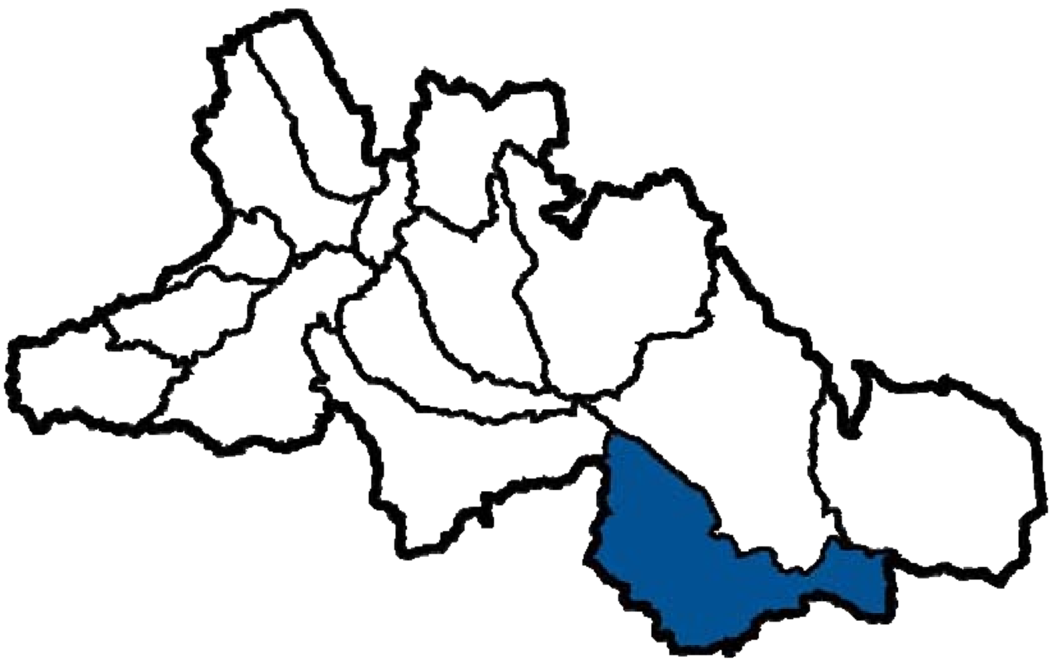
Matzhiwin Subwatershed



Red Deer River Watershed Alliance

State of the Watershed

4.14 Matzhiwin Creek Subwatershed

4.14.1 Watershed Characteristics

The Matzhiwin Creek subwatershed encompasses about 726,689 ha and is located in the Counties of Cypress, Newell No. 4 and Wheatland (Figure 353).

The Matzhiwin Creek subwatershed is located south of Red Deer River in the southeastern region of the Red Deer River watershed. The subwatershed lies in the Northern Fescue, Dry Mixedgrass and Mixedgrass Subregions (Figure 354). The Northern Fescue Subregion is dominated by rough fescue (*F. campestris*). The Dry Mixedgrass Subregion is dominated by spear grass (*Piptochaetium* spp.), blue grama (*B. gracilis*), western wheat grass (*P. smithii*) and northern wheat grass (*E. lanceolatus*). The vegetation of the Mixedgrass Subregion is similar to the Dry Mixedgrass Subregion; however, it is characterized by greater biomass production and a greater abundance of species that tend to favour cooler and moister sites. The majority of Mixedgrass vegetation is dominated by spear grass (*Piptochaetium* spp.), western porcupine grass (*H. spartea*), western wheat grass (*P. smithii*) and northern wheat grass (*E. lanceolatus*). Although much of the natural vegetation has been replaced by agricultural crops in the latter two Subregions, extensive areas of native rangeland remain, which are managed primarily for grazing by domestic livestock (Heritage Community Foundation, 2008).

The geology of the Matzhiwin Creek subwatershed is diverse and dominated by the Paskapoo, Bearpaw, Horseshoe Canyon, Oldman, Scollard and Hand Hills Formation. These formations formed in the Paleocene epoch (56-65 million years ago), the Upper Cretaceous period (65-100 million years ago) and in the Pliocene/Miocene epochs (1.8-5.3 and 5.3-23.0 million years ago, respectively). The youngest of the formations from the Pliocene/Miocene, Hand Hills, occurs in small and isolated pockets and consists of gravel, sandstone, shale, marl and conglomerates. The Scollard Formation (Paleocene and Upper Cretaceous) consists of sandstone, mudstone and thick coal deposits, while the Horseshoe Canyon Formation (Upper Cretaceous) consists of sandstones, mudstones, shales, ironstone, bentonite and minor limestone deposits. The Oldman and Bearpaw Formations (both Upper Cretaceous) consist of feldspathic sandstones, siltstones, mudstones, shales and ironstone beds and blocky and silty shales, sandstone, ironstone and bentonitic beds, respectively. The Paskapoo Formation (Paleocene) consists of diverse sandstones, siltstones/mudstones and shales (Alberta Geological Survey, 2006).

The climate of the Matzhiwin Creek subwatershed is continental, with mean annual temperatures ranging from 3-5 °C and mean May-September temperatures ranging from 11-15 °C. The mean annual precipitation ranges from 350-500 mm, with the May-September precipitation averaging 280-300 mm (Environment Canada, 2006). There are about 90 frost-free days per annum. Chinooks are common in this subwatershed.

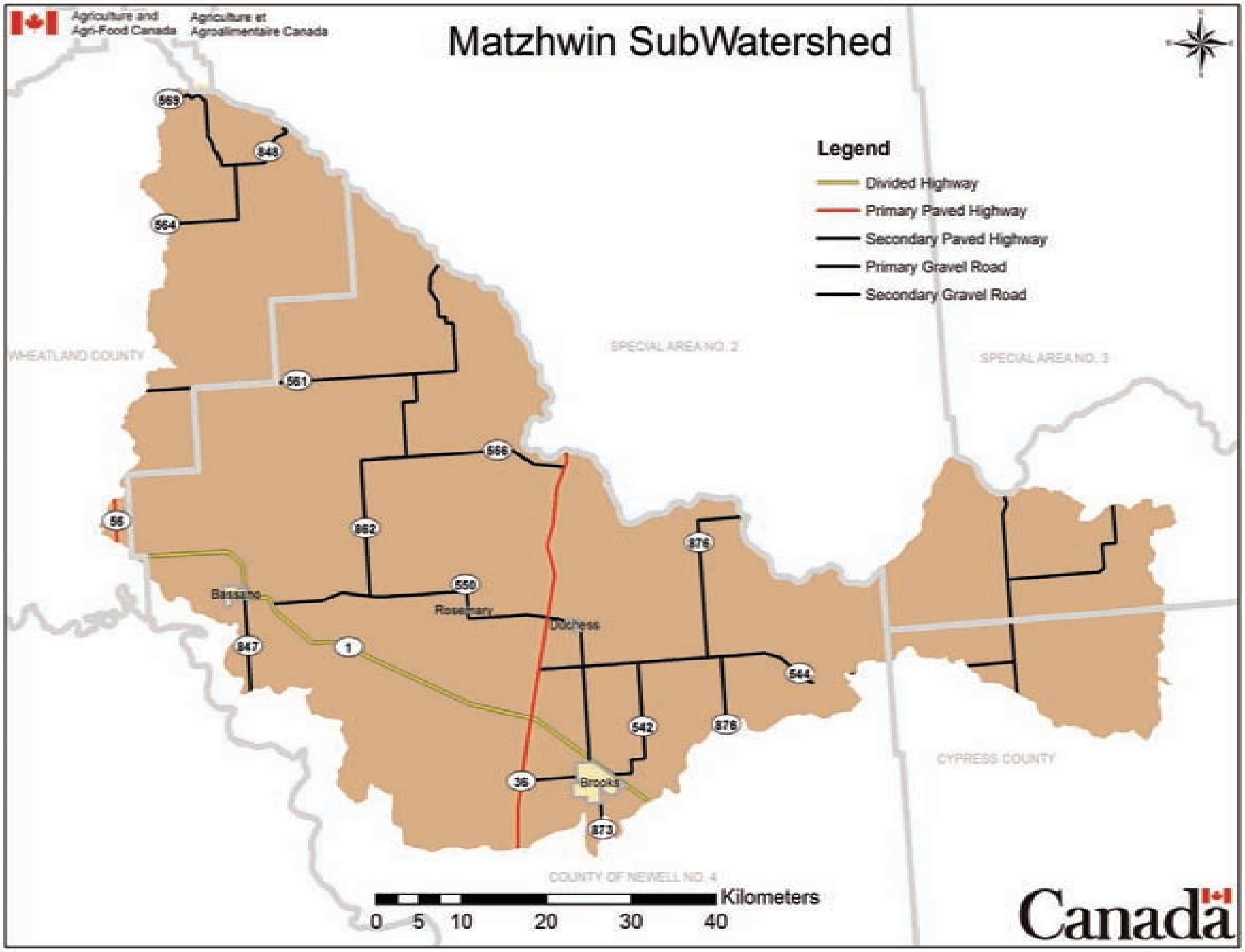


Figure 353. Location of the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

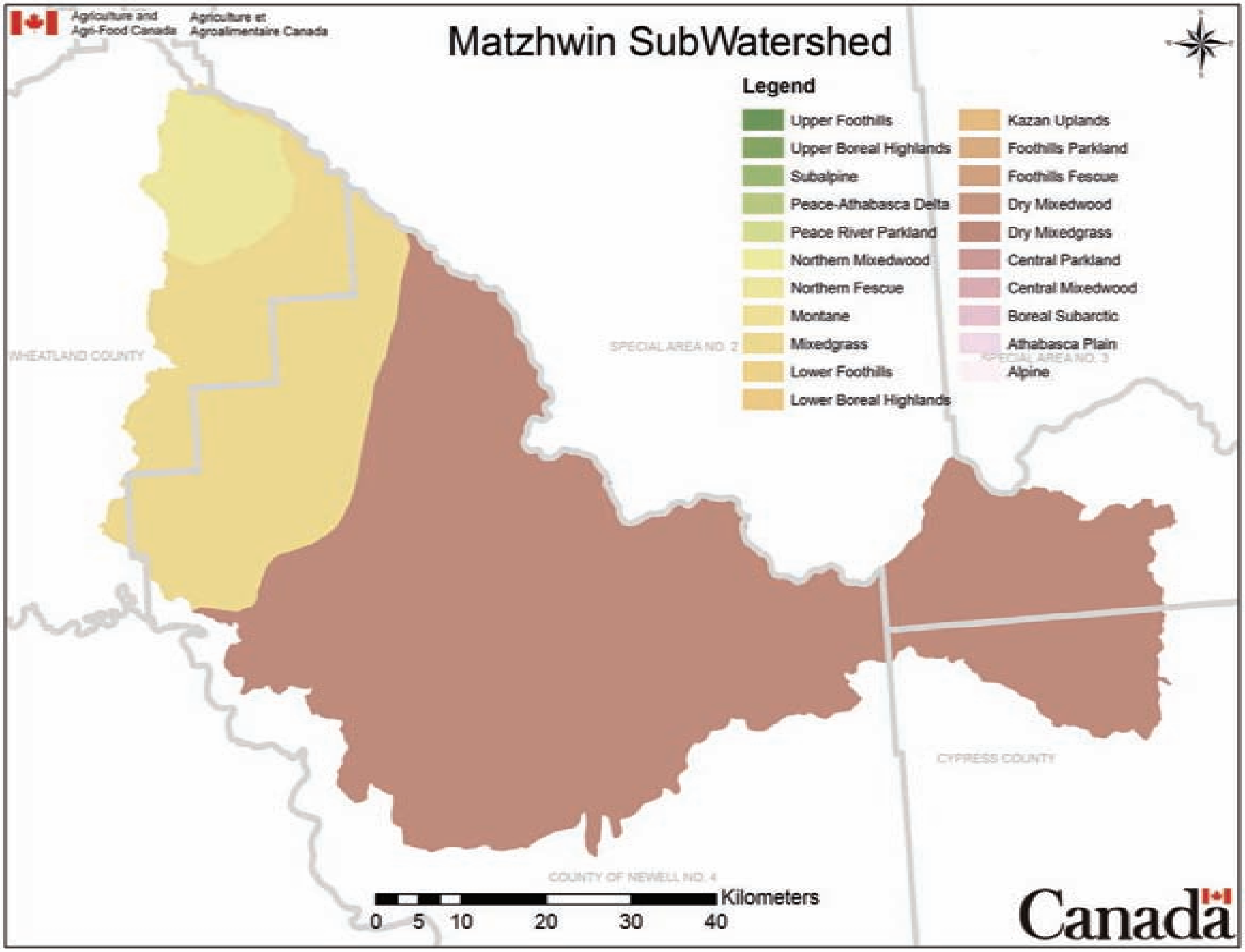


Figure 354. Natural subregions of the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

4.14.2 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.

4.14.2.1 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 23,051 ha of wetlands (3.17% of the total subwatershed area) in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008); however, there are no data on the classes, forms and types of wetlands (*sensu* National Wetlands Working Group, 1997) within the subwatershed. Given the presence of lentic (lakes) and lotic (streams and rivers) systems, marshes and shallow open water wetlands are likely 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 Grassland Natural Region (in the Dry Mixedgrass Subregion) from 1985-2001 (Watmough and Schmoll, 2007). In Alberta, the Grassland Natural Region has lost 7% of its total wetland area and 9% 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 the Prairie Habitat Joint Venture program has assessed wetland losses along only one transects in the Dry Mixedgrass Subregion and none in the other less prominent Subregions in this subwatershed (Watmough and Schmoll, 2007).

4.14.2.2 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.

Riparian health has not been assessed in the Matzhiwin Creek subwatershed.

4.14.2.3 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 21 feedlots/intensive livestock operations in the Matzhiwin Creek subwatershed (Figure 355) (AAFC-PFRA, 2008). Nearly 80% of them finish poultry and cows, with the remainder rearing and finishing swine or finishing dairy cows.

Cattle density is low throughout most of the subwatershed, ranging from 0-0.20 cattle/ha. Conversely, the areas north of Brooks and particularly east of Duchess have among the highest livestock intensity in the subwatershed, 1.61-1.80 cattle/ha and 1.81-4.00 cattle/ha, respectively (Figure 356) (AAFC-PFRA, 2008). Manure production is < 2.5 tonnes manure/ha throughout the majority of the subwatershed; however, it increases to 2.6-5.0 tonnes manure/ha near Duchess and to 12.6-15.7 tonnes manure/ha in the Brooks area (Figure 357) (AAFC-PFRA, 2008). Overall, manure production is considered low in the Matzhiwin Creek subwatershed relative to the remainder of the Red Deer River watershed; however, it is noteworthy that manure production in the Brooks area is the highest of any area in the Red Deer River watershed.

Agricultural intensity, expressed as the percent land cover used as croplands, primarily ranges from 0-40% in the eastern and central areas of the subwatershed. Agricultural intensity increases in the north-western area, peaking at 60-80% south of Drumheller (Figure 358) (AAFC-PFRA, 2008).

