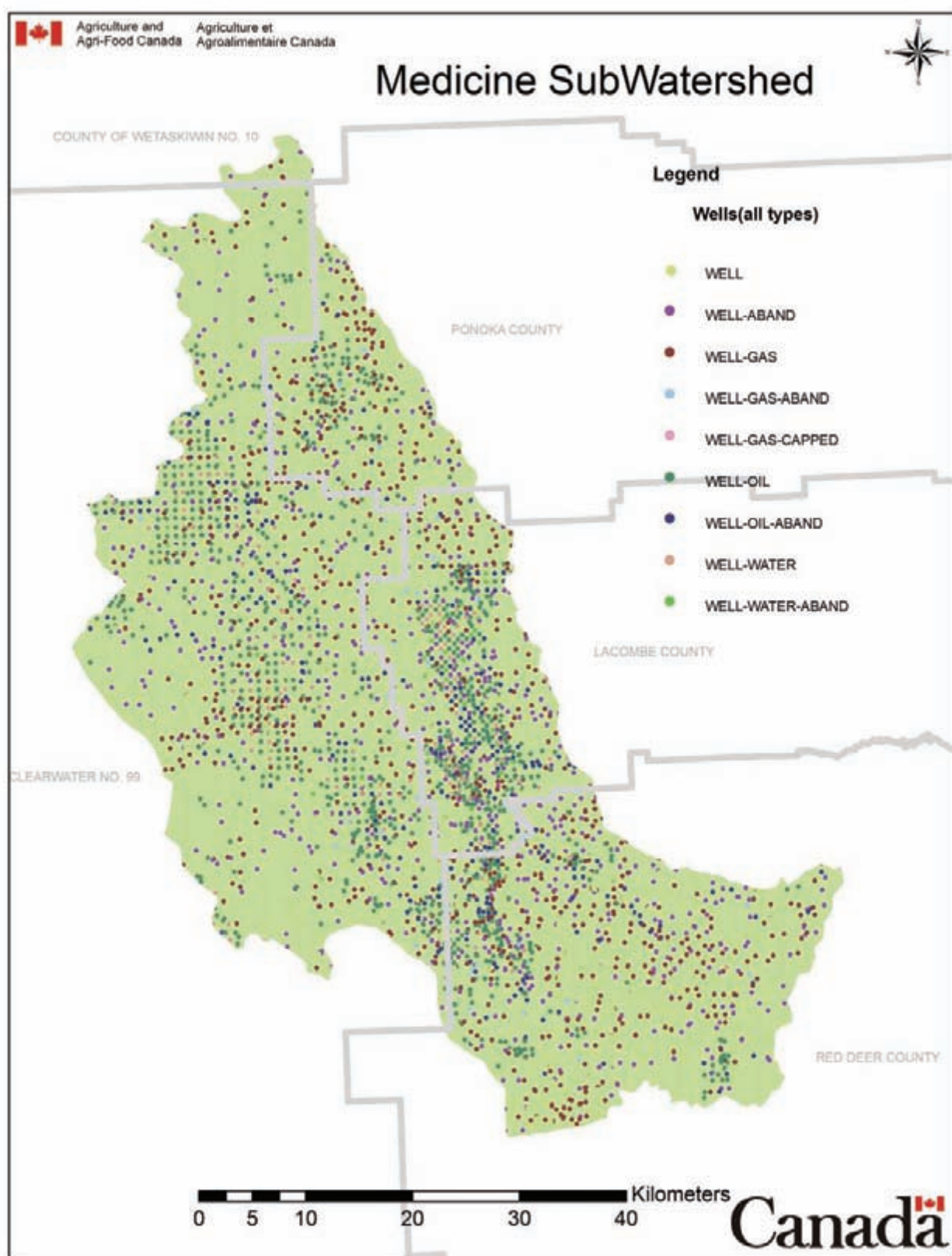
The Medicine River subwatershed has an average well density of 2.31 wells/km<sup>2</sup>. The well density increases up to 10 wells/km<sup>2</sup> north and south of Eckville (west and south-west of Sylvan Lake) and reaches a density of up to 40 wells/km<sup>2</sup> near Eckville and Benalto (Figure 150). About 67% of all wells are active, with the majority of all wells being oil wells, followed by gas and unspecified wells (Table 68) (AAFC-PFRA, 2008).

**Table 68.** Number of known active and abandoned oil, gas, water and other wells in the Medicine River subwatershed (AAFC-PFRA, 2008).

Well type	Quantity
Wells – active *	999
Wells – abandoned *	1,192
<b>Total</b>	<b>2,191</b>
Gas wells – active	1,883
Gas wells – abandoned	152
<b>Total</b>	<b>2,035</b>
Oil wells – active	1,450
Oil wells – abandoned	775
<b>Total</b>	<b>2,225</b>
Water wells – active	172
Water wells – abandoned	83
<b>Total</b>	<b>225</b>
<b>Total active wells in subwatershed</b>	<b>4,504</b>
<b>Total abandoned wells in subwatershed</b>	<b>2,202</b>
<b>Total wells in subwatershed</b>	<b>6,706</b>

\* The purpose of these wells is undefined and may include standing, newly licensed, flowing coalbed methane, testing coalbed methane, carbon dioxide injector or general exploration wells.

Coal bed methane (CBM) is natural gas that is found within coal formations. It has received attention recently as an additional source of energy; however, it brings with it potential environmental impacts, some of which are similar to conventional oil and gas exploration and production endeavors. Conversely, some potential impacts it brings with it are new, including an increased intensity in wells, compressors, pipeline infrastructure and completion and production of natural gas from formations above the base of groundwater protection. Some CBM wells are estimated to produce over 65,000 L of waste water per day (Lennon, 2008). In addition, common to oil, gas and unconventional gas (CBM and Shale gas) production is the risk of groundwater contamination through fracturing. Fracturing results from pumping fluids or gases into bedrock formations at high rates and pressures to 'fracture' the bedrock and increase gas or oil production. Fracturing fluids may contain toxic or carcinogenic compounds, which may leach into groundwater sources and pose a threat to human health through contaminated drinking water (Natural Resources Defense Council, 2002).



**Figure 150.** Known active and abandoned oil, gas, water and other wells in the Medicine River subwatershed (AAFC-PFRA, 2008).

#### 4.5.3 Water Quality Indicators

Changes in water quality indicate either a deterioration or improvement in the condition of the watershed and demonstrate specific areas that require further attention or protection. Changes in water quality result from changes in land use or land management practices, landscape disturbance and natural events. The major anthropogenic impacts on water quality result from natural resource extraction and processing, wetland drainage, dredging, dam construction, agricultural runoff, industrial wastes, municipal wastes, land erosion, road construction and land development. Five metrics were used to indicate changes in water quality in the Red Deer River watershed and its 15 subwatersheds:

- Nutrients – Condition Indicator
- Bacteria – Condition Indicator
- Parasites – Condition Indicator
- Pesticides – Condition Indicator
- Point Source Inputs

These five water quality indicators reflect socioeconomic growth in a region. Hence, while human activities in a region can have negative impacts on aquatic ecosystems, it is important to strive for a balance between socioeconomic growth and the sustainable management of these aquatic ecosystems to ensure their long-term health and enjoyment by future generations.

##### 4.5.3.1 Nutrients

Nitrogen and phosphorus are essential nutrients for most aquatic plants, whereby excess nutrients can lead to eutrophication, i.e., an excessive amount of aquatic plant and phytoplankton growth. Concomitant with increased plant and phytoplankton growth, oxygen levels may significantly decrease in the water column, which may negatively impact aquatic organisms, including fish. In addition, excessive phytoplankton growth, particularly of cyanobacteria, can lead to the release of toxins into the water column, which may be harmful to aquatic organisms, waterfowl, livestock and humans.

The water quality of Black Creek and Horseguard Creek has been assessed thoroughly in the mid to late 1990s and early to mid 2000s, respectively. TP concentrations in both creeks exceeded ASWQ and CCME PAL guidelines (0.199 mg/L and 0.082 mg/L, respectively), and TN concentrations exceeded ASWQ and CCME PAL guidelines in Black Creek (1.090 mg/L) (Table 69). Sources of nitrogen and phosphorus may include surface application of manure and/or fertilizer by agricultural producers (Carpenter et al., 1998; Chambers et al., 2001), municipal wastewater effluents (Servos et al., 2001) and urban run-off (Marsalek et al., 2001), all of which have been demonstrated to be a source of excess nutrients to surface waterbodies. Both agricultural and livestock operations occur in the vicinity of Horseguard Creek in the subwatershed.

