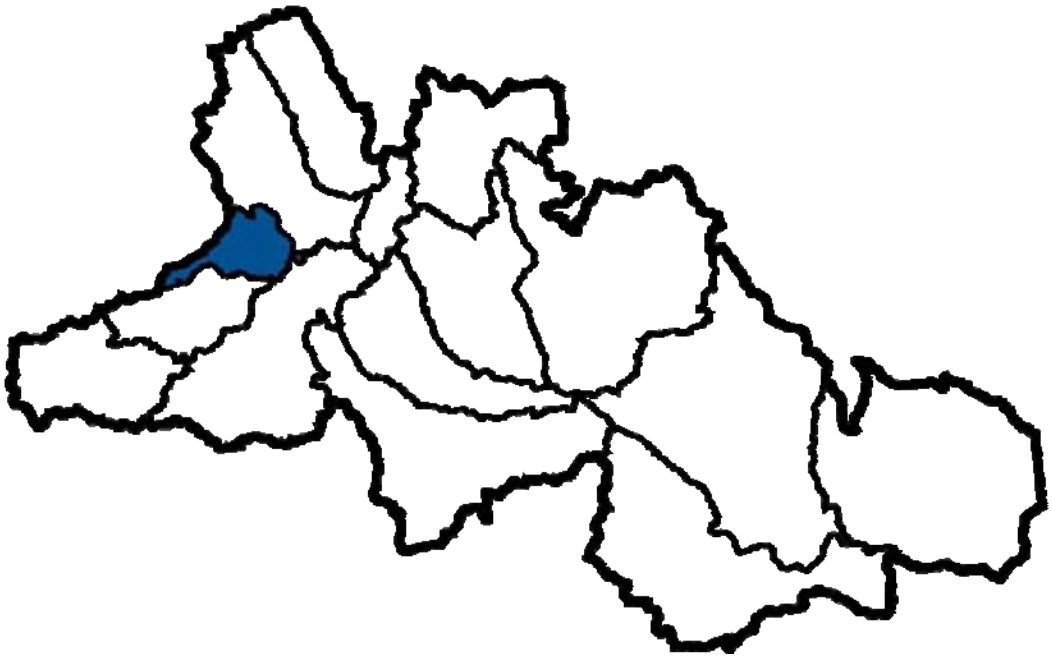
Raven Subwatershed



Red Deer River Watershed Alliance

State of the Watershed

4.3 Raven River Subwatershed

4.3.1 Watershed Characteristics

The Raven River subwatershed encompasses about 111,337 ha and is located in the Counties of Clearwater and Red Deer (Figure 91).

The Raven River subwatershed is located in the upper reach of the Red Deer River north of Sundre. The subwatershed lies in the Upper and Lower Foothills and Dry Mixedwood Subregions (Figure 92). The Upper Foothills Subregion occurs on strongly rolling topography along the eastern edge of the Rocky Mountains with an elevation limit of about 1,500 m. Upland forests are nearly all coniferous and dominated by white spruce (*P. glauca*), black spruce (*P. mariana*), lodgepole pine (*P. contorta*) and subalpine fir (*A. lasiocarpa*). 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 (Heritage Community Foundation, 2008).

The geology of the Raven River subwatershed is dominated by the Paskapoo Formation in addition to less prominent geologic features of the Coalspur and Brazeau Formations. These formations formed in the Paleocene epoch (56-65 million years ago) and in the Upper Cretaceous period (65-100 million years ago). The youngest of the formations from the Paleocene, Paskapoo, consists of diverse sandstones, siltstones/mudstones and minor shale deposits. The Brazeau Formation (Upper Cretaceous) consists of shales, sandstone, mudstone, ironstone, some tuff and thin coal deposits (Alberta Geological Survey, 2006).

The climate of the Raven River subwatershed is subhumid-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 (Environment Canada, 2006).