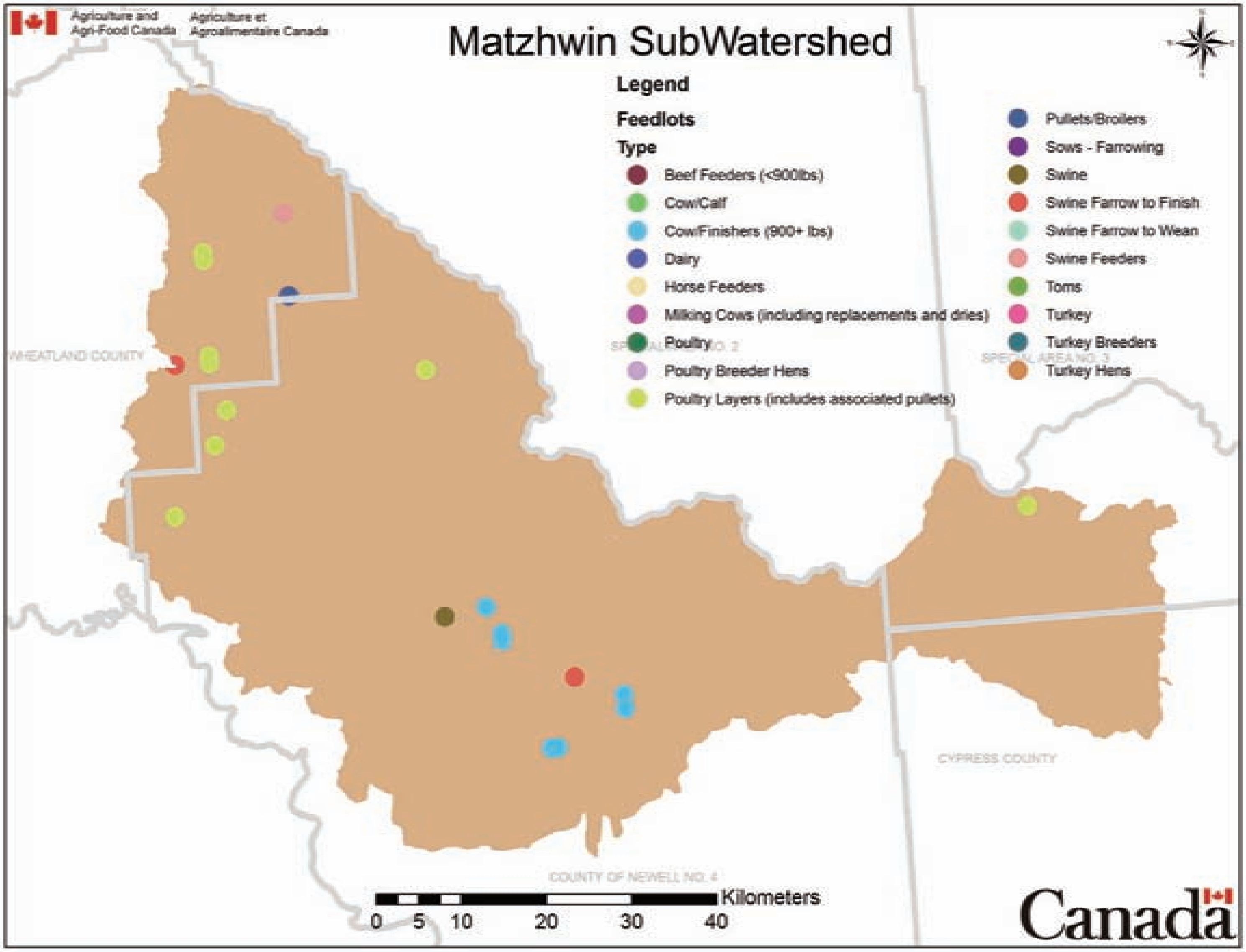


Figure 355. Feedlots and intensive livestock operations in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

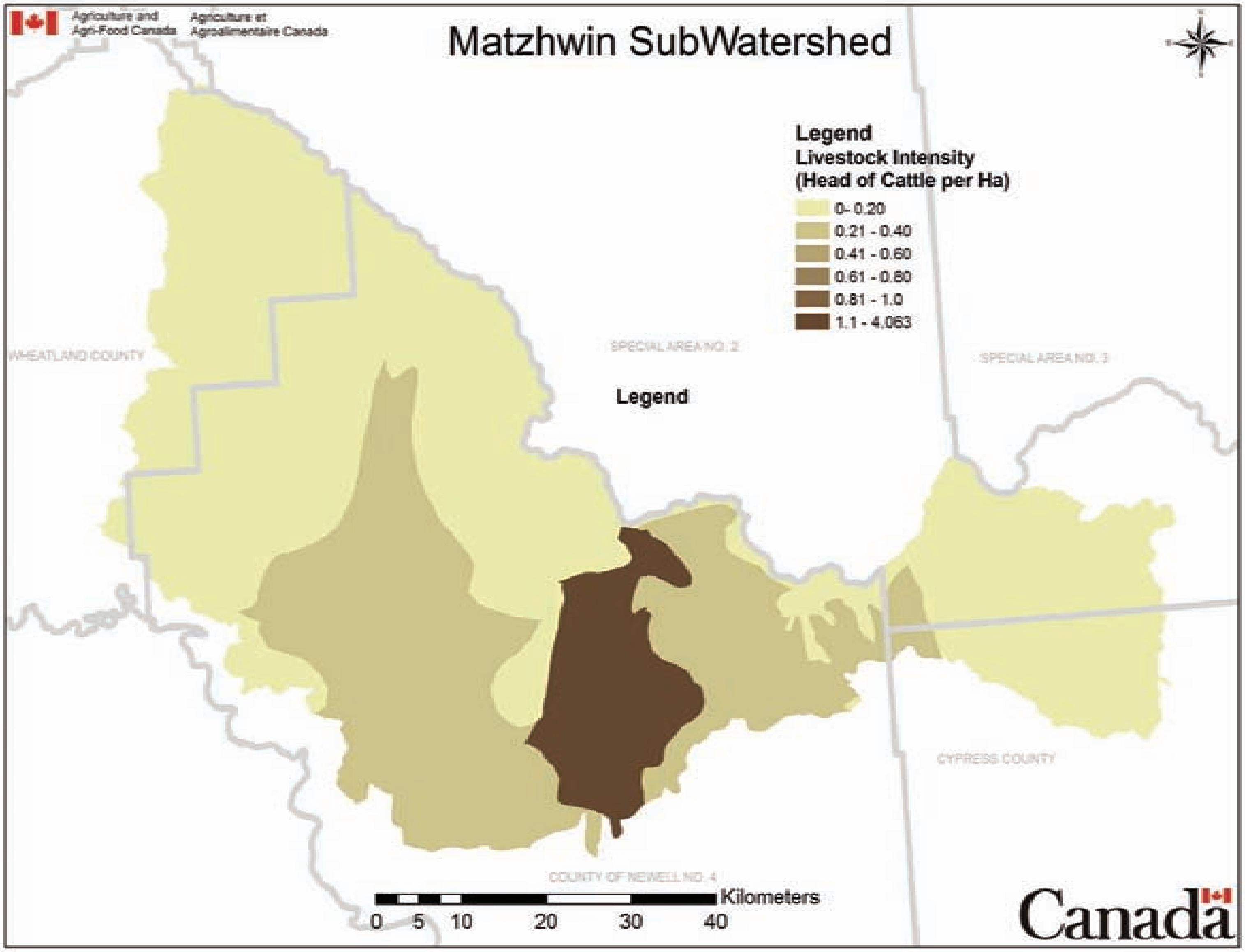


Figure 356. Cattle density (cattle/ha) in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

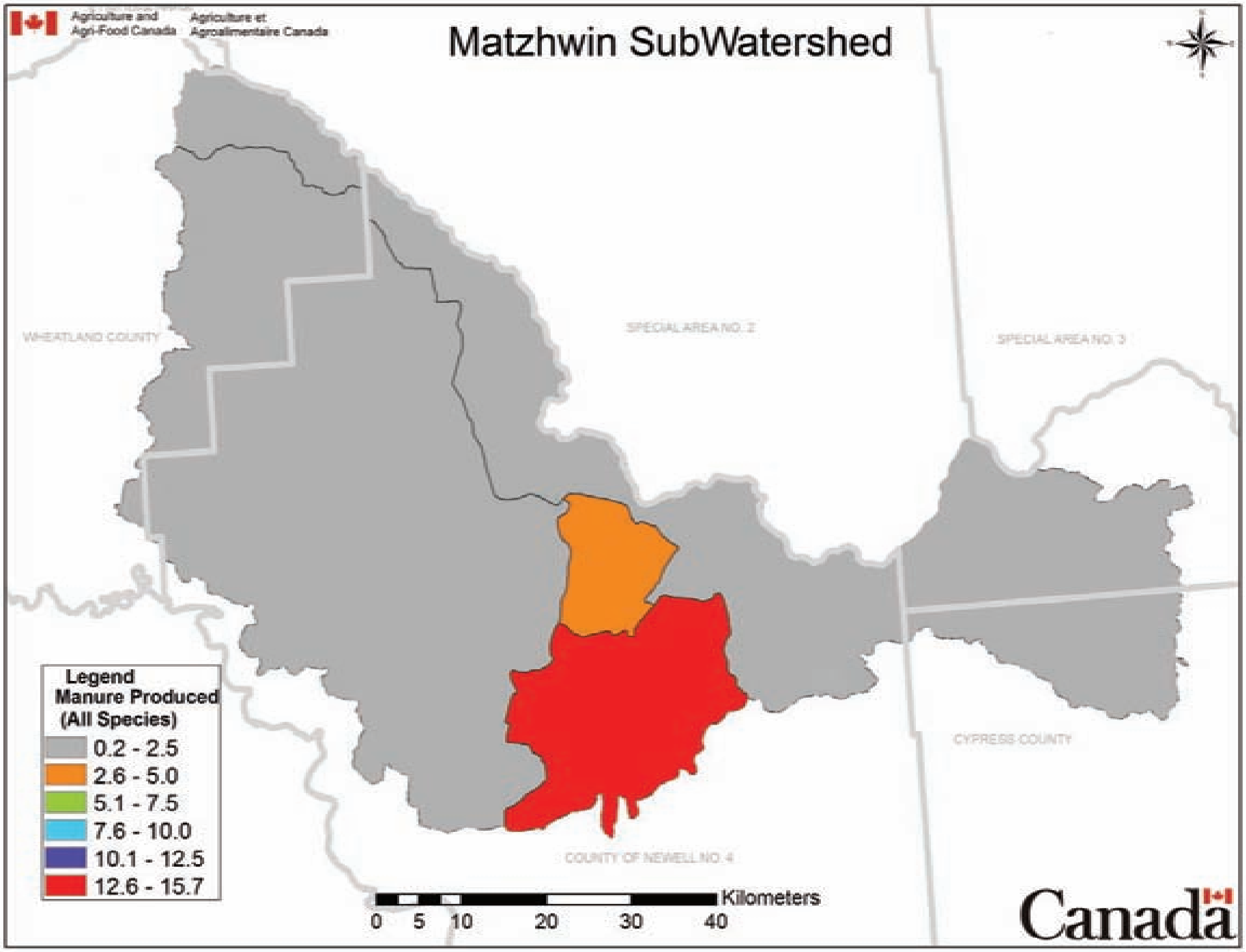


Figure 357. Manure production (tonnes/ha) in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

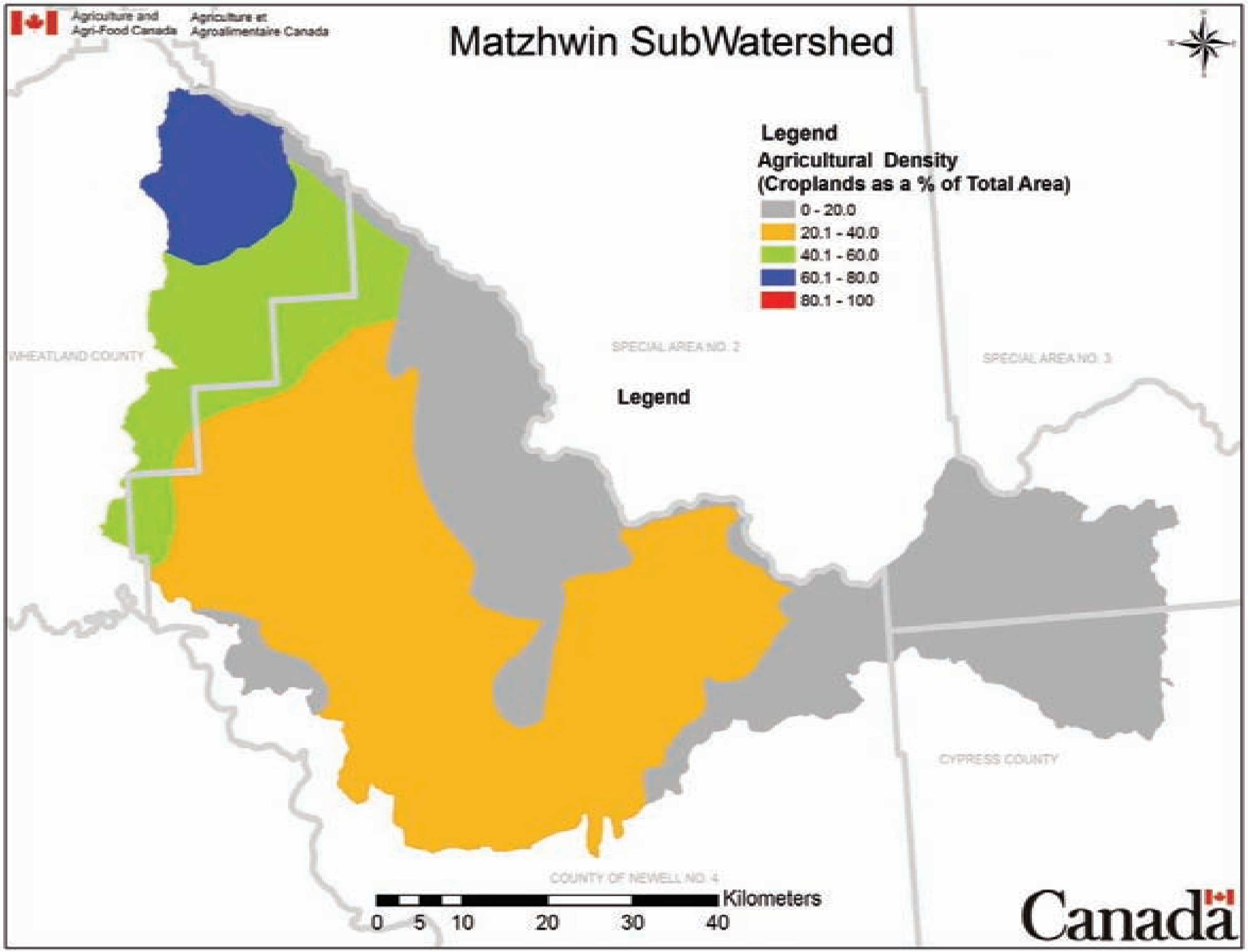


Figure 358. Agricultural intensity (% cropland) in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

4.14.2.4 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 Matzhiwin Creek subwatershed include the City of Brooks, the Town of Bassano, the Villages of Duchess and Rosemary and numerous hamlets, including Cassils, Countess, Gem, Halsbury, Iddesleigh, Jenner, Lathom, Makepeace, Millicent, Patricia, Princess and Western Monarch (Government of Canada, 2006). The subwatershed has two Provincial Parks (PP) and two additional recreation parks (Table 148) (Alberta Tourism, Parks and Recreation, 2008b).

Table 148. Recreational facilities in the Matzhiwin Creek subwatershed (Alberta Tourism, Parks and Recreation, 2008b).

Facility	Characteristics
Dinosaur PP	• 8085.96 ha on the Red Deer River • 126-unit campgrounds (59 with electrical hookups), 10 unit group campgrounds, visitor centre • UN World Heritage Site
Tillebrook PP	• 139.15 ha • 85 unit campgrounds (45 with electrical hookups)
Amusement park	---
Emerson Bridge park	• campgrounds

Note: PP = provincial park.