As part of a collaborative monitoring program, the Medicine River Watershed Society and Alberta Environment collected water samples at four locations (Highway 53, Rainy Creek Road, Range Road 25 and Highway 54) in the Medicine River from spring to fall in 2006 and 2007. In both years, TP and TN exceeded ASWQ PAL guidelines on numerous occasions. TP concentrations ranged from about 0.054-0.123 mg/L in 2006 and from about 0.075-0.35 mg/L in 2007. TN concentrations ranged from about 0.73-1.21 mg/L in 2006 and from about 0.68-2.2 mg/L in 2007. Increased precipitation in 2007 may have

contributed to a greater transport of nutrients and sediments from uplands into the Medicine River, thereby resulting in the overall water quality ratings of “fair” in 2006 and “poor” in 2007 (Medicine River Watershed Society, 2006, 2007).

**Table 69.** Water quality in Black Creek and Horseguard Creek. n = sample size. All concentrations in mg/L unless otherwise noted. Concentrations exceeding water quality guidelines are highlighted \*.

Parameter	Black Creek		Horseguard Creek	
	Mean	n	Mean	n
TP	0.199	59	0.082	16
TDP	0.111	40	0.036	16
TN	1.090	58	0.858	16
NO <sub>3</sub> <sup>-</sup> -NO <sub>2</sub> <sup>-</sup>	0.044	58	0.018	16
NH <sub>3</sub>	0.110	58	0.035	16
DO	---	---	---	---
Chl. <i>a</i> (µg/L)	---	---	---	---
pH	7.97	46	8.24	16
Specific Conductivity (µS/cm)	540	5	458	16
TDS	295	5	299	16
Total coliforms (CFU/100 mL)	---	---	---	---
Fecal coliforms (CFU/100 mL)	---	---	155	15

\* TN from ASWQG PAL chronic exposure guideline; fecal and total coliforms from CCME-Agriculture/Irrigation guideline; all others from CCME PAL. Variable abbreviations as in Table 10. The Black Creek samples were collected from March 1995-September 1997 (Alberta Environment); the Horseguard Creek samples were collected from April 2003-October 2005 (Clearwater County).

#### 4.5.3.2 Bacteria

Coliforms are a broad class of bacteria found in human and animal wastes. Total coliforms include *Escherichia coli*, fecal bacteria and other coliforms that occur naturally in warm blooded animals. *E. coli* is one of three bacteria commonly used to measure the direct contamination of water by human or other mammal wastes. Ingestion of or exposure to fecal bacteria can have negative health impacts. Sources of this type of bacteria include agricultural and municipal runoff, wildlife, faulty septic systems and septic fields.

Fecal coliform concentrations have been monitored in Horseguard Creek from 2003-2005, and they have frequently exceeded CCME Agriculture/Irrigation guidelines (155 CFU/100 mL vs. 100 CFU/100 mL) (Table 69) (Judge and White, 2006). Similarly, fecal coliform and *E. coli* concentrations have been monitored in the Medicine River in 2006 and 2007, where both exceeded CCME Agriculture/Irrigation and Recreation guidelines, particularly in July and early August 2006 and May to mid-July 2007 (Medicine River Watershed Society, 2006, 2007). Fecal coliform bacteria originate primarily from agricultural and municipal runoff, wildlife and faulty septic systems and septic fields. The sources of fecal coliform bacteria and *E. coli* in Horseguard Creek and the Medicine River remain unclear, since the subwatershed is characterized by few feedlots and low manure production and low agricultural

intensity. Highest concentrations in the Medicine River were associated with storm events in the spring and summer months, when sediment and bacteria were transported from uplands into the river (Medicine River Watershed Society, 2006, 2007)

#### 4.5.3.3 Parasites

Waters that are polluted may contain several different disease-causing organisms, commonly called parasites. Enteric parasites, those that live in the intestine of warm blooded animals, can carry or cause a number of infectious diseases. *Cryptosporidium* and *Giardia* spp. are two such parasites. Both occur in almost all environments, including lakes, rivers, reservoirs and groundwater. They come from the feces of rodents, birds, cows, pigs and humans, and the ingestion of these parasites causes gastrointestinal conditions known as cryptosporidiosis and giardiasis.

*Cryptosporidium* and *Giardia* spp. concentrations have been assessed at various locations along the Medicine River (Bill Franz, District Water Specialist, Agriculture and Agri-Food Canada-Prairie Farm Rehabilitation Administration, personal communication). While Health Canada currently does not have Maximum Allowable Concentration (MAC) guidelines for either parasite, USEPA guidelines are 0 oocysts/100 L for *Cryptosporidium* and 0 cysts/100 L for *Giardia* in drinking water. Concentrations of both parasites in the Medicine River consistently exceed USEPA guidelines; although one should not apply drinking water guidelines to raw water guidelines (Table 70).

**Table 70.** Mean concentrations of *Cryptosporidium* and *Giardia* spp. cysts in the Medicine River (personal communication, Bill Franz, District Water Specialist, Agriculture and Agri-Food Canada-Prairie Farm Rehabilitation Administration).

Year	<i>Cryptosporidium</i> (oocysts/100 L)	<i>Giardia</i> (cysts/100 L)
2002	766	1,493
2001	< 20	200
1999	915	795

Most of these data originated from sampling stations in the lower reach of the Medicine River, i.e., from Benalto to the confluence of the Medicine River and the Red Deer River, which is an area of the subwatershed characterized by dairy and swine feeding feedlots and medium livestock manure production and agricultural intensities, which may be sources of these parasites in the Medicine River.

#### 4.5.3.4 Pesticides

Pesticides are a group of chemicals, including herbicides, insecticides, rodenticides and fungicides, used for many purposes, including pest control and aesthetics in urban areas, golf courses and in forestry and agricultural production. Pesticides are a common contaminant of streams and dugouts in the high intensity agricultural areas of Alberta.

In the Medicine River subwatershed, 14 different pesticides have been detected in the Medicine River and one has been detected in Black Creek (Table 71). None of them exceeded CCME PAL guidelines;

however, there are no guidelines for seven of the 14 pesticides. Only MCPA and 2,4-D, both herbicides to control broadleaf plants, occurred in both waterbodies.

**Table 71.** Pesticide concentrations in Medicine River and Black Creek. All concentrations in µg/L. The most common pesticides have been highlighted.

Waterbody	Pesticide	Mean range *	Maximum	CCME PAL	n
Medicine River	2,4-D	0.014-0.016	0.081	4.0	41
	Bromoxynil	0.001-0.005	0.012	5.0	41
	Clopyralid	0.005-0.022	0.062	---	41
	Dicamba	0.001-0.006	0.014	10.0	17
	Diuron	0.007-0.202	0.293	---	41
	Ethalfuralin	0.001-0.005	0.021	---	41
	Imazamethabenz-methyl	0.012-0.058	0.286	---	41
	MCPA	0.019-0.021	0.133	2.6	41
	MCPP	0.001-0.005	0.012	---	41
	Picloram	0.007-0.011	0.093	29.0	41
	Triallate	0.0003-0.005	0.01	0.24	41
	Triclopyr	0.024-0.030	0.311	---	17
	Trifluralin	0.00002-0.005	< 0.005	---	41
Black Creek	2,4-D	0.007-0.023	0.035	4.0	5
	MCPA	0.002-0.005	0.005	2.6	3

\* A precise mean could not be determined because the analytical methods used do not distinguish between values of zero and values that are below the detection limit (BDL). The range of the mean was calculated by first assuming that all BDL samples were equal to zero (providing the lower end of the range), and then by assuming that all BDL samples were equal to the detection limit (providing the upper end of the range). Where no values below the detection limit were present, a single average value was calculated. In the Medicine River, water samples were collected August 1974-December 2006 (data from Alberta Environment and the Medicine River Watershed Society); in Black Creek, water samples were collected April 1995-June 1997 (data from Alberta Environment and CAESAA).

#### 4.5.3.5 Point Source Inputs

Point source inputs include effluents from waste water treatment plants (WWTP), stormwater outfalls and industry. Effluent from WWTP's, although regulated, generally has higher concentrations of certain compounds (e.g., nutrients, solids, pharmaceuticals, metals, etc.) than the receiving environment. Similarly, stormwater outfalls contain elevated levels of nutrients, salts and solids compared to the receiving environment, and industrial effluents can contribute elevated levels of a suite of different contaminants, such as metals, solids, hydrocarbons and/or salts, as well as other chemicals used in processing or manufacturing, to aquatic ecosystems.