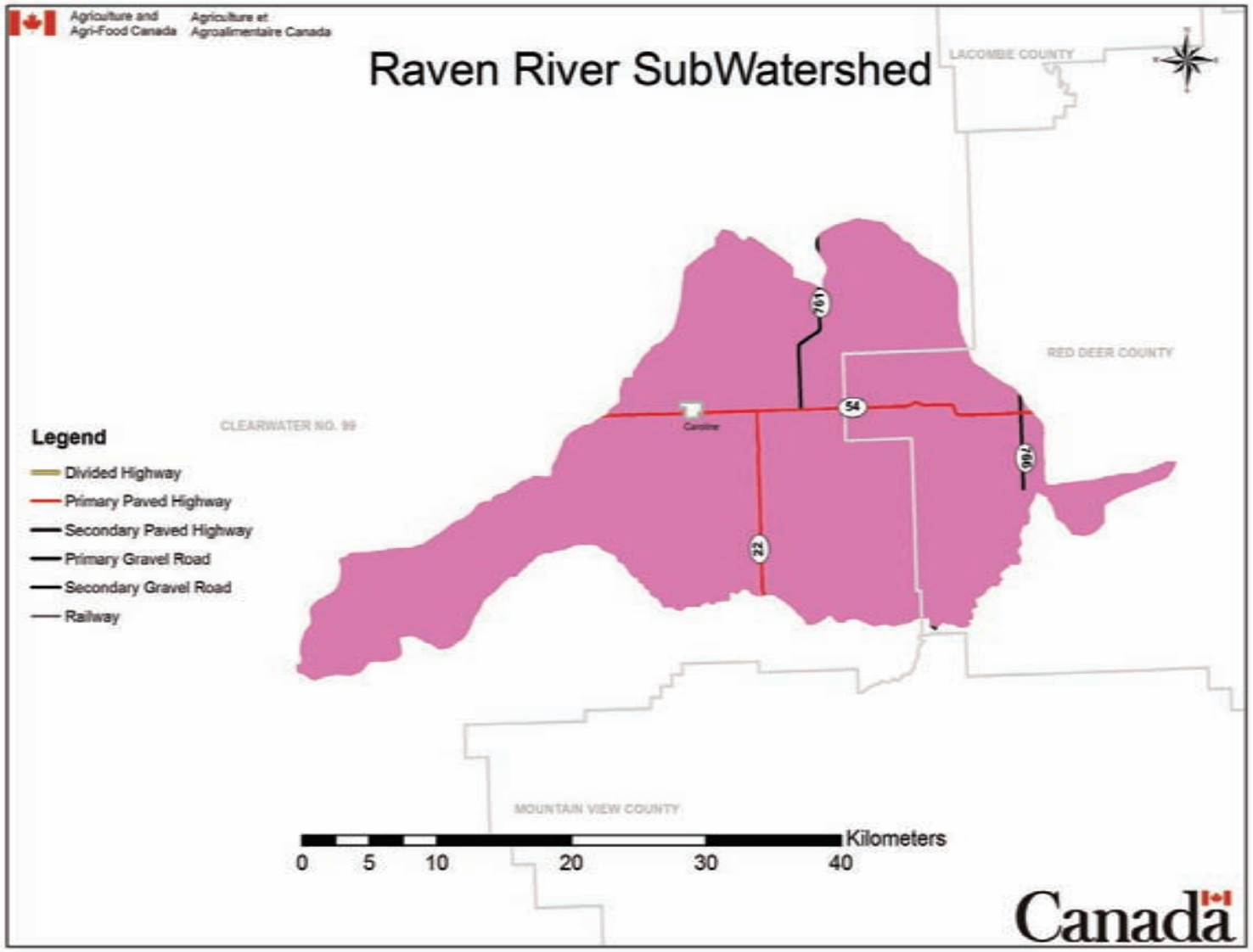


Figure 91. Location of the Raven River subwatershed (AAFC-PFRA, 2008).