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 359). For those years with available data, the average number of visitors per year was 23,091 in Dinosaur PP and 11,162 in Tillebrook PP. An average 34,253 visitors have used these two recreation facilities annually from 1994-2003; however, there are several years with incomplete visitation data (lack of group camping data) for Tillebrook PP, and the number of visitors to this recreation facilities is likely substantially higher (Alberta Tourism, Parks and Recreation, 2008b).

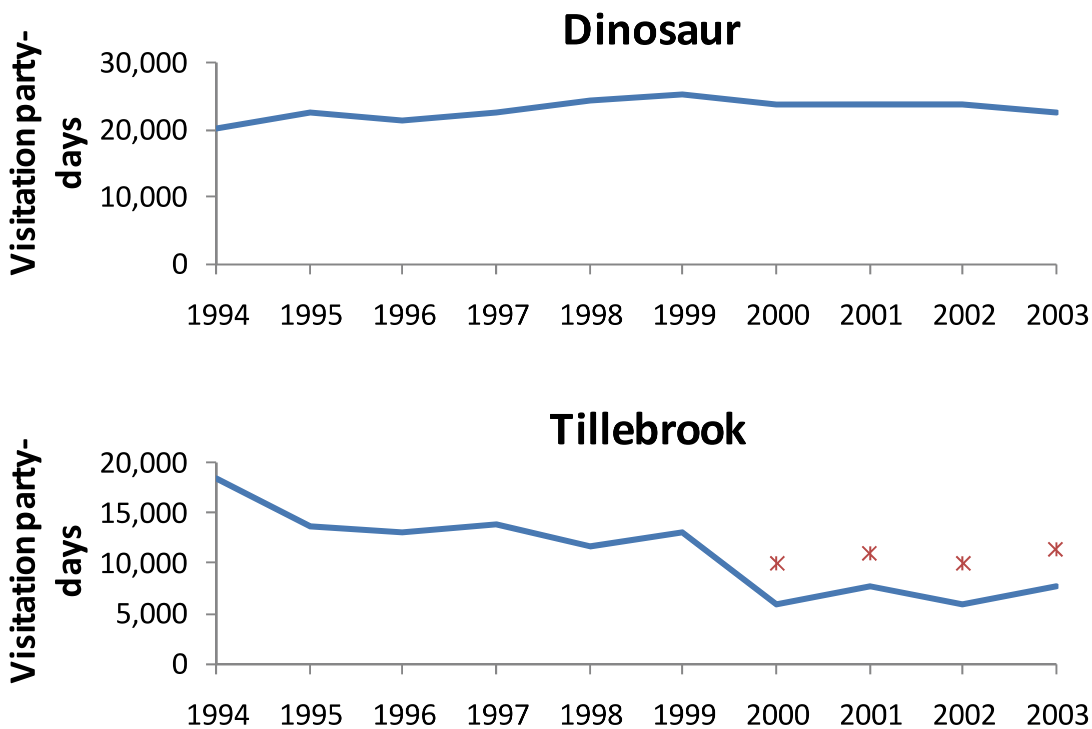


Figure 359. Visitation statistics for two recreation facilities in the Matzhiwin Creek subwatershed (Alberta Tourism, Parks and Recreation, 2008b). Asterisks indicate years for which group camp data were not available.

4.14.2.5 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 Matzhiwin Creek subwatershed are urban and rural roads, which have a total length of 3,900 km and cover 62.4 km^2 of the subwatershed's landbase. Other major linear developments include pipelines and cutlines/trails (Table 149). In total, all linear developments cover an area of 160.1 km^2, or 2.2% of the total area of the subwatershed (Figure 360) (AAFC-PFRA, 2008).

In addition to linear developments, the Matzhiwin Creek subwatershed has 343 bridges that cross waterbodies, mostly streams and creeks, or culverts that connect waterbodies (Figure 361) (AAFC-PFRA, 2008). Pipeline crossings are distributed throughout the Matzhiwin Creek subwatershed, although their density is lower in the southern and western areas of the subwatershed compared to the northern, east-central and eastern areas. Pipeline crossing densities are particularly high in the Patricia-Princess-Cowoki Lake area and north-east of Jenner (Figure 362) (AAFC-PFRA, 2008).

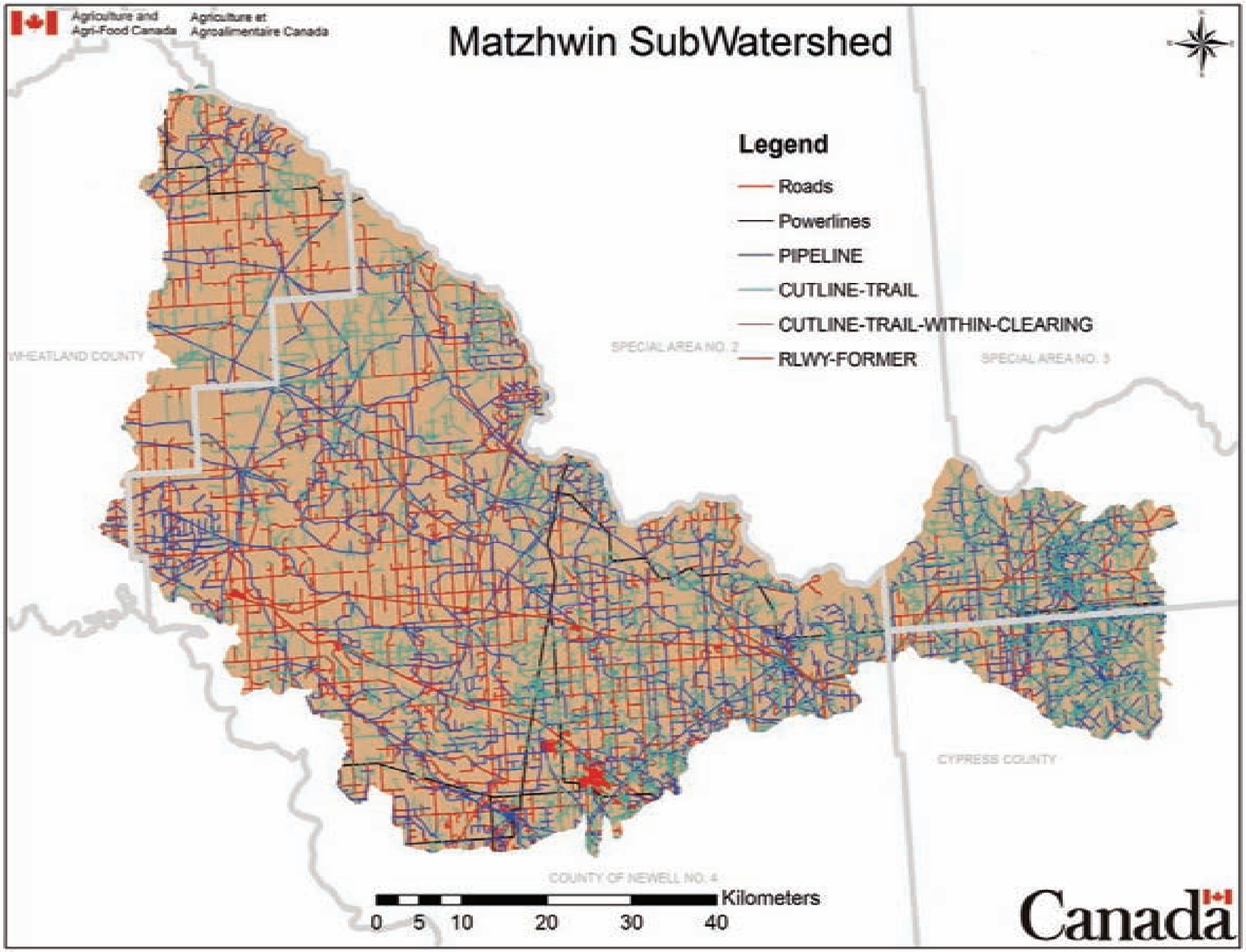


Figure 360. Linear developments in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

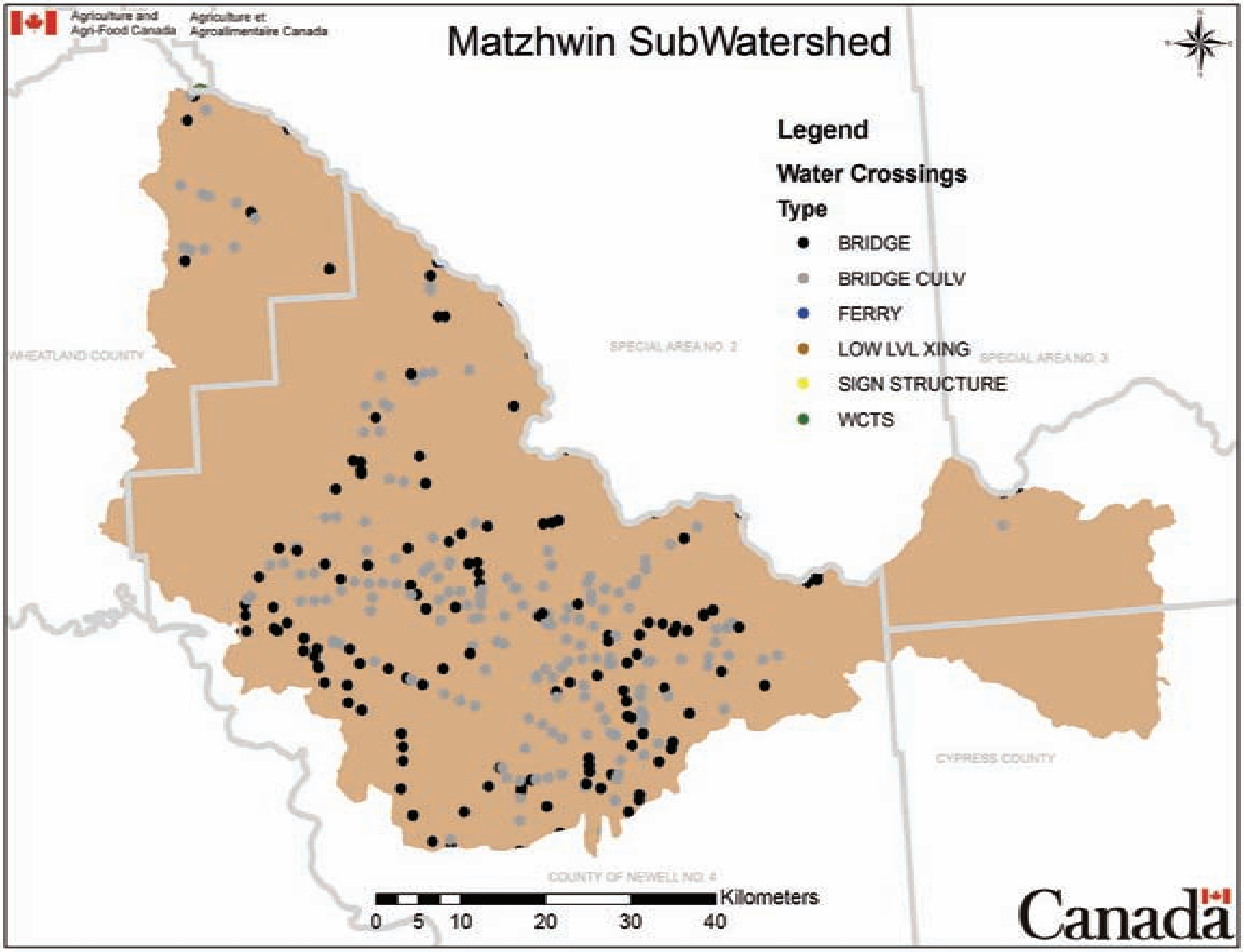


Figure 361. Waterbody crossings in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

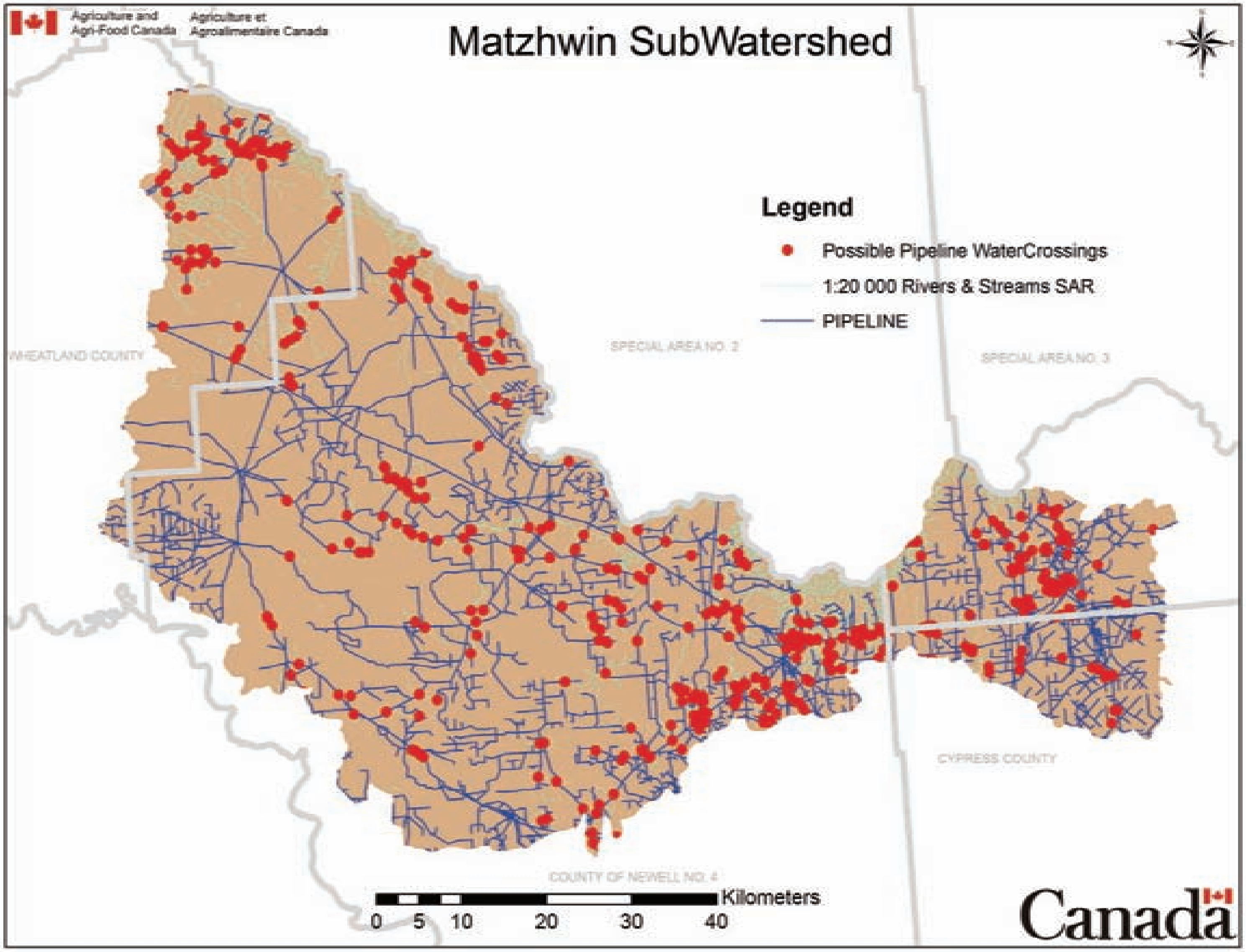


Figure 362. Pipeline crossings over waterbodies in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

Table 149. Linear developments in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008). The dominant linear development is highlighted.