At least 80 upstream oil/gas facilities and one oil/gas refining/storage facility have released pollutants continuously or sporadically into the air in the Medicine River subwatershed since 2002. Pollutants from the upstream oil/gas facilities include volatile organic compounds (VOCs), carbon monoxide (CO), nitrous oxide (N<sub>2</sub>O), hydrogen sulphide (H<sub>2</sub>S), sulphur dioxide (SO<sub>2</sub>), particulate matter < 10 µm in size and a suite of hydrocarbon, including benzene, toluene and xylene. The pollutants from the oil/gas processing facilities include N<sub>2</sub>O, CO and particulate matter < 10 µm in size (NPRI, 2008). No pollutants were released directly into aquatic ecosystems according to the National Pollution Release Inventory.

#### 4.5.4 *Water Quantity Indicators*

Water quantity is important for the maintenance of aquatic habitat, it has functions related to water quality and it is essential for the treatment and production of sufficient volumes of drinking water to meet current demands. Irrigation, industry and livestock production are highly dependent on a minimum amount of water. Sufficient water quantity is necessary for many recreational activities, and in recent years many cottagers and recreational lake users across Alberta have voiced concerns about the decreasing volumes of water seen across the province. Five metrics were used as water quantity indicators in the Red Deer River watershed and its 15 subwatersheds:

- Volume
- Minimum Flows to Maintain Ecological Integrity – Condition Indicator
- Contributing Areas to the Watershed
- Allocations
- Groundwater Recharge/Discharge

Water discharge rates, allocations and minimum flow rates to maintain ecological integrity can reflect socioeconomic growth in a region. Human activities in a region frequently reduce available water quantities required to maintain healthy aquatic ecosystems. It is important to balance socioeconomic growth and the sustainable management of these aquatic ecosystems to ensure their long-term health and enjoyment by future generations.

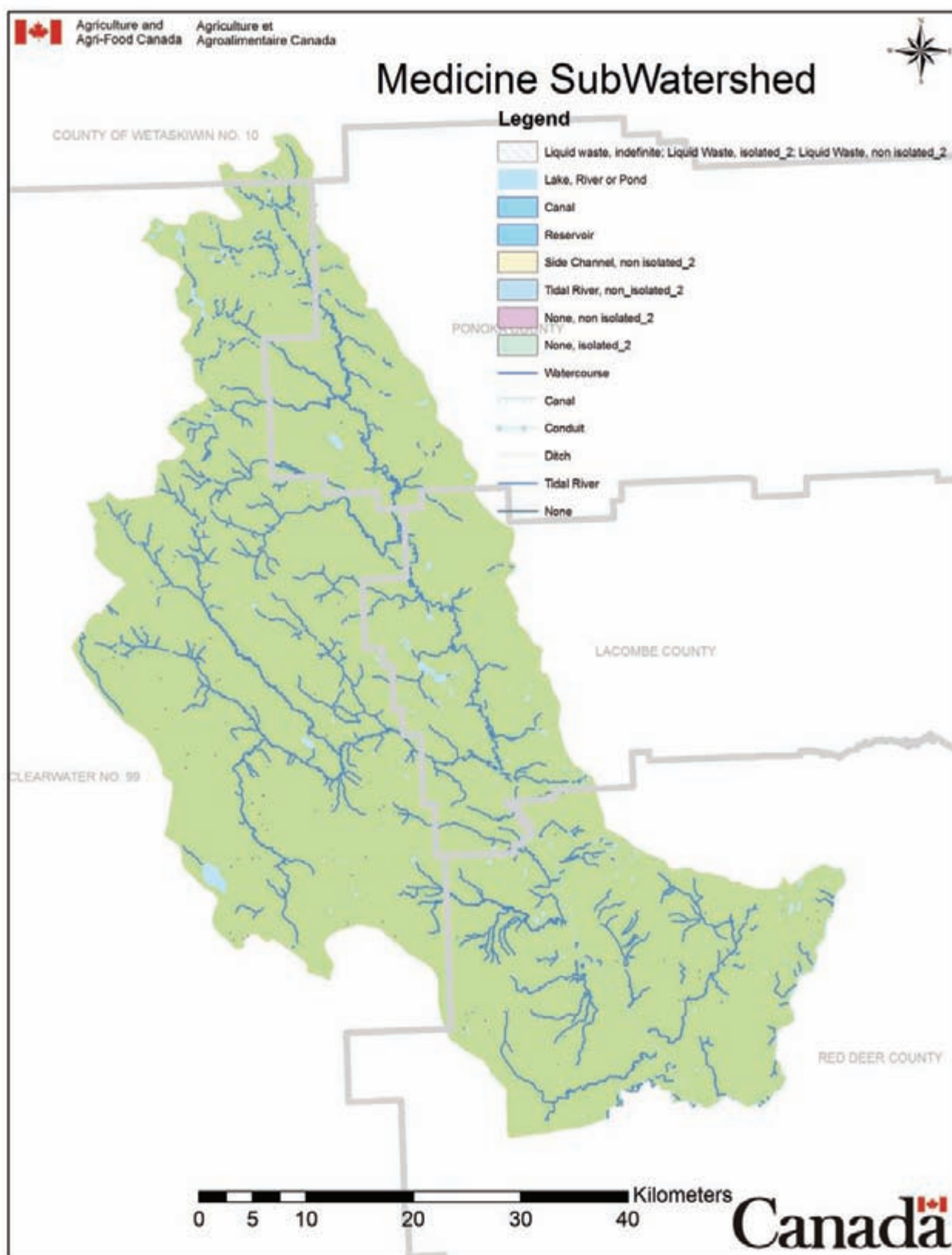
##### 4.5.4.1 Volume

Water volume is the amount of water flowing past one point over a given time, or in the case of lakes or other standing waterbodies, the total amount of water present in the waterbody at a given time. This amount varies seasonally and annually with shifts in weather patterns. Water withdrawals for consumptive uses have increased dramatically in recent years and have resulted in some watersheds within the province being closed to new water licenses.

The total length of water courses in the Medicine River subwatershed is about 1,297 km (Figure 151) (AAFC-PFRA, 2008). The major streams in the subwatershed are Black Creek, Blueberry Creek, Dickson Creek, Gilpatrick Creek, Horseguard Creek, (East and West) Lobstick Creek, Open Creek, Tindastoll Creek and Wilson Creek. Major lakes in the subwatershed include Gabriel Lake and Medicine Lake. In addition, there are numerous small creeks and sloughs in the subwatershed (Government of Canada, 2006).