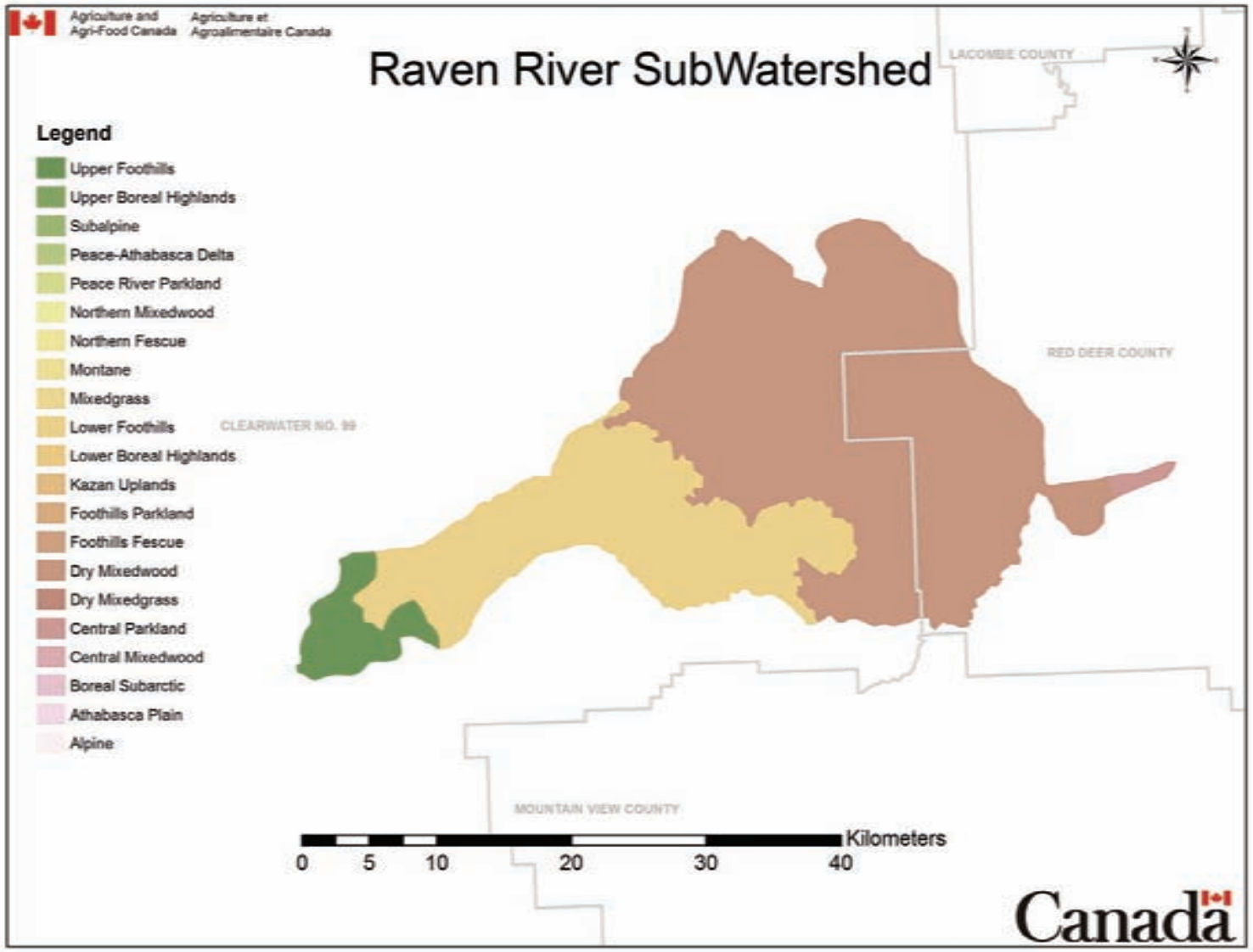


Figure 92. Natural subregions of the Raven River subwatershed (AAFC-PFRA, 2008).

4.3.2 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.

4.3.2.1 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 1,123 ha of wetlands (1.01% of the total subwatershed area) in the Raven River 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 in the subwatershed, marshes and shallow open water wetlands are likely present. In addition, peatlands (bogs and fens) may be common (Heritage Community Foundation, 2008). There are no data on wetland loss in the Raven River subwatershed.

4.3.2.2 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 been assessed in the Raven River subwatershed by Cows and Fish and the Alberta Conservation Association in 2008; however, the data were unavailable for inclusion in this report.

4.3.2.3 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 two feedlots/intensive livestock operations in the Raven River subwatershed (swine and dairy cows) (Figure 93) (AAFC-PFRA, 2008), which is among the lowest density in the entire Red Deer River watershed.