Linear Development	Length (km)	Width (m)	Area (km^2)	Proportion of total linear disturbances (%)
All roads	3,900	16	62.40	39.0
Cutlines/trails	4,100	6	24.60	15.4
Pipelines	3,900	15	58.50	36.5
Powerlines	330	30	9.90	6.2
Railways	316.2	15	4.74	3.0
Total	**12,546**		**160.14**	

4.14.2.6 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 Matzhiwin Creek subwatershed has the highest well density among the 15 subwatersheds of the Red Deer River watershed at 3.15 wells/km^2. Well densities are lowest near Seiu Lake in the north-western region of the watershed, but increases to 2-10 wells/km^2 throughout most of the remainder of the subwatershed. In the Brooks-Cassils-Southesk-Lathom corridor in the south of the subwatershed, well densities range from 10-40 wells/km^2. The highest oil/gas well density occurs near Jenner in the eastern region of the subwatershed. This is also the area with the highest oil/gas well density of the entire Red Deer River watershed (Figure 363). About 83% of all wells are active, with the majority being gas wells, followed by unspecified and oil wells (Table 150) (AAFC-PFRA, 2008).

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).

Table 150. Number of known active and abandoned oil, gas, water and other wells in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

Well type	Quantity
Wells – active *	2,809
Wells – abandoned *	2,509
Total	**5,318**
Gas wells – active	14,258
Gas wells – abandoned	723
Total	**14,981**
Oil wells – active	1,672
Oil wells – abandoned	653
Total	**2,325**
Water wells – active	235
Water wells – abandoned	50
Total	**285**
Total active wells in subwatershed	**18,974**
Total abandoned wells in subwatershed	**3,935**
Total wells in subwatershed	**22,909**

* 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.

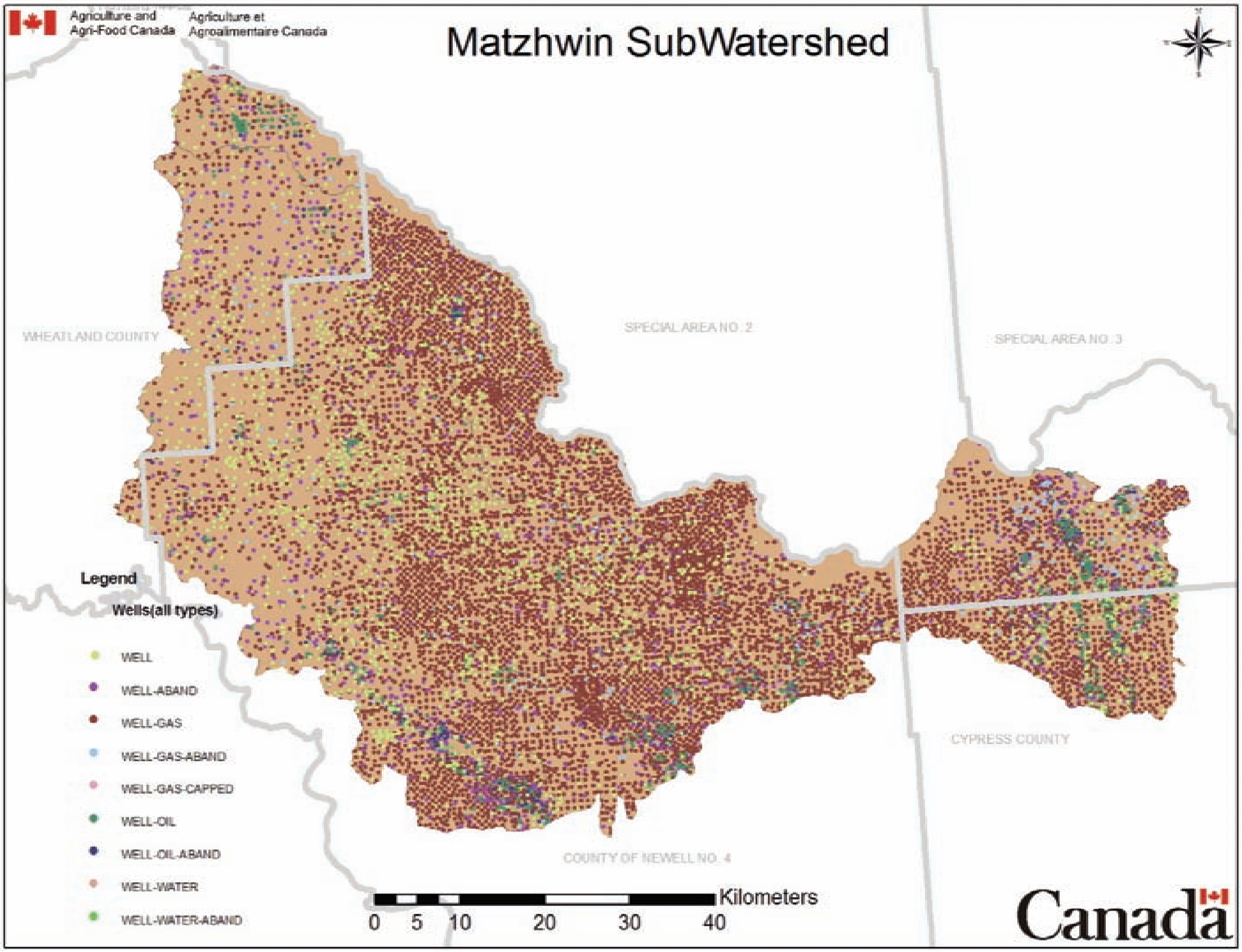


Figure 363. Known active and abandoned oil, gas, water and other wells in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

4.14.3 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.

4.14.3.1 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.

Total phosphorus (TP) concentrations in Crawling Valley Reservoir have significantly decreased over the past 20 years, i.e., since its construction ($p = 0.027$) (Figure 364). Elevated TP concentrations following the construction of the reservoir were likely due to the decay of organic matter on the bottom of the reservoir following flooding of the landscape. More recent data are sparse, and it is impossible to predict current TP concentrations in the reservoir.

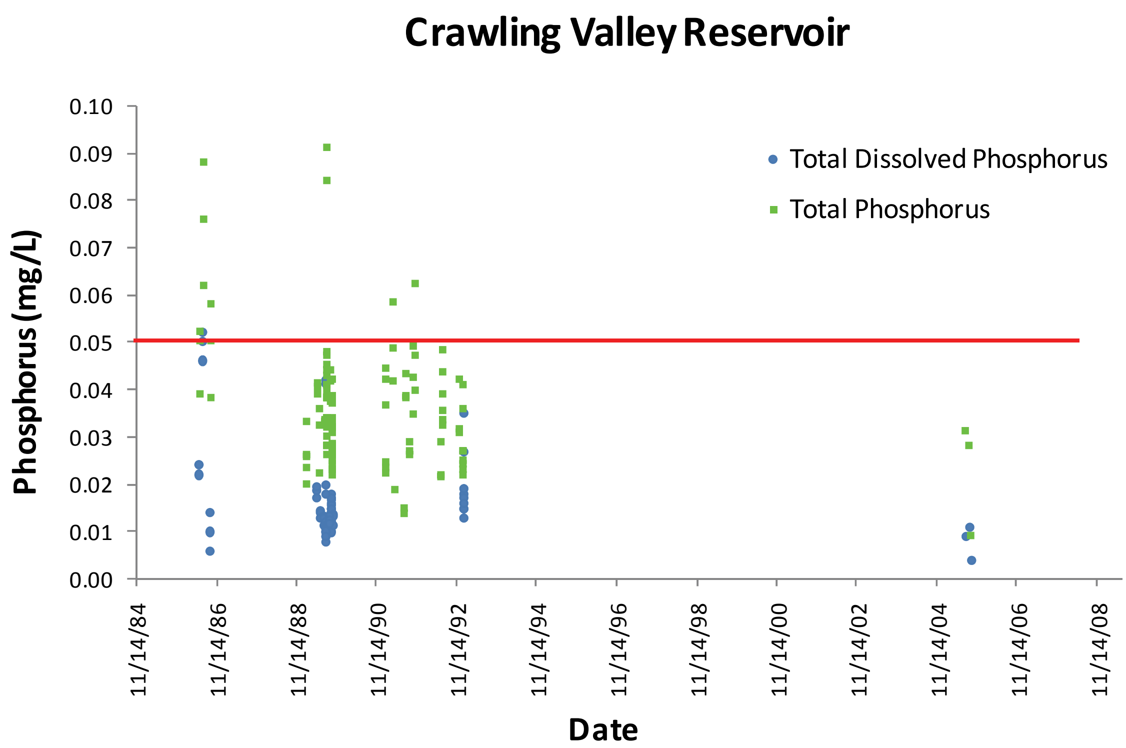


Figure 364. Total phosphorus (TP) and total dissolved phosphorus (TDP) concentrations in Crawling Valley Reservoir (data from Alberta Environment). The ASWQG PAL for TP (0.05 mg/L) is indicated by the red line.

Total nitrogen (TN) concentrations were measured regularly following the construction and initial operation of the Crawling Valley Reservoir, but recent data are not available (Figure 365). There were a number of instances where TN concentrations exceeded ASWQG PAL limits following the construction and initial operation of the reservoir; however, the water quality has improved thereafter. The initially high values are almost certainly a result of the breakdown of vegetation and organic matter submerged upon the initial filling of the reservoir.

NH_3 and NO_3^--NO_2^- concentrations in the Crawling Valley Reservoir follow a similar pattern as TN, with initially high and considerably variable values following the onset of operations of the reservoir (Figures 366, 367, respectively). Since then, NH_3 concentrations have decreased and become less variable. More recent data are sparse, and it is impossible to determine if NH_3 concentrations have decreased further, remained stable or increased. Similar to TP concentrations, the initially high NH_3 concentrations were almost certainly a result of the breakdown of organic matter, which was submerged upon the initial filling of the reservoir.

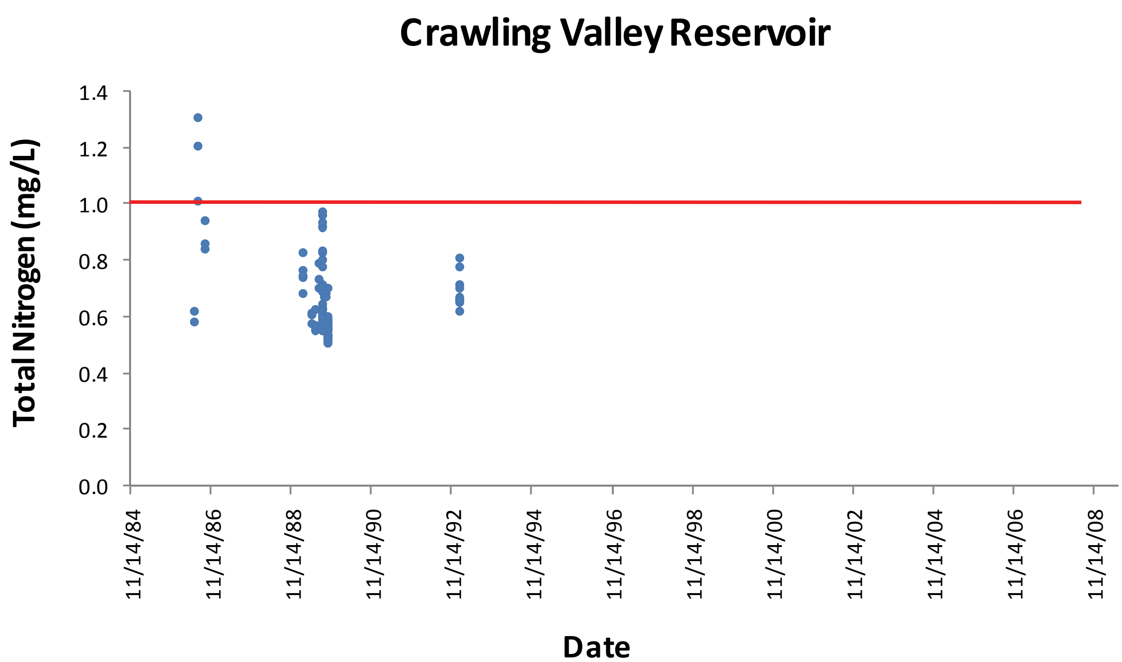


Figure 365. Total nitrogen (TN) concentrations in the Crawling Valley Reservoir (data from Alberta Environment). The ASWQG PAL for TN (1.0 mg/L) is indicated by the red line.

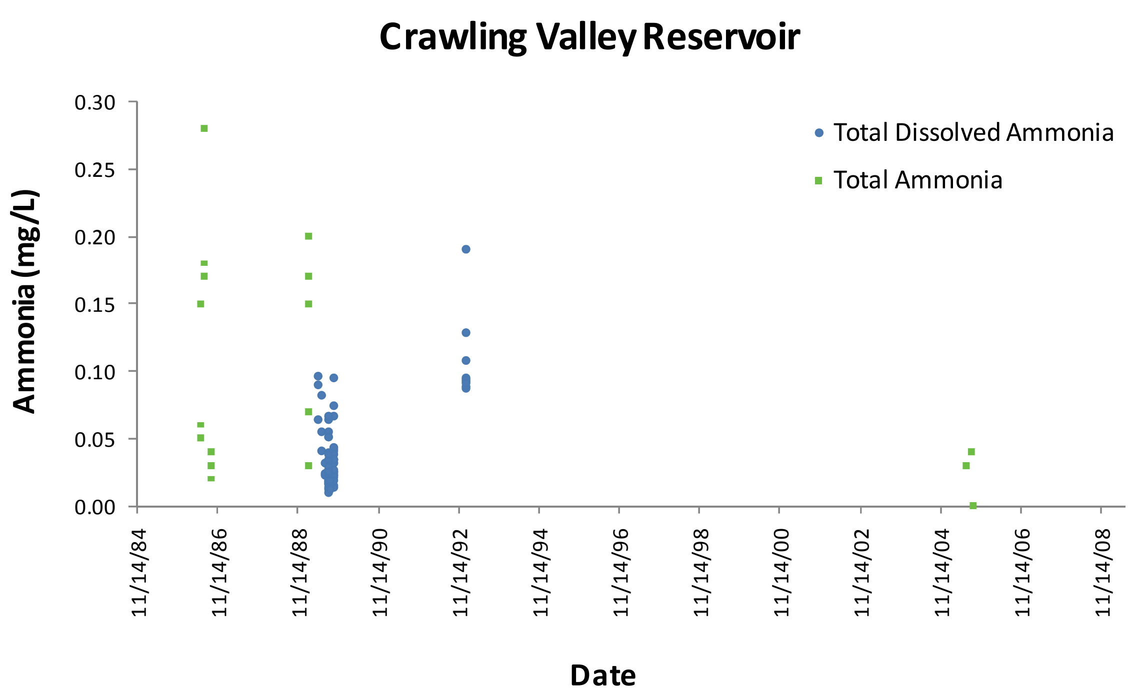


Figure 366. Total ammonia and total dissolved ammonia concentrations in the Crawling Valley Reservoir (data from Alberta Environment).