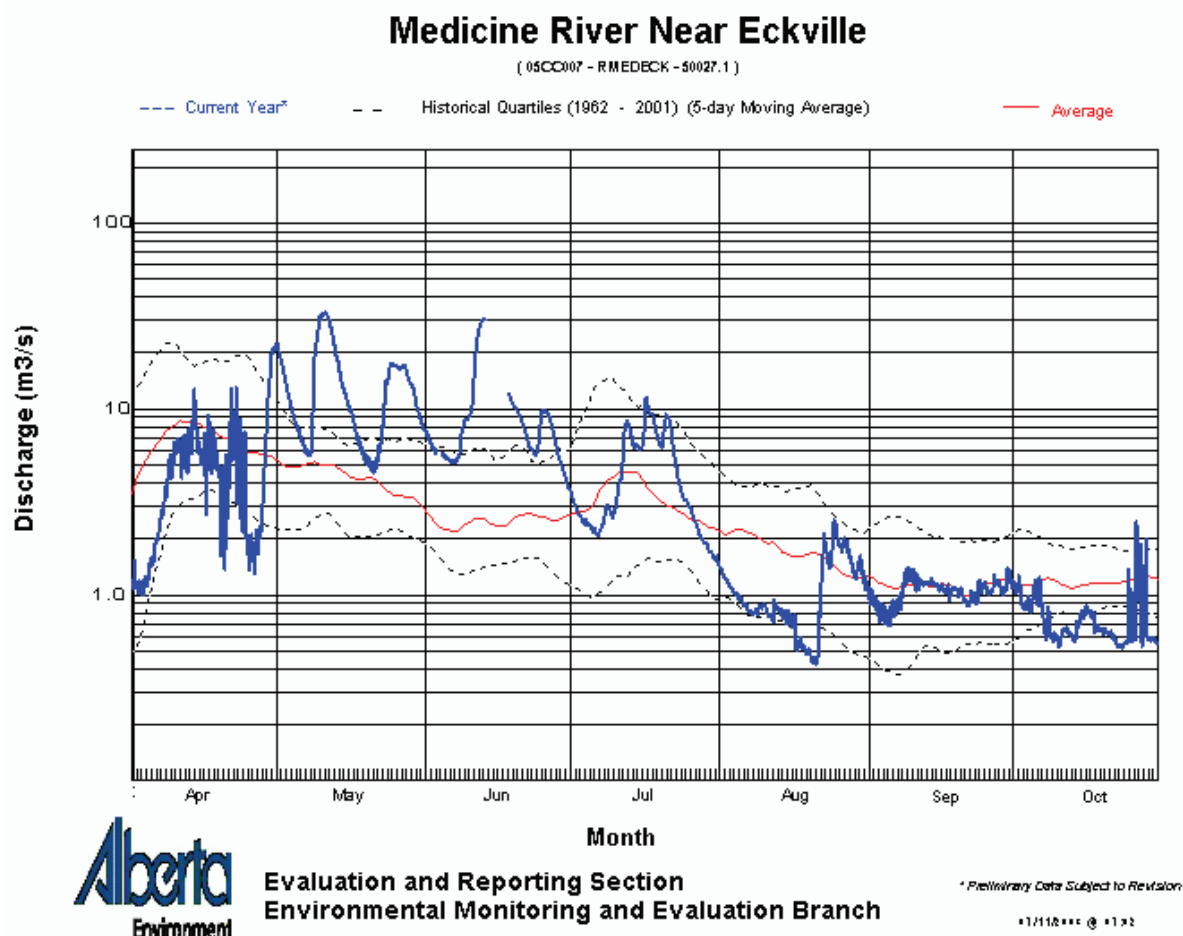
Alberta Environment has been monitoring water discharge rates at four locations in the Medicine River subwatershed: Black Creek (active, 05CC010), Lasthill Creek above the confluence with Medicine River (real-time active, 05CC013), Medicine River south of Eckville (real-time active, 05CC007) and near the mouth of Tindastoll Creek (discontinued, 05CC012) (Government of Alberta, 2008c).





**Figure 151.** Waterbodies in the Medicine River subwatershed (AAFC-PFRA, 2008).

In the Medicine River south of Eckville, average water discharge rates vary from 4-9 m<sup>3</sup>/sec in early spring (April) and then decrease to 2-5 m<sup>3</sup>/sec in May and June. Water discharge rates increase in July, reaching 3-5 m<sup>3</sup>/sec, before declining for the remainder of the year (1-2 m<sup>3</sup>/sec August to October). Historically, water discharge rates at this location have reached maxima of 11-12 m<sup>3</sup>/sec in spring and 10-11 m<sup>3</sup>/sec for the mid-summer peak in July. Conversely, discharge rates have also been considerably lower in the past, dropping below 1 m<sup>3</sup>/sec, particularly in late summer and fall. Water discharge rates were well above average levels in the spring and early summer 2008, when they exceeded 20 m<sup>3</sup>/sec (Figures 152). They were similar to average levels thereafter (Government of Alberta, 2008c).



**Figure 152.** Discharge rates of the Medicine River near Eckville (Government of Alberta, 2008c). “Current year” indicates water discharge rates in 2008.

One major dam is located in the Medicine River subwatershed (Figure 153). It is the Open Creek Dam located on Open Creek, a tributary of the Medicine River in the northwest of the subwatershed. In addition, there are numerous smaller water infrastructures in the subwatershed, e.g., small dams, sluices, weirs and dykes, which control water flow.



**Figure 153.** Major dams in the Medicine River subwatershed (AAFC-PFRA, 2008).

#### 4.5.4.2 Minimum Flows to Maintain Ecological Integrity

Minimum flows to maintain ecological integrity are the lowest flows or volumes (lakes) required to sustain native aquatic species and natural ecosystem functions. Minimum flows must be determined before allocation of water can safely take place to preserve the ecological functionality of aquatic ecosystems.

Minimum flow requirements for the maintenance of ecological integrity have not been determined in the Medicine River subwatershed.

#### 4.5.4.3 Contributing Areas to the Watershed

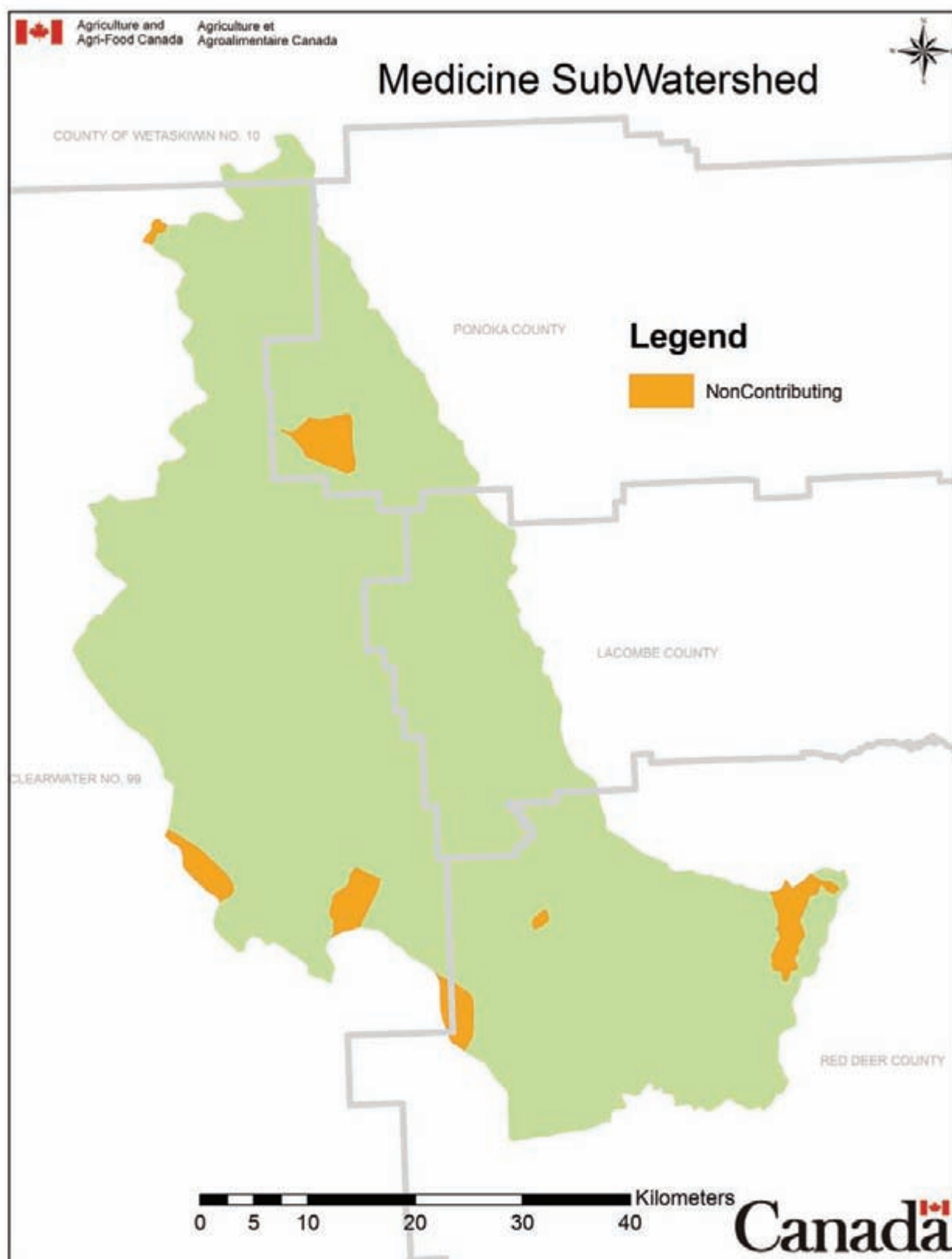
Contributing areas to the watershed are areas from which runoff flows into the lakes, creeks and rivers of the watershed. These data are used to determine an estimated volume of water contributed to the river on an annual basis.

In the Medicine River subwatershed, 10,087 ha (or 3.5% of the total area of the subwatershed) of land do not contribute to the drainage of the subwatershed (Figure 154). These areas are located south of Condor and Codner, southeast of Stauffer, southwest of Red Deer and between Welch Creek and Medicine River. These areas are characterized by a generally flat topography compared to the remainder of the subwatershed (Figure 155) (AAFC-PFRA, 2008).