Cattle density ranges from 0-0.20 cattle/ha in the south-western area of the subwatershed to 0.41-0.60 cattle/ha in the remainder of the subwatershed (Figure 94) (AAFC-PFRA, 2008). Cattle and all other livestock operations produce 2.6-5.0 tonnes manure/ha throughout the subwatershed (Figure 95) (AAFC-PFRA, 2008), which is considered low relative to the remainder of the Red Deer River watershed.

Agricultural intensity, expressed as the percent land cover used as croplands, in the Raven River subwatershed is low in the western areas (0-20%) and generally increases to 20-40% in the eastern areas. In the far east of the subwatershed, agricultural intensity peaks at 40-80%, particularly near Gleniffer Lake Reservoir (Figure 96) (AAFC-PFRA, 2008).

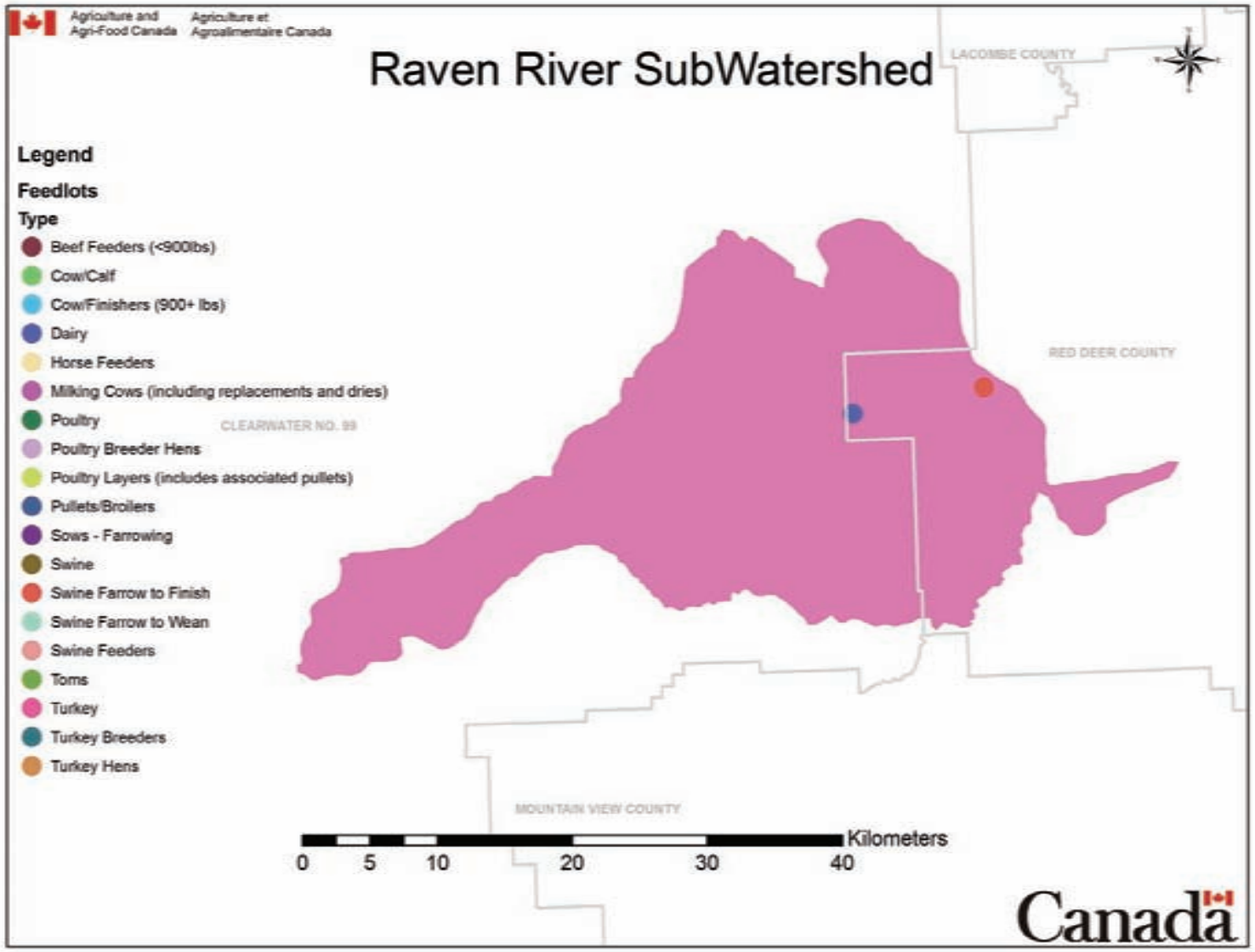


Figure 93. Feedlots and intensive livestock operations in the Raven River subwatershed (AAFC-PFRA, 2008).