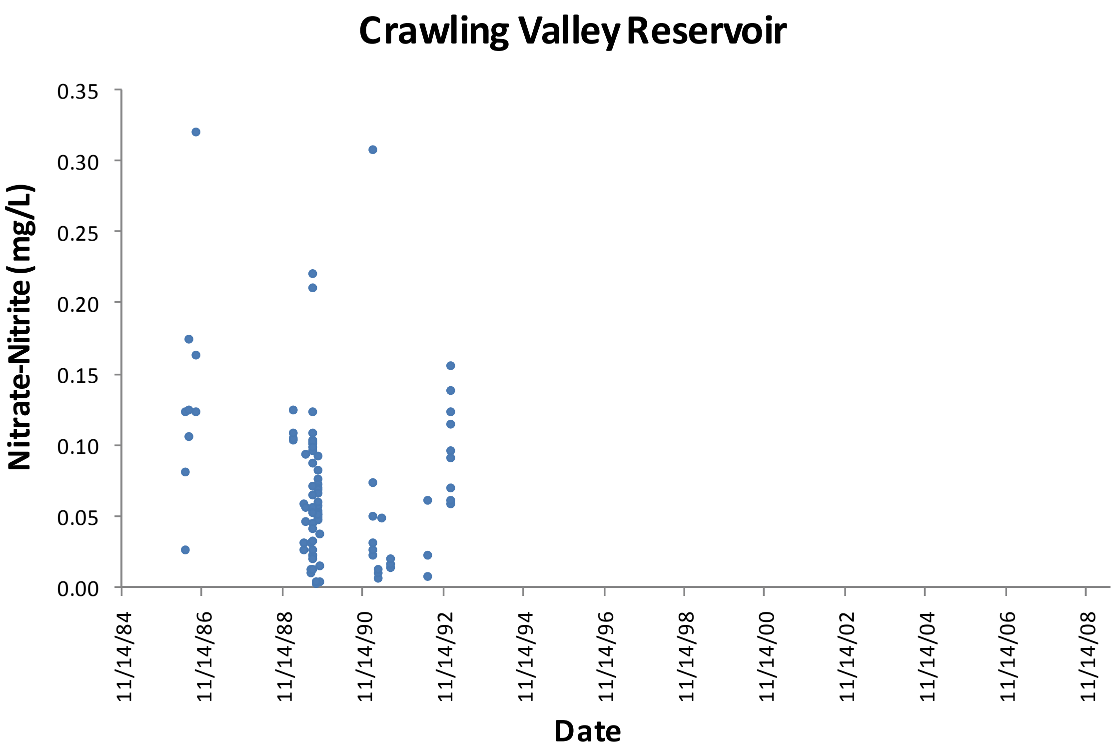


Figure 367. Nitrate-nitrite concentrations in the Crawling Valley Reservoir (data from Alberta Environment).

Dissolved oxygen (DO) concentrations in the Crawling Valley Reservoir are elevated during the summer months and at the water surface, but drop below the minimum ASWQG PAL limit in winter and at lower depths (Figure 368), especially early after the onset of reservoir operations. The lower DO concentrations during the first years of operation of the reservoir are likely a result of the decay of organic matter, which was submerged during the initial filling of the reservoir. The most recently available data do not indicate the presence of any hypoxic or anoxic conditions; however, those data were collected in late summer/early fall prior to ice cover formation. Further sampling is necessary to determine if winterkill conditions exist at the present time.

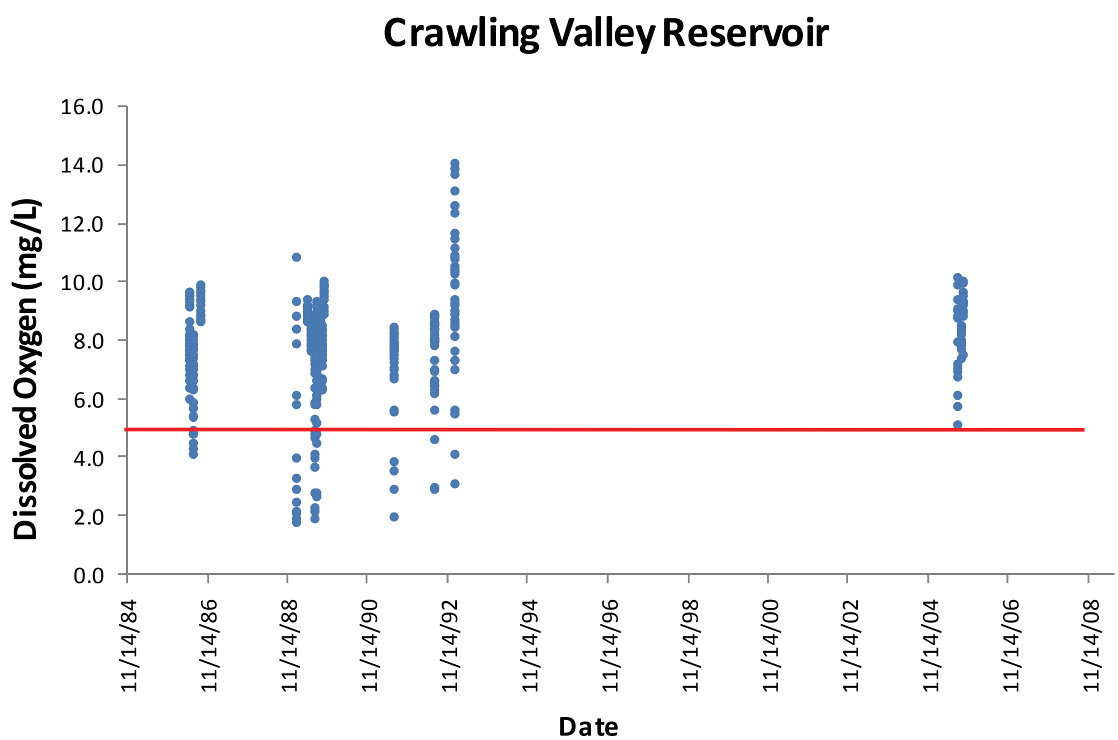


Figure 368. Dissolved oxygen (DO) concentrations in the Crawling Valley Reservoir (data from Alberta Environment). The ASWQG PAL lower limit for DO (5.0 mg/L) is indicated by the red line.

The water quality has been assessed sporadically in various streams and creeks in the Matzhiwin Creek subwatershed from 1982-1998. Most water samples have been collected in Matzhiwin Creek and Sandhill Creek. TP concentrations exceed CCME PAL guidelines in four of the five streams, averaging 0.079 mg/L, 0.411 mg/L, 0.139 mg/L and 0.366 mg/L in the Bassano Dam diversion, Little Sandhill Creek, Matzhiwin Creek and Onetree Creek, respectively. In addition, TN concentrations were above CCME PAL guidelines in Little Sandhill Creek (1.175 mg/L vs. 1.0 mg/L) (Table 151). Sources of phosphorus and nitrogen 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 throughout the subwatershed and may contribute to the nutrient loading of these waterbodies.

Table 151. Water quality in waterbodies in the Matzhiwin subwatershed. n = sample size. All concentrations in mg/L unless otherwise noted. Concentrations exceeding water quality guidelines are highlighted *.

Parameter	Bassano Dam Diversion		Crawling Valley Reservoir Outlet		Little Sandhill Creek		Matzhiwin Creek		Onetree Creek	
	Mean	n	Mean	n	Mean	n	Mean	n	Mean	n
TP	0.079	11	---	---	0.411	5	0.139	21	0.366	15
TDP	0.053	11	---	---	0.126	5	0.035	21	0.128	14
TN	---	---	---	---	1.175	5	0.732	20	0.980	14
NO_3^--NO_2^-	0.409	3	---	---	0.027	5	0.077	21	0.116	15
NH_3	---	---	---	---	0.035	5	0.655	20	0.041	15
DO	---	---	---	---	8.36	9	9.25	21	8.91	15
Chl. *a* (µg/L)	---	---	---	---	---	---	---	---	---	---
pH	7.40	3	---	---	8.25	9	8.20	22	8.15	16
Specific Conductivity (µS/cm)	271	12	---	---	640	9	595	22	1,103	16
TDS	---	---	---	---	---	---	481	9	1,135	9
Total coliforms (CFU/100 mL)	---	---	1,580	6	---	---	484.4	12	700	8
Fecal coliforms (CFU/100 mL)	---	---	---	---	1,148	47	198	17	735	13

* TN from ASWQG PAL chronic exposure guideline; fecal and total coliforms from CCME-Agriculture/Irrigation guideline; all others from CCME PAL. At the Bassano Dam Diversion, water samples were collected May-October 1981; at the Crawling Valley Reservoir Outlet, water samples were collected May-October 1989; in Little Sandhill Creek, water samples were collected August 1991, July-August 1996, and June-October 1999; in Matzhiwin Creek, water samples were collected August 1982-September 1983, August 1991-October 1992, and June 1996-July 1998; in Onetree Creek, water samples were collected August 1982-October 1983 and July 1996-August 1998 (data from Alberta Environment). Variable abbreviations as in Table 10.

4.14.3.2 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.

Coliform bacterial concentrations have been assessed in various streams in the Matzhiwin Creek subwatershed. Total coliform or fecal coliform concentrations exceeded CCME Agriculture/Irrigation guidelines in the Crawling Valley Reservoir outlet, Little Sandhill Creek, Matzhiwin Creek and Onetree Creek, with Little Sandhill Creek having the highest concentrations of fecal coliforms (1,148 CFU/100 mL) and the Crawling Valley Reservoir outlet the highest concentrations of total coliform (1,580 CFU/100 mL) (Table 151). Sources of these bacteria include agricultural and livestock operations, both of which are common throughout the subwatershed.

4.14.3.3 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.

Parasite data were not located for any waterbody in the Matzhiwin Creek subwatershed.

4.14.3.4 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.

Pesticide data were not located for any waterbody in the Matzhiwin Creek subwatershed.

4.14.3.5 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.

Over 100 upstream oil/gas facilities, 6 oil/gas refining/storage facilities and 2 commercial facilities have released pollutants continuously or sporadically into the air in the Matzhiwin Creek subwatershed since 2002. Pollutants from the upstream oil/gas and refining/storage facilities include volatile organic compounds (VOCs), carbon monoxide (CO), nitrous oxide (N_2O) and particulate matter < 10 µm in size. The pollutants from the commercial facilities include N_2O, VOCs, particulate matter < 10 µm in size, chlorine (Cl^-), alcohols and ammonia (NH_3) (NPRI, 2008). No pollutants were released directly into aquatic ecosystems according to the National Pollution Release Inventory.

4.14.4 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.

4.14.4.1 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 all water courses in the Matzhiwin Creek subwatershed is about 3,503 km (Figure 369) (AAFC-PFRA, 2008). The major streams in the subwatershed are Crawling Creek, Deadhorse Creek, Dip Creek, Douglas Creek, Little Sandhill Creek, Matzhiwin Creek, Onetree Creek, Seiu Creek and Spring Hill Canal. Alkali Lake, Barkenhouse Lake (Crawling Valley Reservoir), Canalta Slough, Crownd Lake, Cutting Lake, Jamieson Lake, Lathom Lake, Mattoyekin Lake, Onetree Reservoir, Rocky Lake, San Francisco Lake, Seiu Lake and Wolf Lake are the largest lakes and reservoirs in the subwatershed (Government of Canada, 2006).

Alberta Environment has been monitoring water discharge rates of tributaries to the Red Deer River in the Matzhiwin Creek subwatershed in three locations: in Matzhiwin Creek below Ware Coulee (real-time active, 05CJ012), in Matzhiwin Creek north of Dutchess (discontinued, no station information) and in Onetree Creek near Patricia (real-time active, 05CJ006) (Government of Alberta, 2008c).

In Matzhiwin Creek below Ware Coulee, water discharge rates are low in the spring (April), ranging from 0.4-0.6 m^3/sec. They then increase to 4-6 m^3/sec in the months of May and June before decreasing to below 1 m^3/sec by mid to late-October. Historically, water discharge rates are remarkably similar, varying only by about 1-2 m^3/sec during high flow months (May-October). In 2008, water discharge rates were generally below average levels from mid-May to mid-October, ranging from 1-4 m^3/sec (Figure 370) (Government of Alberta, 2008c).

Water discharge rates in Onetree Creek near Patricia increase from about 0.1-0.5 m^3/sec to 3 m^3/sec from early spring to early June and then remain relatively constant until late August, when they begin to decrease for the remainder of the year. In 2008, water discharge rates were lower than average levels, ranging primarily from 1-2 m^3/sec before decreasing below 1 m^3/sec in late summer (Figure 371) (Government of Alberta, 2008c).

In addition to hydrometric stations in Red Deer River tributaries, there are also a number of hydrometric stations located in lakes and reservoirs throughout the subwatershed. Active stations are located at Eastern Irrigation District (EID) North Branch Canal near Bassano (05CJ001), C.P.R. CO. East Branch Canal near Bassano (05CJ002), EID East Branch Canal near Lathom (05CJ003) and EID Springhill Canal near Lathom (05CJ004). Discontinued station are located at Ware Coulee above Matzhiwin Creek (05CJ008), EID Main Branch Canal at Bassano Dam (05CJ013), EID Main Bantry Canal above Aqueduct (05BN001), EID West Bantry Canal near Headgate (05BN003), EID East Branch Canal above Antelope Crossing (05BN011), EID East Branch Canal below Bow Slope Canal (05BN013) and Onetree Creek Spillway near Aqueduct (05BN017) (Government of Alberta, 2008c).