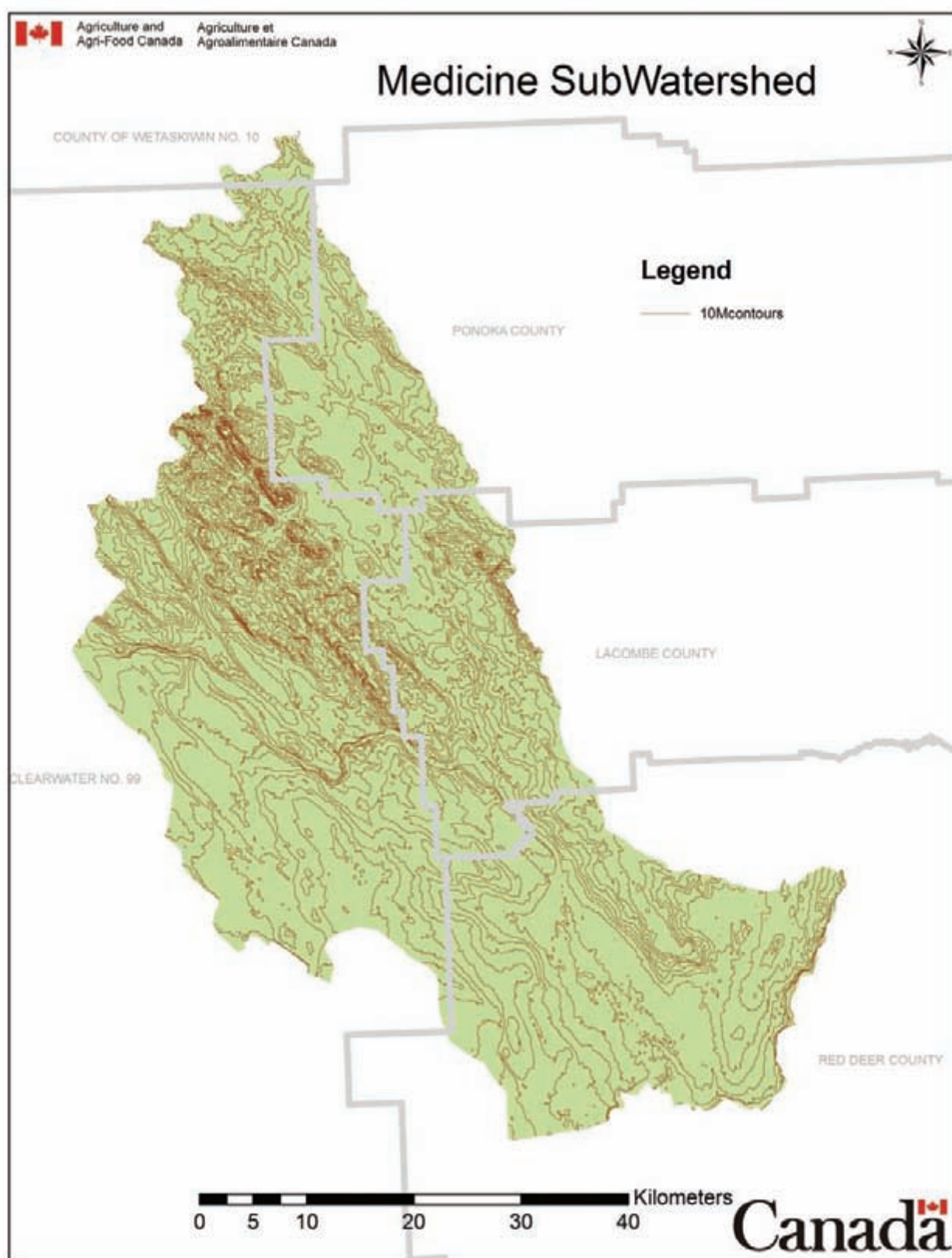
The Medicine River has had several high streamflow advisories in 2005 in response to high precipitation events throughout the summer months (June-September) (Table 72) (Alberta Environment, 2008c).

**Table 72.** Advisories and warnings in the Medicine River subwatershed since 2001 (Alberta Environment, 2008c).

Advisory	Waterbody	Date
High streamflow	Medicine River	June 06, 2005
		June 17, 2005
		June 23, 2005
		August 23, 2005
		September 10, 2005



**Figure 154.** Non-contributing drainage area in the Medicine River subwatershed (AAFC-PFRA, 2008).



**Figure 155.** Topography (10-m contour intervals) of the Medicine River subwatershed (AAFC-PFRA, 2008).



## 4.5.4.4 Allocations

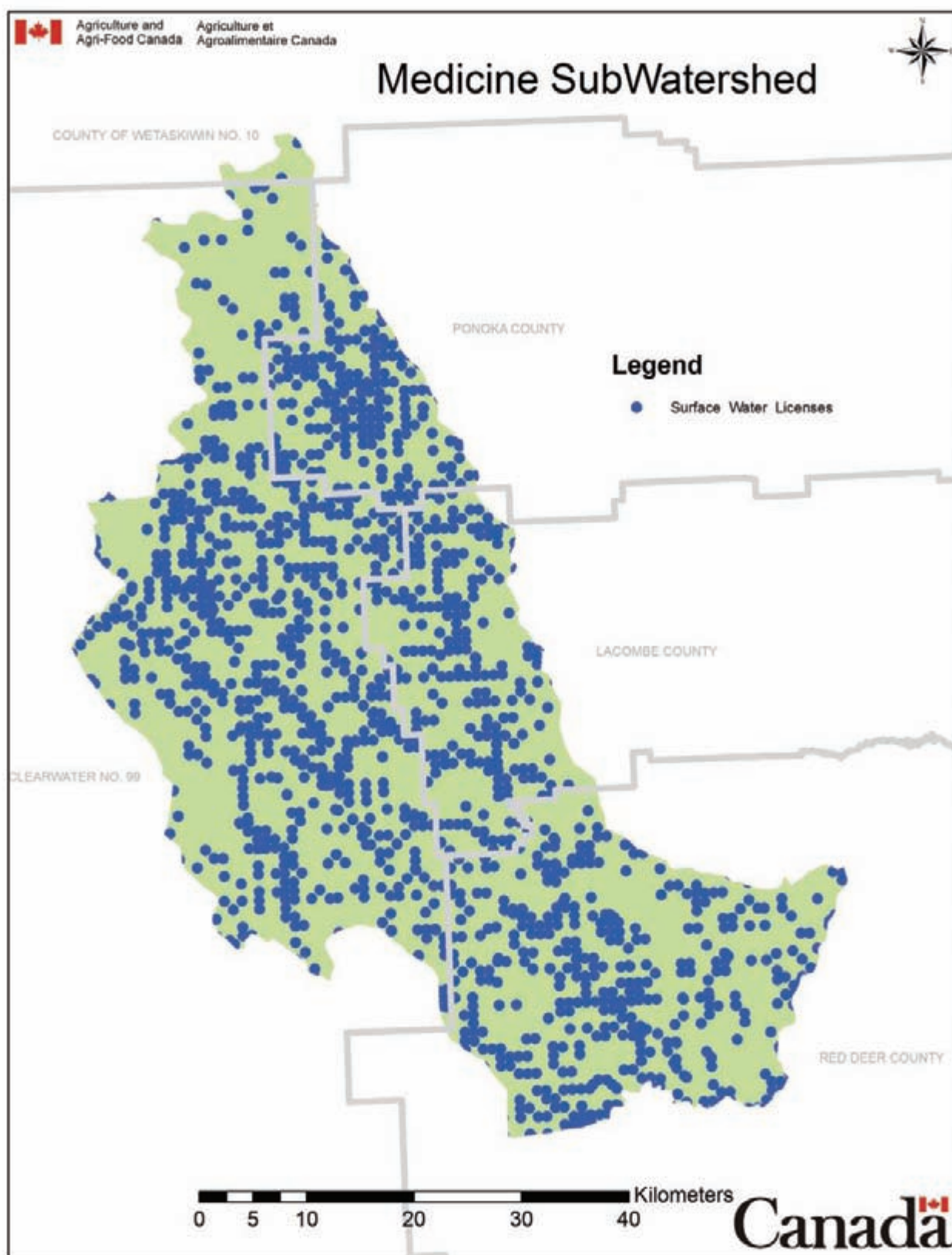
Surface and groundwater water withdrawal permits for the watershed are quantified by user sector along with information on licenses, consumption and return flows. This information will be used along with water flow data to identify areas of potential future constraints on surface water availability, which may have implications for future development.