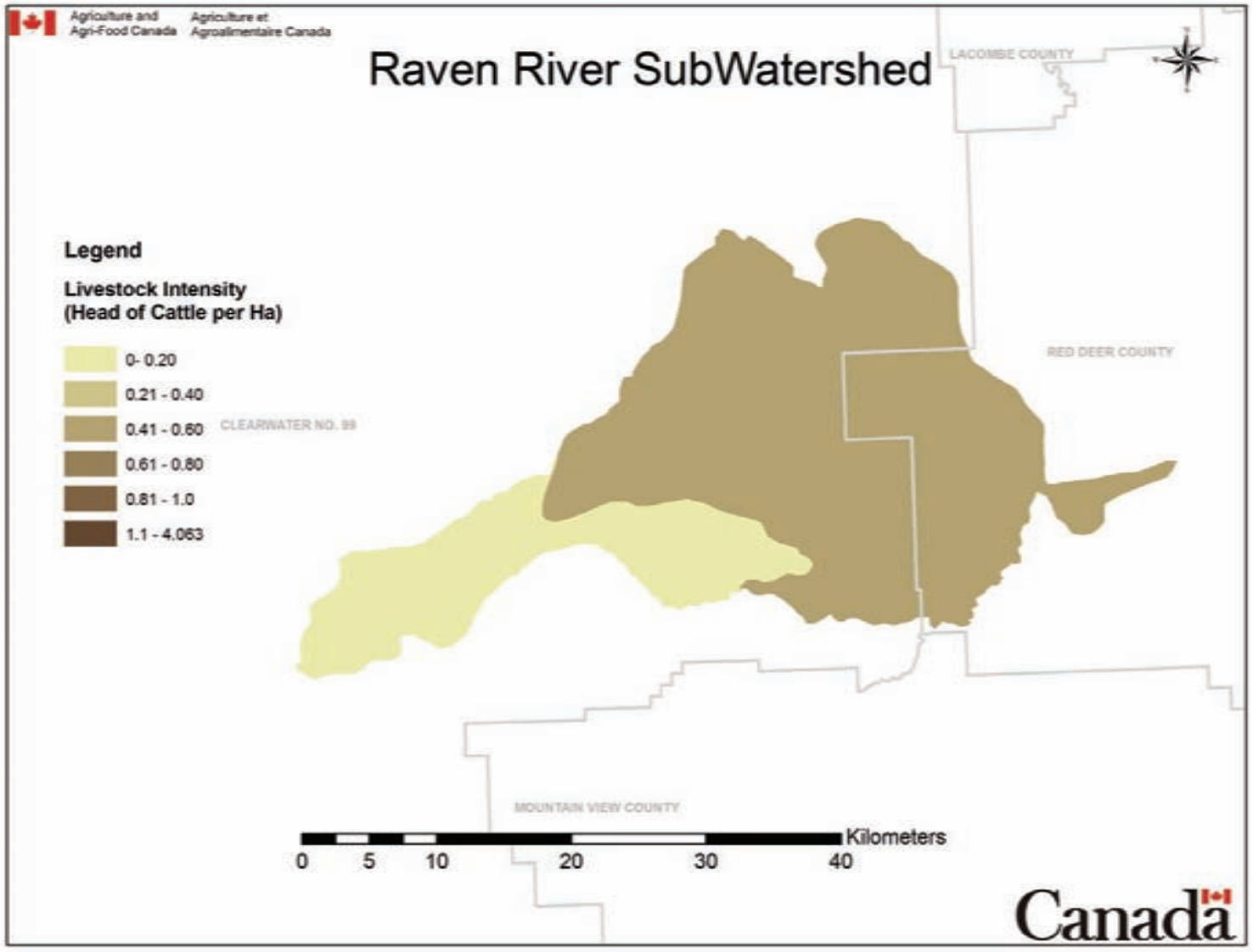


Figure 94. Cattle density (cattle/ha) in the Raven River subwatershed (AAFC-PFRA, 2008).