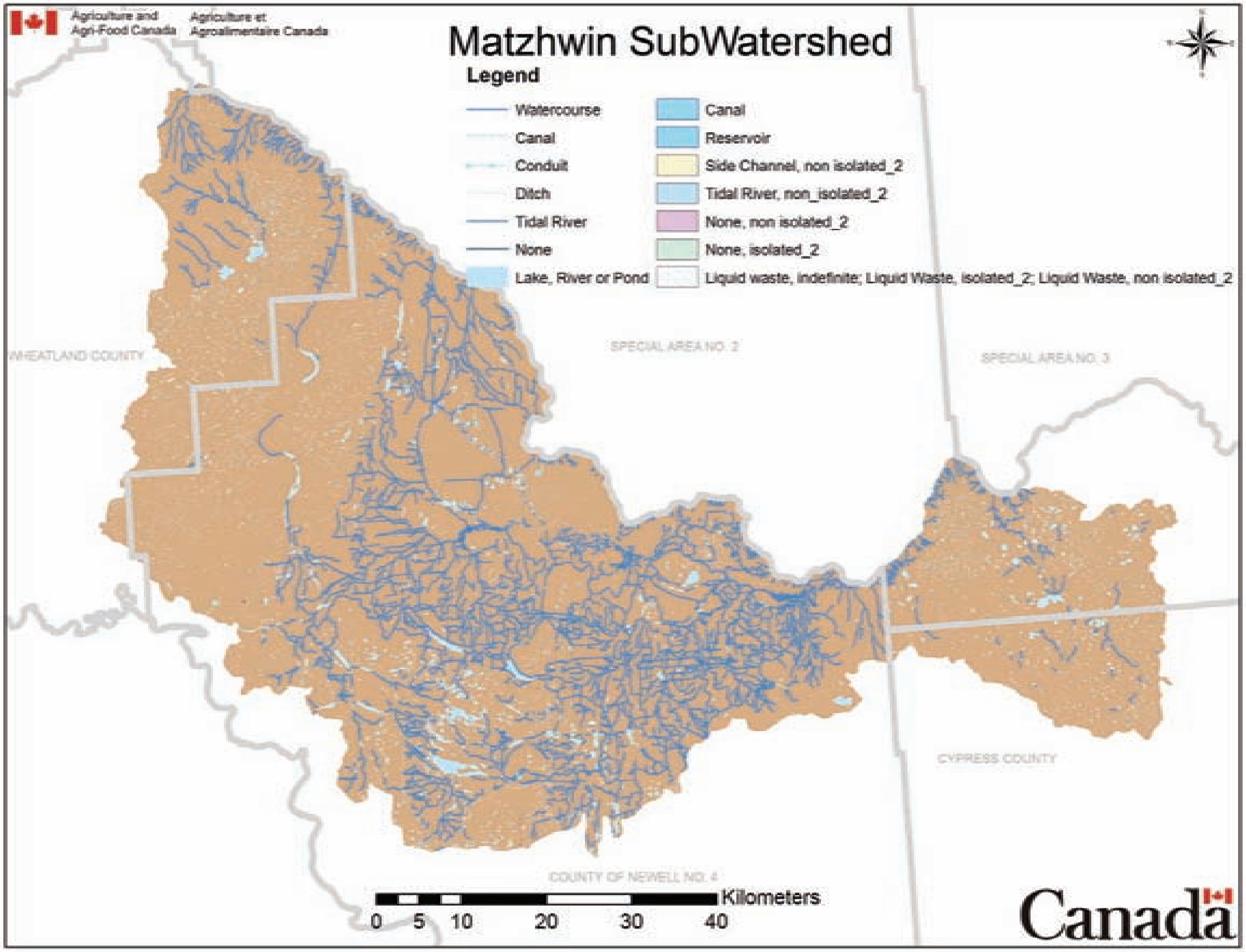


Figure 369. Waterbodies in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

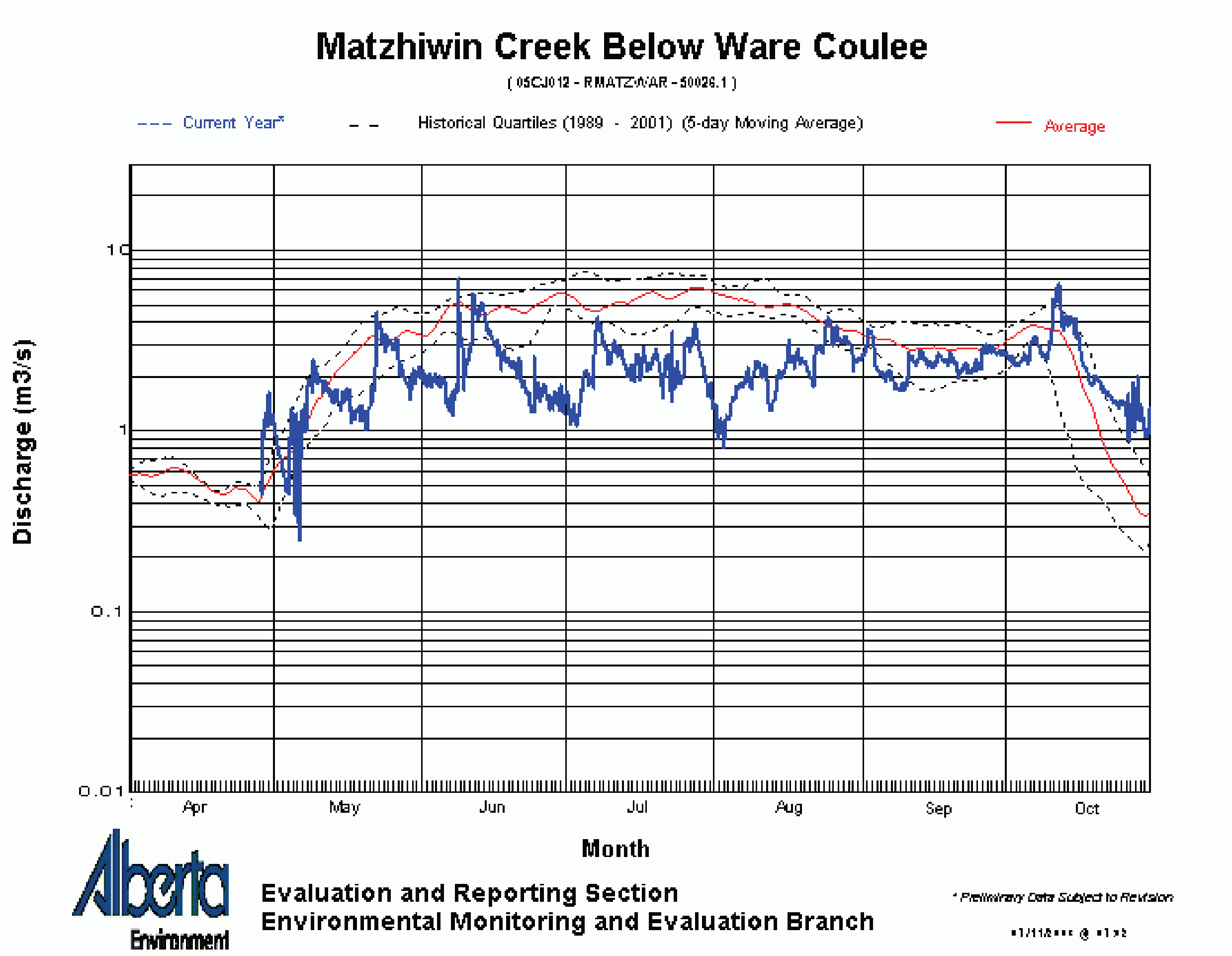


Figure 370. Discharge rates in Matzhiwin Creek below Ware Coulee (Government of Alberta, 2008c). “Current year” indicates water discharge rates in 2008.

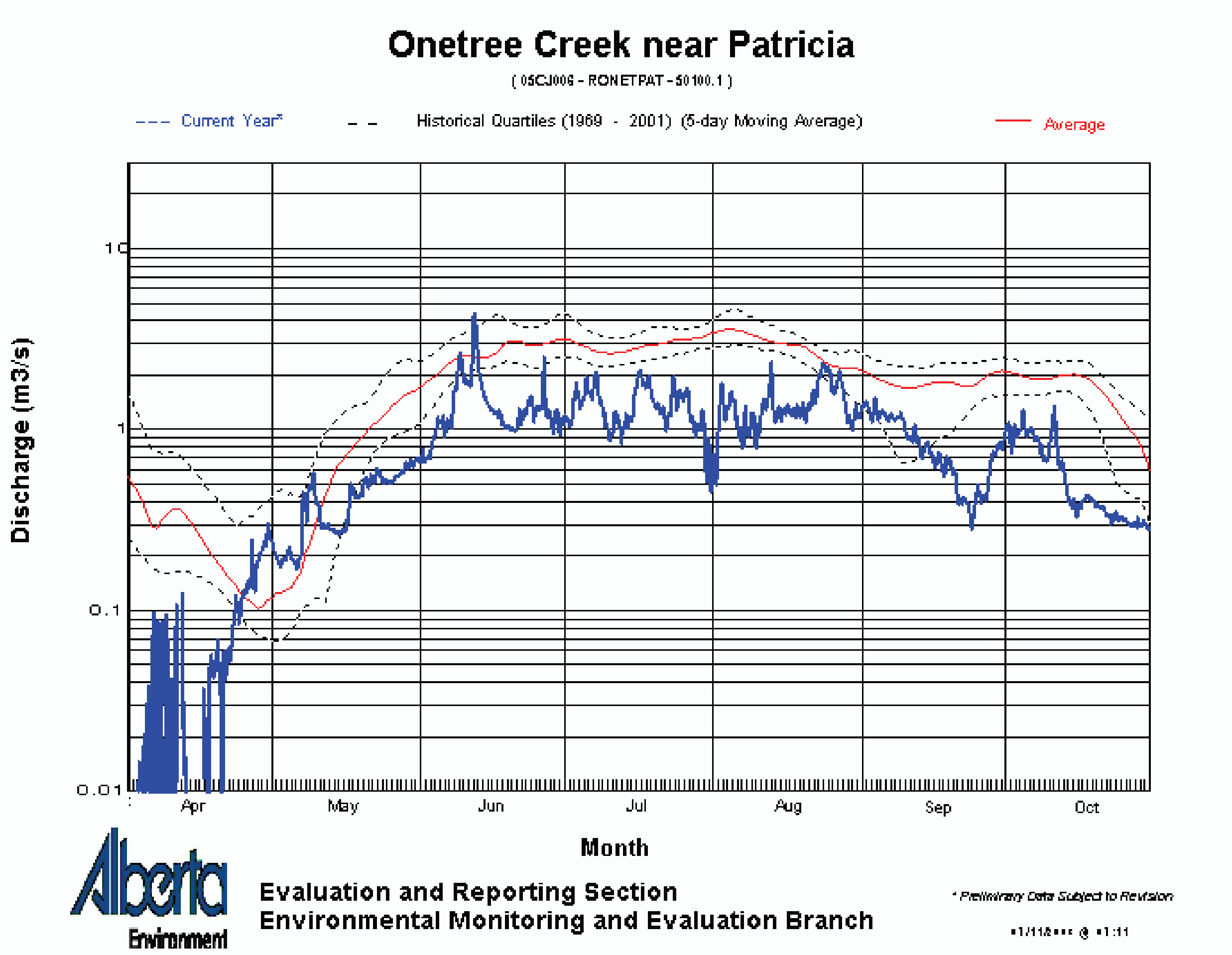


Figure 371. Discharge rates in Onetree Creek near Patricia (Government of Alberta, 2008c). "Current year" indicates water discharge rates in 2008.

There are six major dams in the Matzhiwin Creek subwatershed (Figure 372). Crawling Valley Dam is located on Crawling Valley Reservoir, the largest waterbody in the Matzhiwin Creek subwatershed. Three major dams are located north of Brooks on Jamieson Lake, Onetree Reservoir and on Cutting Lake. South-west of Dutchess, Rock Lake Dam is located on the east side of Rock Lake, while Spring Hill Canal Dam is located on the western constructed canal that feeds Rock Lake. In addition, there are numerous smaller water infrastructures in the subwatershed, e.g., small dams, sluices, weirs and dykes, which control water flow.

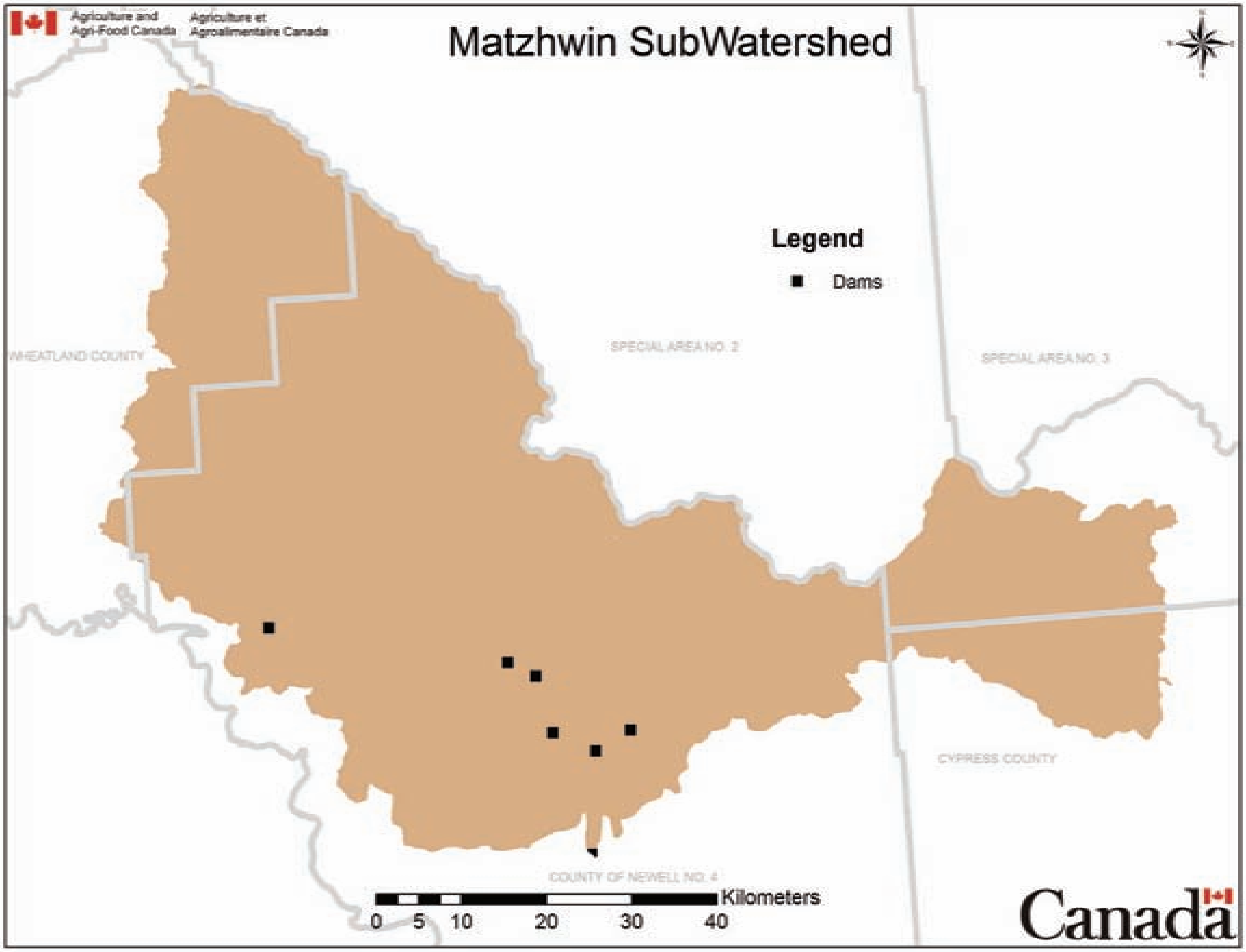


Figure 372. Major dams in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

4.14.4.2 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 Matzhiwin Creek subwatershed.

4.14.4.3 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 Matzhiwin Creek subwatershed, 334,798 ha (or 67.6% of the total area of the subwatershed) of land do not contribute to the drainage of the subwatershed (Figure 373). These areas are located primarily in the western and eastern areas of the subwatershed and exclude areas in the vicinity of Matzhiwin Creek and tributaries of the Red Deer River. Areas that do not contribute to the drainage within the subwatershed are characterized by a relatively flat topography (Figure 374) (AAFC-PFRA, 2008).