In the Medicine River subwatershed, 2,904 surface water licenses and 1,834 groundwater licenses have been issued for water diversion projects (Figures 156, 157, respectively). They are distributed throughout the subwatershed (AAFC-PFRA, 2008).

About 5.46 million m<sup>3</sup> of surface and groundwater are diverted annually in the Medicine River subwatershed (AAFC-PFRA, 2008). The most prominent use of surface water is for industrial operations (63% of total surface water diversions) and the management of fish (13% of total surface water diversions), while the most prominent users of groundwater are industrial (39% of total groundwater diversions) and agricultural operations (38% of total groundwater diversions) (Table 73). The majority of water diverted in the entire subwatershed comes from surface water sources, e.g., lakes, streams and rivers (57%) (AAFC-PFRA, 2008). Additional groundwater diversion information is provided in HCL (2001a, 2003a, 2004, 2005).

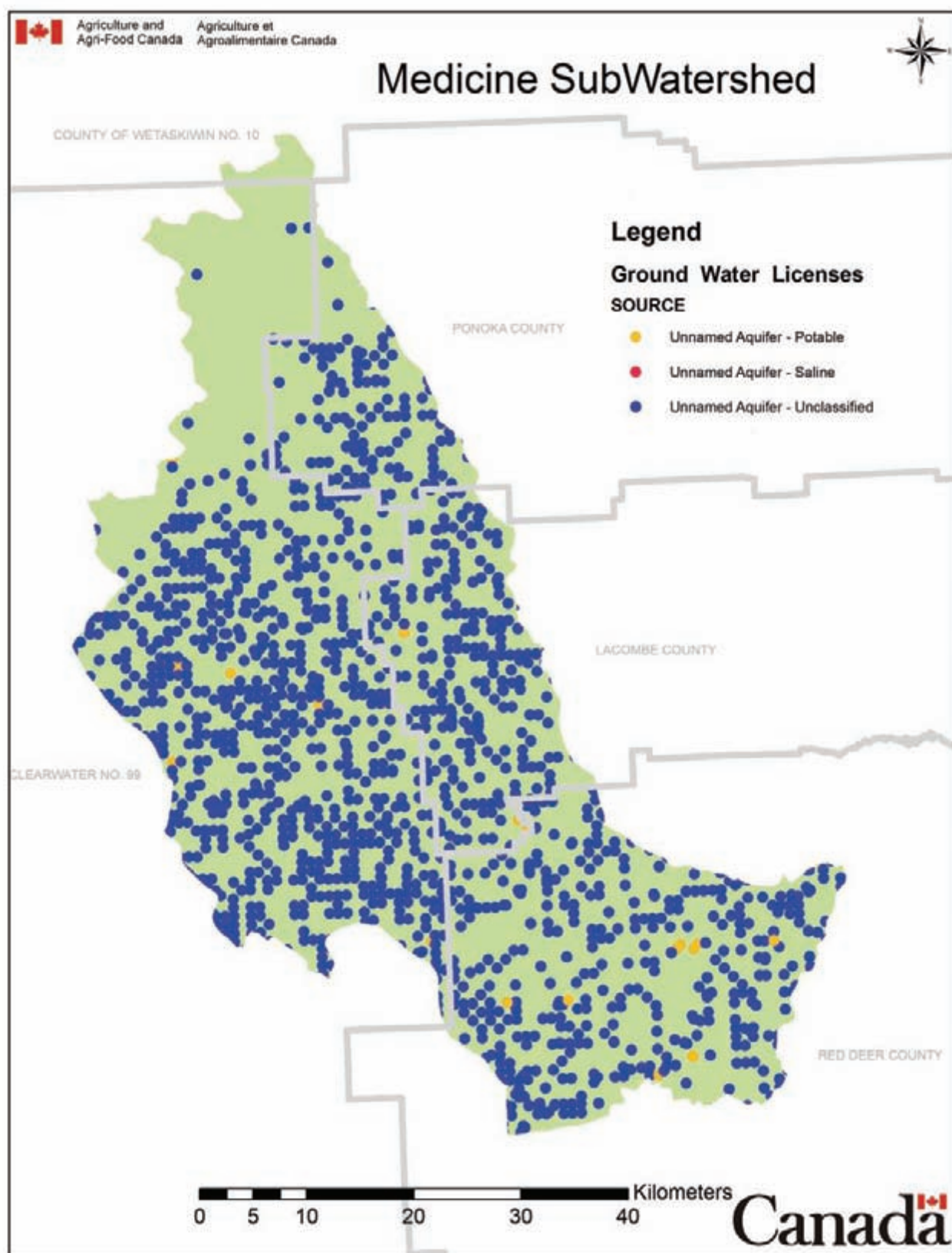
**Table 73.** Surface and groundwater diversions in the Medicine River subwatershed (Government of Alberta, 2008d). The highest uses for water have been highlighted. Data reported exclude any water diverted from the Red Deer River mainstem.

Purpose	Surface water (m <sup>3</sup> /yr)	Groundwater (m <sup>3</sup> /yr)
Agriculture	324,582	905,494
Commercial	90,220	90,705
Dewatering	---	8,182
Habitat enhancement	1,230	---
Industrial	1,936,480	928,747
Irrigation	339,280	---
Management of fish	397,170	6,423
Municipal	---	423,979
Other purposes specified by the Director	2,000	1,770
<b>Total</b>	<b>3,090,962</b>	<b>2,365,800</b>
<b>Grand total</b>		<b>5,456,762</b>



**Figure 156.** Surface water licenses in the Medicine River subwatershed (AAFC-PFRA, 2008).





**Figure 157.** Groundwater licenses in the Medicine River subwatershed (AAFC-PFRA, 2008).

#### 4.5.4.5 Groundwater Recharge/Discharge

Areas where groundwater gets recharged or discharges to the surface indicate areas where the groundwater table is close to the surface and the soils are generally more permeable. These areas are at greater risk of becoming negatively impacted from development or agricultural and/or industrial activities. Knowing where groundwater recharges and discharges occur will help to identify areas requiring special protection and limitations to land use.

Freshwater springs are points in the landscape where the aquifer surface meets the ground surface, i.e., freshwater springs are areas of groundwater discharge. The Medicine River subwatershed has about 70 freshwater springs, which are scattered throughout the subwatershed.

The Medicine River subwatershed lies in the Counties of Clearwater, Lacombe, Ponoka and Red Deer. Groundwater assessments have been conducted for each of these counties by HCL (2001a, 2003a, 2004, 2005). The assessments indicated that the headwaters of the Medicine River are generally groundwater recharge areas (i.e., water moves from the surface into groundwater reservoirs), while the middle and lower reaches of the Medicine River are primarily groundwater discharge areas (i.e., water moves from groundwater reservoirs to the surface) or transition areas (no groundwater discharge or recharge). Specific areas of groundwater recharge include small depressions in the landscape and temporary and ephemeral wetlands, which collect rainwater and snow melt and release a proportion of this accumulated water into shallow groundwater and regional aquifers (van der Kamp and Hayashi, 1998; Hayashi et al., 2003). Additional information on aquifers, water quantity and quality of the groundwater associated with each aquifer, hydraulic relationship among aquifers and possible groundwater depletion areas associated with each upper bedrock aquifer is provided in HCL (2001a, 2003a, 2004, 2005).

#### 4.5.5 *Biological Indicators*

Bioindicators are biological (plant and animal) data from which various aspects of ecosystem health can be determined or inferred. The presence, absence and abundance of such data can be linked to water quality, quantity and ultimately to overall watershed health. Four metrics were used as biological indicators in the Red Deer River watershed and its 15 subwatersheds:

- Wildlife Biodiversity
- Fish
- Land Cover – Condition Indicator
- Species at Risk

Changes in biological populations often reflect socioeconomic growth in a region. Human settlement and the subsequent exploration and extraction of natural resources alters the landscape and with it the habitat of the indigenous flora and fauna. It is important to balance socioeconomic growth with the preservation of natural habitat integrity to ensure the long-term health of natural biological populations.

##### 4.5.5.1 Wildlife Biodiversity

Wildlife inventories to determine the biodiversity within the watershed will indicate changes in environmental conditions (e.g., habitat fragmentation, loss of nesting and breeding sites, nutrient enrichment, etc.). A loss of biodiversity can cause an ecosystem to become less stable and more

vulnerable to environmental change. A change in diversity may also affect nutrient cycling and/or energy flow through the ecosystem.

Wildlife biodiversity assessment data have not been located for the Medicine River subwatershed.