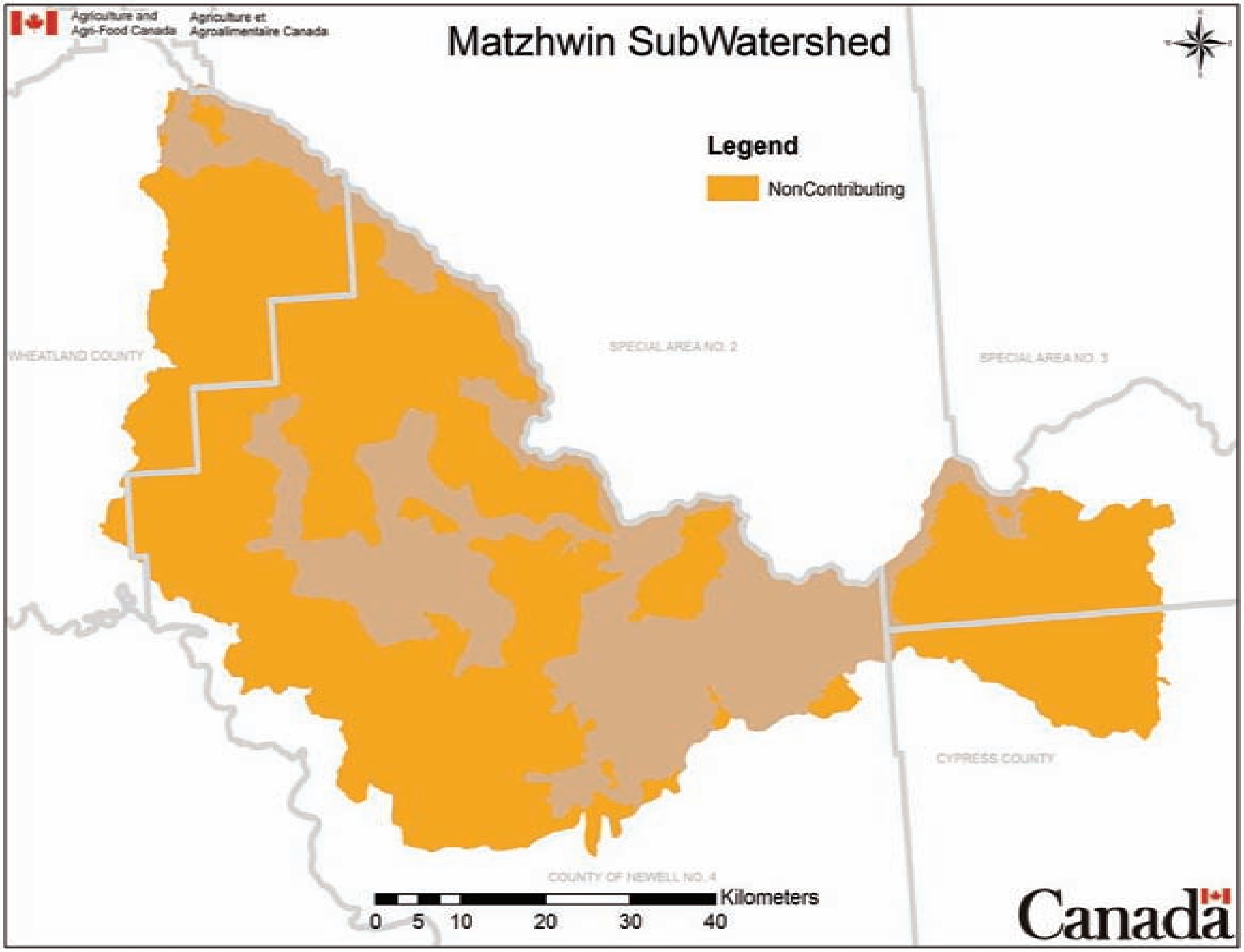


Figure 373. Non-contributing drainage area in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

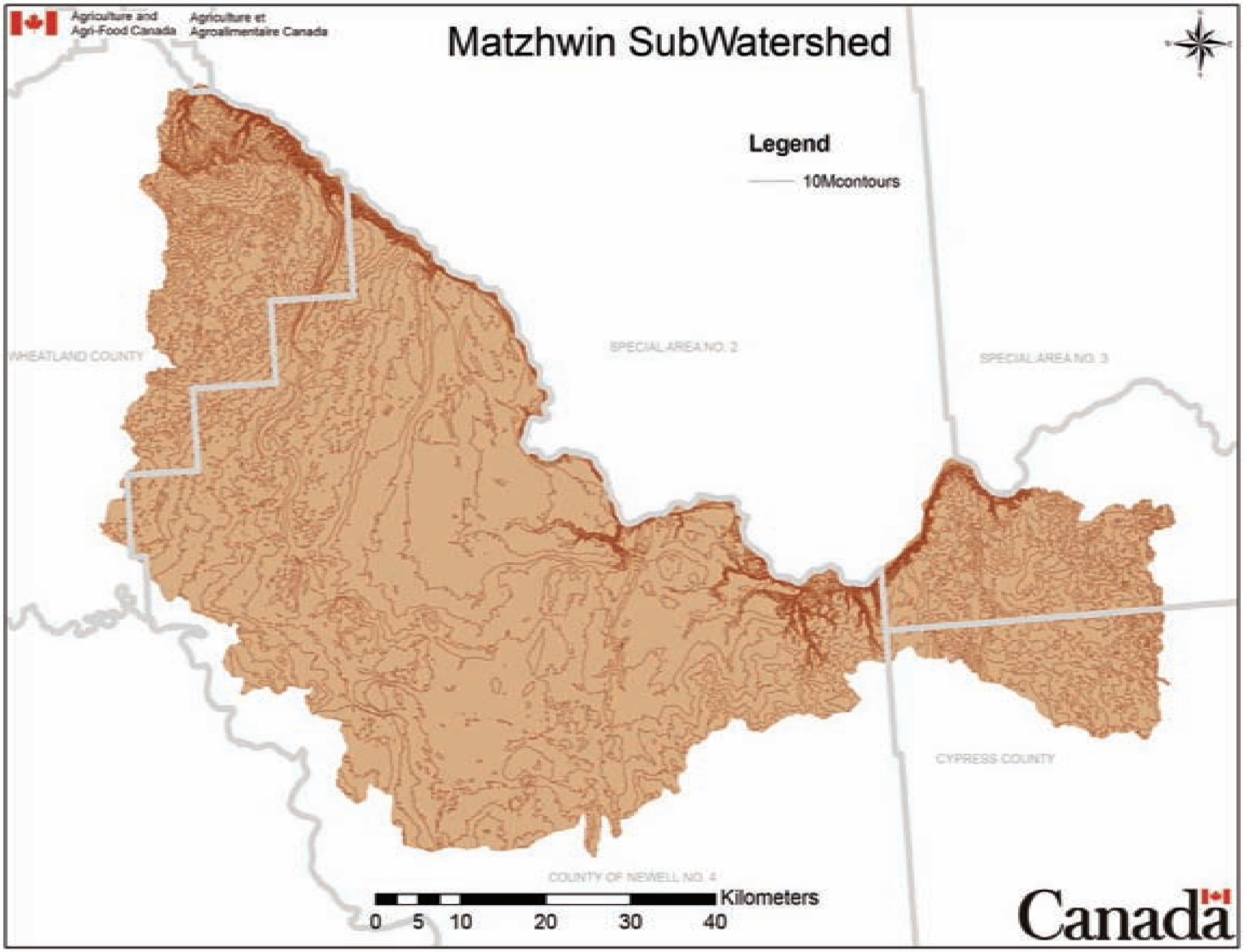


Figure 374. Topography (10-m contour intervals) of the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

4.14.4.4 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 Matzhiwin Creek subwatershed, 928 surface water licenses and 280 groundwater licenses have been issued for water diversion projects (Figures 375, 376. respectively) (AAFC-PFRA, 2008). They are distributed throughout the entire subwatershed.

About 3.23 million m^3 of surface and groundwater are diverted annually in the Matzhiwin Creek subwatershed (Government of Alberta, 2008d). The most prominent uses of surface water are for irrigation (53% of total surface water diversions) and agricultural operations (39% of total surface water diversions), while the most prominent users of groundwater are agricultural operations (86% of total groundwater diversions) and municipalities (12% of total groundwater diversions) (Table 152). The majority of water diverted in the entire subwatershed comes from surface water sources, e.g., lakes, streams and rivers (70%) (Government of Alberta, 2008d). Additional groundwater diversion information is provided in HCL (2001b, 2003b) and WorleyParsons Komex (2008).

Table 152. Surface and groundwater diversions in the Matzhiwin Creek 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^3/yr)	Groundwater (m^3/yr)
Agriculture	889,382	840,413
Commercial	---	2,470
Groundwater exploration	---	12,340
Habitat enhancement	14,800	---
Irrigation	1,187,810	---
Management of fish	11,100	---
Municipal	152,181	116,700
Recreation	---	1,230
Total	**2,255,273**	**973,153**
Grand total		**3,228,426**

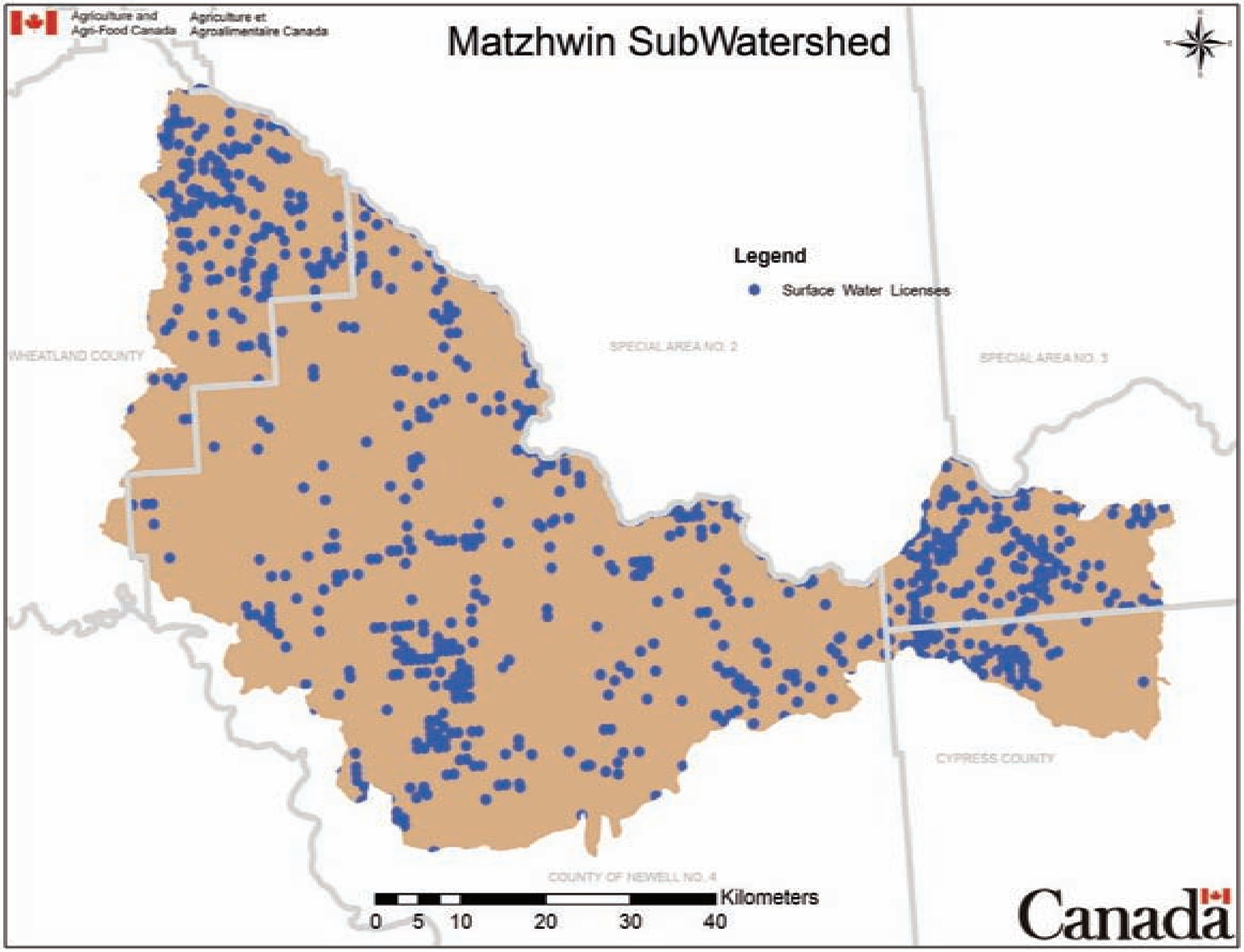


Figure 375. Surface water licenses in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

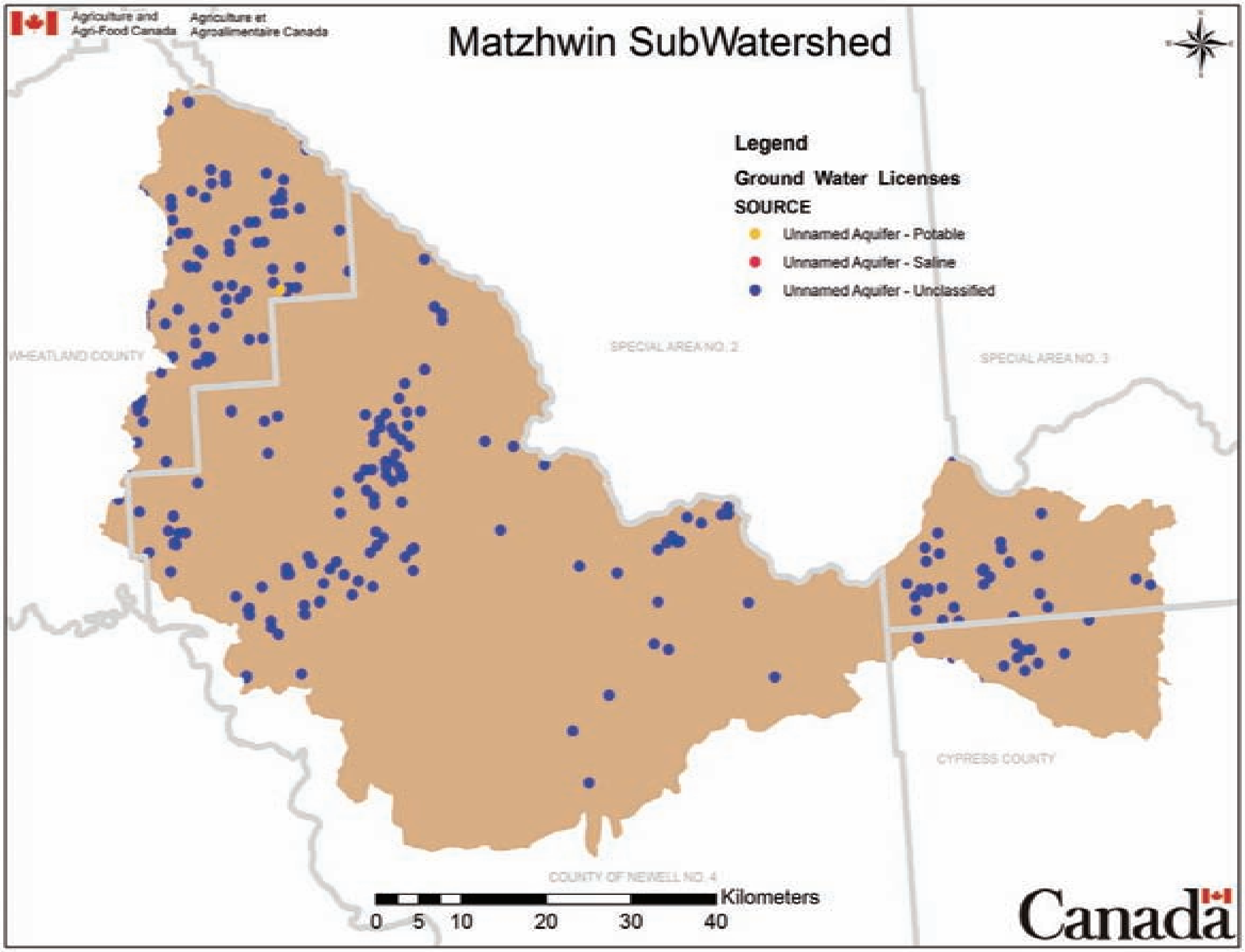


Figure 376. Groundwater licenses in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

4.14.4.5 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 Matzhiwin Creek subwatershed has about 30 freshwater springs located primarily along the Red Deer River, the lower reach of Matzhiwin Creek near the Village of Dutchess and east of Dinosaur Provincial Park.

The Matzhiwin Creek subwatershed lies in the Counties of Cypress, Newell No. 4 and Wheatland. Groundwater assessments for each of these counties have been conducted by HCL (2001b, 2003b) and WorleyParsons Komex (2008). The assessments indicated that most of the subwatershed is a groundwater recharge area (i.e., water moves from the surface into groundwater reservoirs), with only isolated areas of groundwater discharge (i.e., water moves from groundwater reservoirs to the surface) south of Drumheller and near rivers/creeks. 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 (2001b, 2003b) and WorleyParsons Komex (2008).

4.14.5 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.

4.14.5.1 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 Matzhiwin Creek subwatershed.

4.14.5.2 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 Crawling Valley Reservoir are spottail shiner, walleye, white sucker and yellow perch (Figure 377). There have been no significant changes in the populations of these fish over the sampling period ($p > 0.5$, 0.1, 0.3 and 0.6, respectively).