#### 4.5.5.2 Fish

Inventories of selected fish populations may show increases or declines through introductions or changes in environmental conditions. Indicator species sensitive to environmental pollution may show areas of concern through their absence, while others may show similar with their presence. Invasive species, if present, will indicate areas of concern requiring future monitoring.

The predominant species in Medicine River are longnose sucker, white sucker and walleye. There are not enough data to determine if there have been any significant changes in the populations of these species over time; however, there has been a significant decrease in the northern pike populations ( $p = 0.03$ ). Northern pike was the only species found every year over the course of the sampling period (Figure 158).

The longnose sucker inhabits cold, clear waters. It is a bottom-feeding fish, eating aquatic plants, algae and small invertebrates. They are preyed upon by larger predatory fish, such as bass, walleye, trout, northern pike, muskellunge and burbot. They are fished for game and food and also used as bait to catch the larger predators (Nelson and Paetz, 1992; Scott and Crossman, 1998).

The white sucker is a bottom feeding fish and spend most of its time in shallow, warm waters, where it searches for aquatic plants, algae and small invertebrates, particularly worms and crustaceans. It makes its homes in holes and areas around windfalls or other underwater obstructions. White suckers lay their eggs among pebble and gravel beds in lake and river shallows during the spring. They have been accused of consuming large quantities of eggs from more desirable food and sport fish species, but there is no conclusive evidence to support this contention (Nelson and Paetz, 1992; Scott and Crossman, 1998).

Walleye are tolerant of a great range of environmental situations, but appear to reach greatest abundance in large, shallow, turbid lakes. Large streams or rivers, provided they are deep or turbid enough to provide shelter in daylight, are also preferred habitat of the walleye. They use sunken trees, boulder shoals, weed beds or thicker layers of ice and snow as a shield from the sun. Generally, it is a "cool-water" species, preferring warmer water than trout and cooler water than bass and panfish. Walleye feeds at night, mainly on insects and fishes (prefers yellow perch and freshwater drum but will take any fish available) but also on crayfish, snails, frogs, mudpuppies and small mammals when fish and insects are scarce (Nelson and Paetz, 1992; Scott and Crossman, 1998).

Northern pike are found in sluggish streams and shallow, weedy places in lakes, as well as in cold, clear, rocky waters. Pike are typical ambush predators, feeding mainly on fish, but on occasion also feed on frogs, insect, leeches, water voles and ducklings (Nelson and Paetz, 1992; Scott and Crossman, 1998).

## 4.5.5.3 Land Cover

Land cover is the type of vegetation, or lack thereof, covering the landscape. Inventory of vegetation populations may show increases or declines through introductions or changes in environmental conditions. Indicator species that are sensitive to environmental pollution may show areas of concern with their absence, while others may show areas of concern with their presence. Changes in land cover can indicate a change in land use and identify areas that need restoration, are at risk of erosion and/or areas with rare plant species that need protection. Land cover is a separate measurement from land use even though these two terms are sometimes used interchangeably.

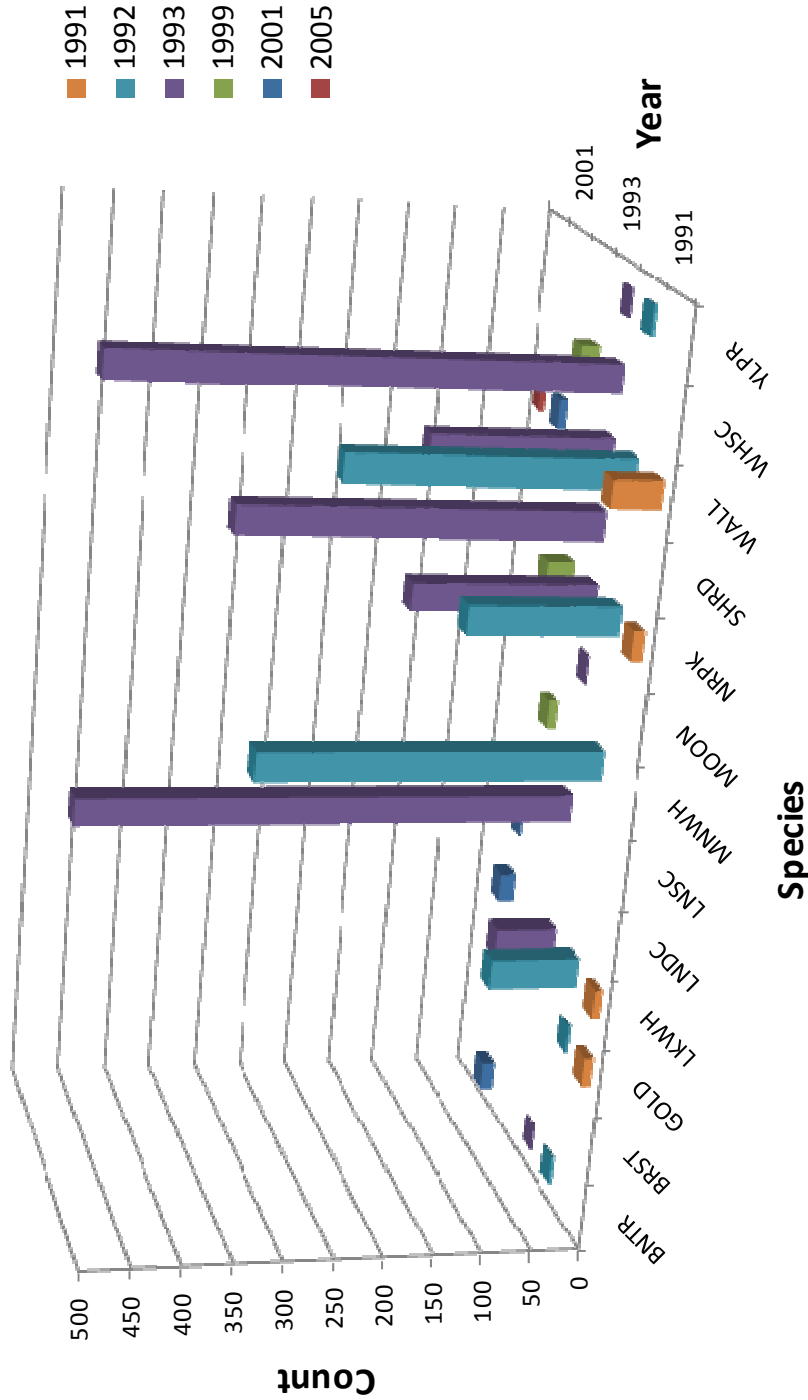
The majority of the land base of the Medicine River subwatershed is covered by perennial and annual cropland/pastures (39% and 32%, respectively). Coniferous and deciduous forests cover about 20% of the landbase in the subwatershed. There are few exposed or developed lands, wetlands, grasslands, shrublands or mixed forests (Figure 159, Table 74) (AAFC-PFRA, 2008).

**Table 74.** Land cover in the Medicine River subwatershed (AAFC-PFRA, 2008). The most prominent land cover types are highlighted.