The spottail shiner is a shore line species that inhabits sandy and rocky pools and runs of small to large rivers, preferring clear water. It feeds on aquatic insects and larvae, zooplankton and some plant material. Spottail shiners spawn in June or July over sandy bottom and at the mouths of streams, where the ripe fish assemble in large aggregations. It is preyed upon by larger fish species, including walleye, sauger and pike (Nelson and Paetz, 1992; Scott and Crossman, 1998).

The white sucker is a bottom feeding fish that lives 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.

Yellow perch inhabit lakes, ponds, pools of creeks and rivers and is also found in brackish water and in salt lakes. Most commonly found in clear water near vegetation; tends to shoal near the shore during spring. It feeds on immature insects, larger invertebrates, fishes and fish eggs during the day. Yellow perch are preyed upon by fishes and birds. It spawns from February-July (Nelson and Paetz, 1992; Scott and Crossman, 1998).

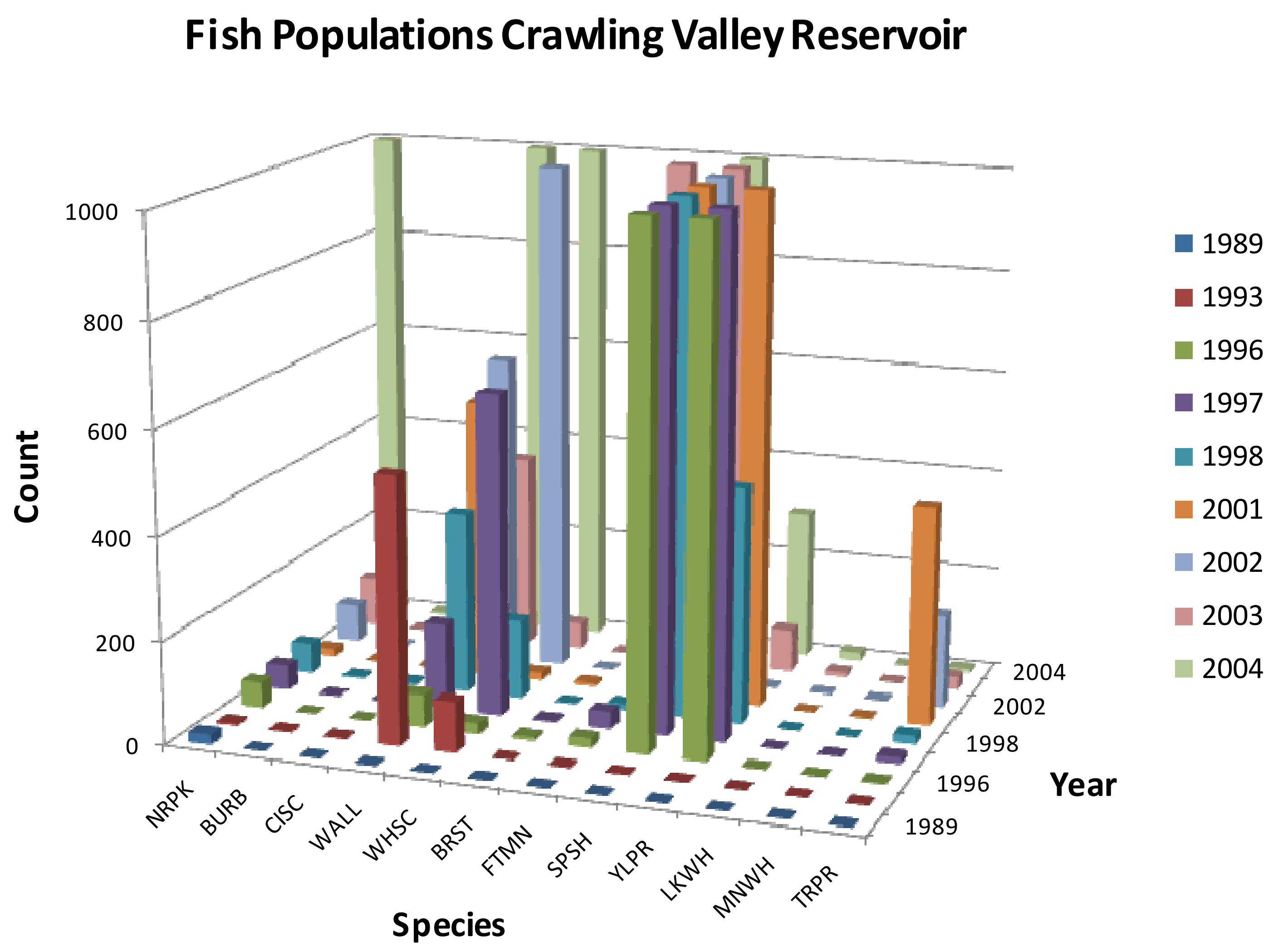


Figure 377. Fish populations in the Crawling Valley Reservoir from 1989-2004 (data from Alberta Sustainable Resource Development, 2008). The y-axis has been modified for better data representation. For full species names, please refer to Table 23.

4.14.5.3 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 Matzhiwin Creek subwatershed is covered by grassland (41%) and annual and perennial croplands/pastures (34% and 12%, respectively). The remaining land cover types cover < 5% individually (Figure 378, Table 153) (AAFC-PFRA, 2008).

Table 153. Land cover in the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008). The most prominent land cover types are highlighted.

Land cover type	Area (ha)	Proportion of subwatershed area (%)
Waterbodies	14,171	1.95
Exposed land	5,831	0.80
Developed land	4,242	0.58
Shrubland	1,145	0.16
Wetland	23,051	3.17
Grassland	298,505	41.08
Annual cropland	247,216	34.02
Perennial cropland/pastures	88,309	12.15
Coniferous forests	1,448	0.20
Deciduous forests	1,648	0.23
No data	41,122	5.66
Total	**726,689**	

There are four Ecologically Significant Areas in the Matzhiwin Creek subwatershed: Dinosaur, Jenner Springs, Lathom-San Francisco Lakes and Wintering Hills (Table 154). There are no nationally designated Ecologically Significant Areas in the subwatershed (Alberta Environmental Protection, 1997).

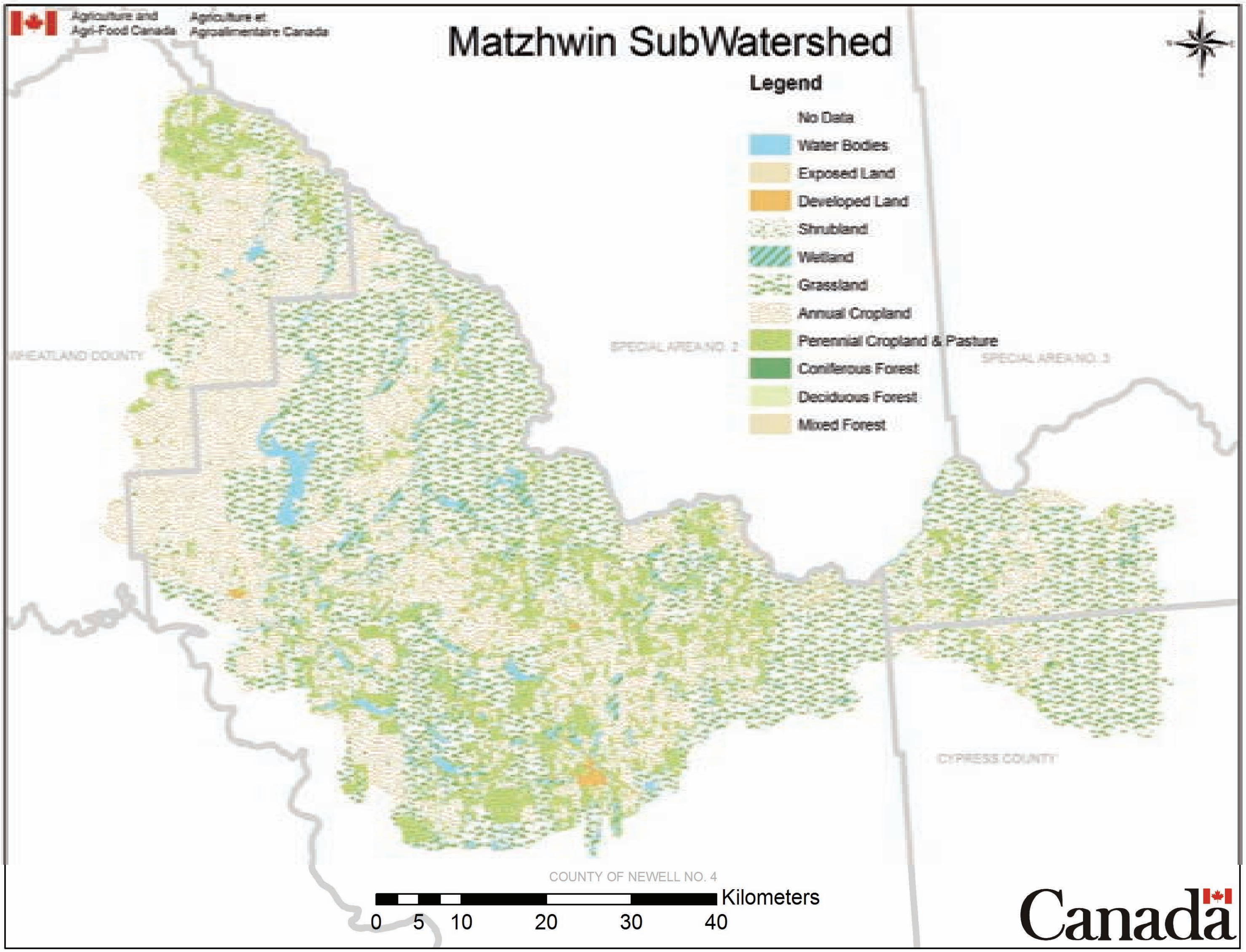


Figure 378. Land cover of the Matzhiwin Creek subwatershed (AAFC-PFRA, 2008).

Table 154. Ecologically Significant Areas in the Matzhiwin Creek subwatershed (Alberta Environmental Protection, 1997).

Ecologically Significant Area	Location	Area (ha)	Significance	Description
Dinosaur	Twp. 20-21, Rge. 11-13, W 4, County of Newell No. 4	22,886	Internationally	Much of the area is a World Heritage Site, noted for its paleontological, riparian and badland features, one of the most diverse river valley/badland complexes in the grasslands of Canada; extensive cottonwood, tall shrub and low shrub riparian habitats, some of which are ungrazed; diverse breeding bird habitat; key mule and white-tailed deer habitat; active great blue heron colony; uncommon birds including saw-whet owl; nesting area for COSEWIC endangered loggerhead shrikes and several rare birds of prey, including COSEWIC vulnerable ferruginous hawk as well as golden eagle and prairie falcon; rare plants, including annual lupine (*Lupinus pusillus*), nodding umbrella plant (*Eriogonum cernuum*), Powell's salt sage (*Atriplex powellii*) and runcinate-leaved rush-pink (*Stephanomeria runcinata*), the last three species are rare in Canada; locally important for breeding geese; hibernacula for bull snake and prairie rattlesnake; habitat for leopard frog, a rare species in Alberta
Jenner Springs	Twp. 21, Rge. 8, W 4, Special Area 2	962	Provincially	One of the most intact and extensive upland spring systems in the Dry Mixedgrass Subregion of Alberta, extensive springs at edge of alkali wetlands; diverse slightly saline spring-fed plant communities creating fen-like conditions with floating mats of organic material; surrounded by native mixed grassland; numerous plants which are rare or disjunct in the grassland region; healthy populations of northern leopard frog, a rare species in Alberta

Lathom-San Francisco Lakes and adjacent wetlands and uplands	Twp. 19-20, Rge. 15-17, W 4, County of Newell No. 4	11,889	Provincially	Open water and extensive marshes associated with irrigation developments; provincially significant for moulting ducks; waterfowl staging and production area, mainly for puddle ducks, but also for diving ducks and grebes; diverse marsh and shore bird populations; locally important for breeding geese; abundant Richardson ground squirrel populations; feeding area for American white pelicans and rare birds of prey, including prairie falcons and threatened ferruginous hawk
Wintering Hills	Twp. 18, Rge. 26, W 4, Wheatland County	10,993	Provincially	Remnant Tertiary gravel cap, rare geological feature in Alberta, hills rise about 120 m above the surrounding plain; disjunct aspen communities; important prehistoric sites; fossil vertebrate site in Cretaceous Edmonton Formation, where the rare carnivorous dinosaur, *Dromaeosauras*, was unearthed; critical white-tailed deer habitat in disjunct aspen woodland

4.14.5.4 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 Matzhiwin Creek subwatershed is home to four endangered species (burrowing owl, *A. cunicularia*; piping plover, *C. melodus circumcinctus*; sage thrasher, *O. montanus*; swift fox, *V. velox*), three threatened species (slender mouse-ear-cress, *H. virgata*; loggerhead shrike, *L. ludovicianus excubitorides*; Sprague's pipit, *A. spragueii*) and four species of special concern (great plains toad, *B. cognatus* ; long-billed curlew, *N. americanus*; monarch butterfly, *D. plexippus*; yellow rail, *C. noveboracensis*). Detailed treaties of these species can be found in section 3.1.3.7.

4.14.6 Subwatershed Assessment

The Matzhiwin Creek subwatershed lies in the Northern Fescue, Dry Mixedgrass and Mixedgrass Subregions and is characterized by low to medium livestock and agricultural intensities relative to the Alberta average. Its 25 feedlots are in the vicinity of urban centres, including the City of Brooks, the Town of Bassano and several villages and hamlets. Resource exploration and extraction have contributed to a complex network of linear developments (primarily roads) and the establishment of 18,974 wells (primarily natural gas wells). Despite these land use practices, no riparian health assessments have been conducted on any waterbody. While the water quality in Crawling Valley Reservoir has improved substantially since its construction, the overall water quality in streams and creeks throughout the subwatershed is poor and characterized by TP and TN concentrations that frequently exceed CCME PAL guidelines. Concomitantly, total and fecal coliform bacterial concentrations frequently exceed CCME Agriculture/Irrigation guidelines. No parasite and pesticide data were located for any waterbody in the subwatershed. A total of 1,208 water diversion licenses have been issued in the Matzhiwin Creek subwatershed, permitting the diversion of 3.23 million m^3 of water annually. Most of this water is used for irrigation and agricultural activities. Water discharge rates of Matzhiwin and Onetree Creeks do not exceed 5 m^3/sec following the spring freshet, and the majority of the subwatershed is a groundwater recharge area and does not contribute to the drainage of the land. No biodiversity assessment data were located for the grassland and annual cropland-dominated subwatershed, although spottail shiner, walleye, white sucker and yellow perch are the most frequently caught fish in Crawling Valley Reservoir and four endangered species, three threatened species and four species of special concern are known to occur in the 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 Matzhiwin Creek subwatershed receives a rating of “fair” for the condition indicators and a rating of “medium” for the risk indicators (Tables 155, 156). Overall, this subwatershed receives a ranking of “B”. 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) bacterial 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, (2) 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 and (3) the high oil/gas well density, which represents a substantial risk to aquatic resources and habitats.

Table 155. Condition and risk indicator summary for the Matzhiwin Creek subwatershed. Gray logos indicate data gaps.

Condition Indicators

Risk Indicators

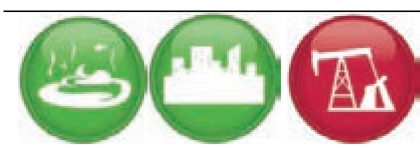


Table 156. Condition and risk assessments of the Matzhiwin Creek subwatershed. Indicators with a "poor" or "high" ranking are highlighted.

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