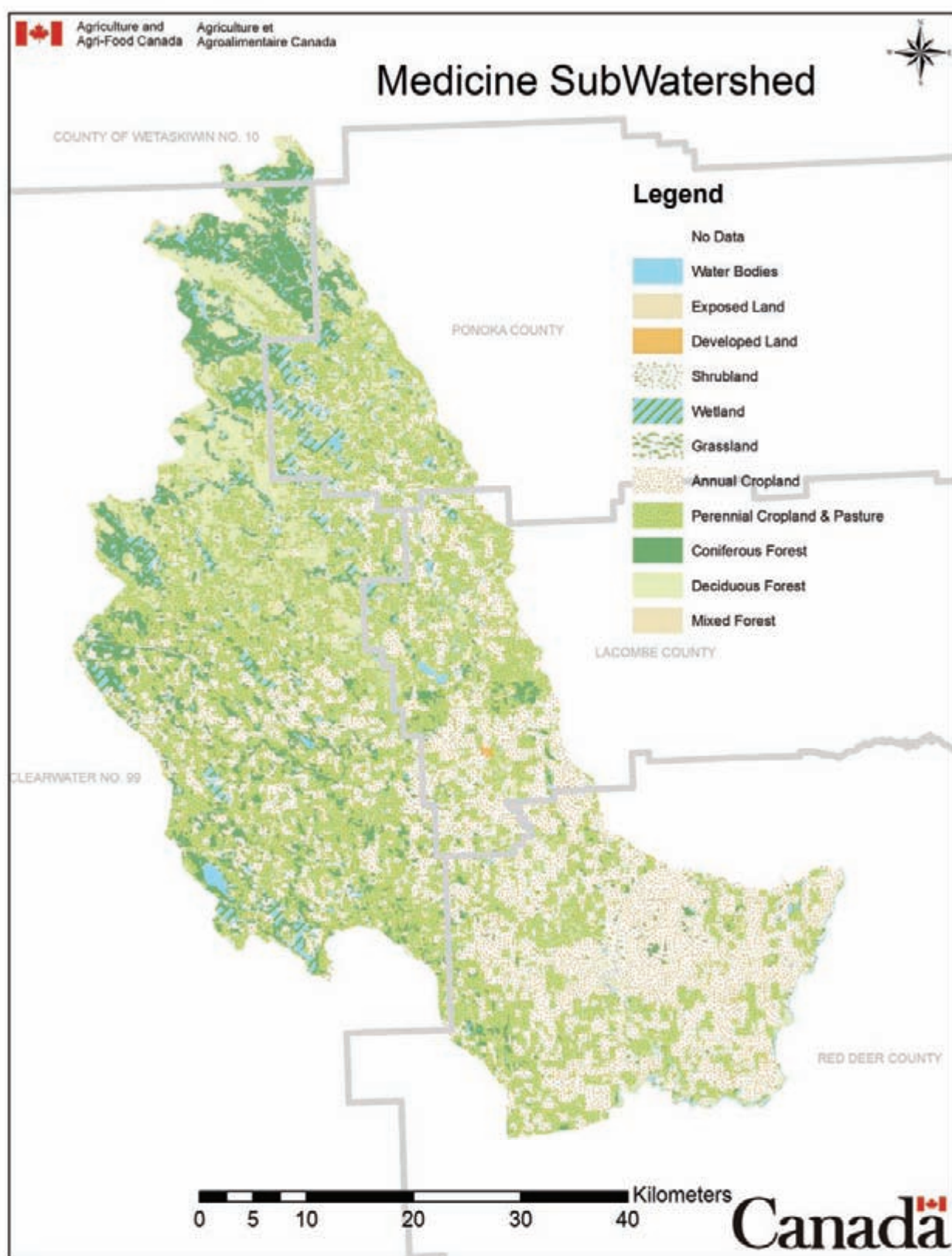
Land cover type	Area (ha)	Proportion of subwatershed area (%)
Waterbodies	2,216	0.76
Exposed land	225	0.08
Developed land	1,610	0.56
Shrubland	4,249	1.47
Wetland	11,635	4.01
Grassland	2,886	1.00
Annual cropland	91,399	31.56
Perennial cropland/pastures	112,996	38.97
Coniferous forests	27,198	9.38
Deciduous forests	30,256	10.44
Mixed forests	2,512	0.87
No data	2,760	0.95
<b>Total</b>	<b>289,943</b>	

There are no provincially, nationally or internationally designated Ecologically Significant Areas in the Medicine River subwatershed (Alberta Environmental Protection, 1997).

## Fish Populations Medicine River



**Figure 158.** Fish populations in Medicine River in the Medicine River subwatershed, 1991-1993, 1999, 2001 and 2005 (data from Alberta Sustainable Resource Development, 2008). For full species names, please refer to Table 23.



**Figure 159.** Land cover of the Medicine River subwatershed (AAFC-PFRA, 2008).

#### 4.5.5.4 Species at Risk

Identifying species at risk and their habitats will help to determine sensitive areas and level of protection required. The *Species at Risk Act* (SARA) was introduced in June 2003 to provide legal protection of wildlife species and conservation of biological diversity. The Act aims to prevent Canadian indigenous species, subspecies and distinct populations from becoming extirpated or extinct, to provide for the recovery of endangered or threatened species and encourage the management of other species to prevent them from becoming at risk. Currently, there are 363 species listed as either endangered (169 species), threatened (110 species) or of special concern (84 species) (Species at Risk, 2008).

“Endangered species” are those species that face imminent extirpation or extinction, while “threatened species” are those that are likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction. “Species of special concern” are those species that warrant special attention to ensure their conservation.

The Medicine River subwatershed is home to three species of special concern, i.e., native species, subspecies or ecologically significant units that warrant special attention to ensure their conservation. These are the monarch butterfly (*D. plexippus*), western toad (*B. boreas*) and yellow rail (*C. noveboracensis*). There are no endangered or threatened species in the subwatershed. Detailed descriptions of these species can be found in section 3.1.3.7.

#### 4.5.6 Subwatershed Assessment

The Medicine River subwatershed is located in the Lower Foothills, Dry Mixedwood and Central Parkland Subregions, which contributes to its biogeophysical complexity. Livestock and agricultural densities are medium relative to the Alberta average, which supports the predominance of perennial and annual croplands and pastures. Urban centres include the Town of Eckville and numerous hamlets located throughout the subwatershed. Resource exploration and extraction activities have created a complex network of linear developments, which consist predominantly of roads. In addition, there are 4,504 active wells in the subwatershed; most are natural gas wells. Despite an abundance of streams and creeks, few riparian health assessments have been conducted anywhere in the subwatershed. Moreover, water quality assessments are similarly limited. Those that exist show that TP and TN exceeded CCME PAL guidelines, and 14 different pesticides were detected in aquatic ecosystems in the Medicine River subwatershed, although none exceeded water quality guidelines. Annual water discharge rates peak following the spring freshet and heavy precipitation events (10-40 m<sup>3</sup>/sec), which has resulted in several high stream flow advisories in the Medicine River. Agricultural and industrial operations are the primary users of water resources in the subwatershed, where 4,738 water diversion licenses for about 5.46 million m<sup>3</sup> of water have been issued. While no biodiversity assessment data were located for the subwatershed, longnose sucker, white sucker and walleye are the dominant fish species, and three SARA species of special concern inhabit the Medicine River subwatershed.

An Indicator Workshop held in March 2008 identified a total of 20 indicators to be used to assess the overall health of the Red Deer River watershed and its 15 subwatersheds. These indicators included land use, water quality, water quantity and biological indicators. In November 2008, a subset of these



indicators was selected to indicate the overall condition of, or risk to, the individual subwatersheds. There were nine “condition indicators” and three “risk indicators”. The condition indicators were ranked “good”, “fair” or “poor” based on existing guidelines, while risk indicators were ranked “low”, “medium” or “high” relative to the other subwatersheds. The overall subwatershed ranking is based on an “A”-“B”-“C” ranking system with “+” and “-” subrankings. The overall ranking system is based on a subjective evaluation of the combined rankings of the condition and risk indicators.

Based on the available data, the Medicine River subwatershed receives a rating of “poor” for the condition indicators and a rating of “medium” for the risk indicators (Tables 75, 76). Overall, this subwatershed receives a ranking of “C-”. There are substantial data gaps, and several of the condition rankings are based on limited data. Consequently, it is recommended to implement a detailed water quality sampling program, conduct a wetland inventory and regularly monitor riparian health conditions along the major waterbodies in the subwatershed. Of particular concern are (1) the extensive network of linear developments (roads), primarily due to natural resource exploration and extraction activities throughout the subwatershed, (2) TP concentrations that occasionally exceed water quality guidelines, likely due to widespread impaired riparian area health conditions and excessive agricultural runoff, municipal effluent and urban runoff that reach waterbodies throughout the subwatershed, (3) the conversion of the landbase from its natural state to annual and perennial croplands or pastures and (4) the loss of wetlands, which likely occurred as a result of agricultural land conversions, drainage, infilling and the disruption of their hydrology following linear developments.

**Table 75.** Condition and risk indicator summary for the Medicine River subwatershed. The gray logo indicates a data gap.

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**Condition Indicators**



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**Risk Indicators**





**Table 76.** Condition and risk assessments of the Medicine River subwatershed. Indicators with a “poor” or “high” ranking are highlighted.

Indicators		Rating
Condition	Wetland loss	POOR
	Riparian health	FAIR
	Linear developments	POOR
	Nutrients	
	Total phosphorus	POOR
	Total nitrogen	FAIR
	Bacteria	POOR
	Parasites	POOR
	Pesticides	GOOD
	Minimum flows to maintain ecological integrity	---
	Land cover	POOR
Overall		POOR
Risk	Livestock manure production	LOW
	Urban, rural, agricultural and recreational developments	MEDIUM
	Oil/gas wells	HIGH
Overall		MEDIUM