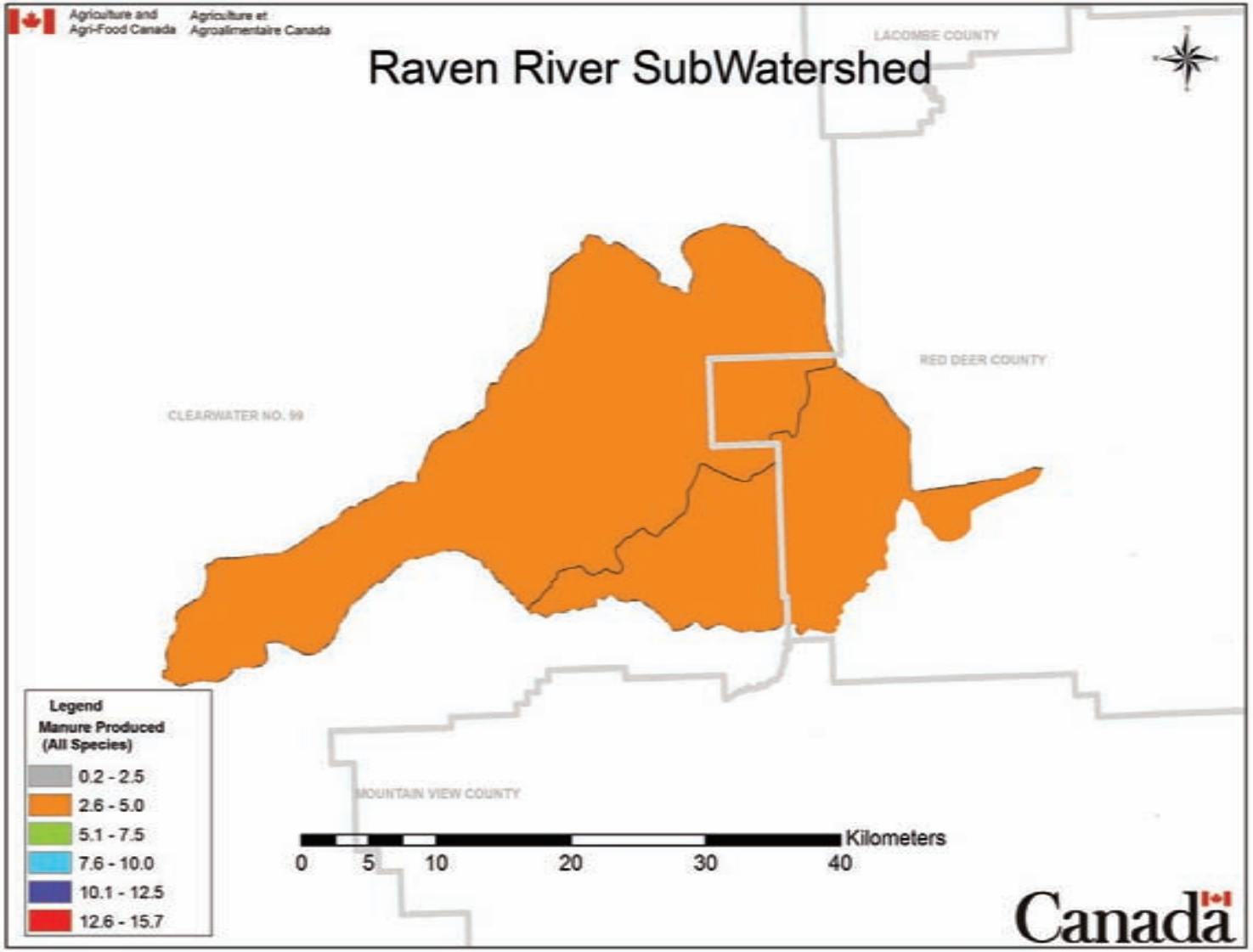


Figure 95. Manure production (tonnes/ha) in the Raven River subwatershed (AAFC-PFRA, 2008).

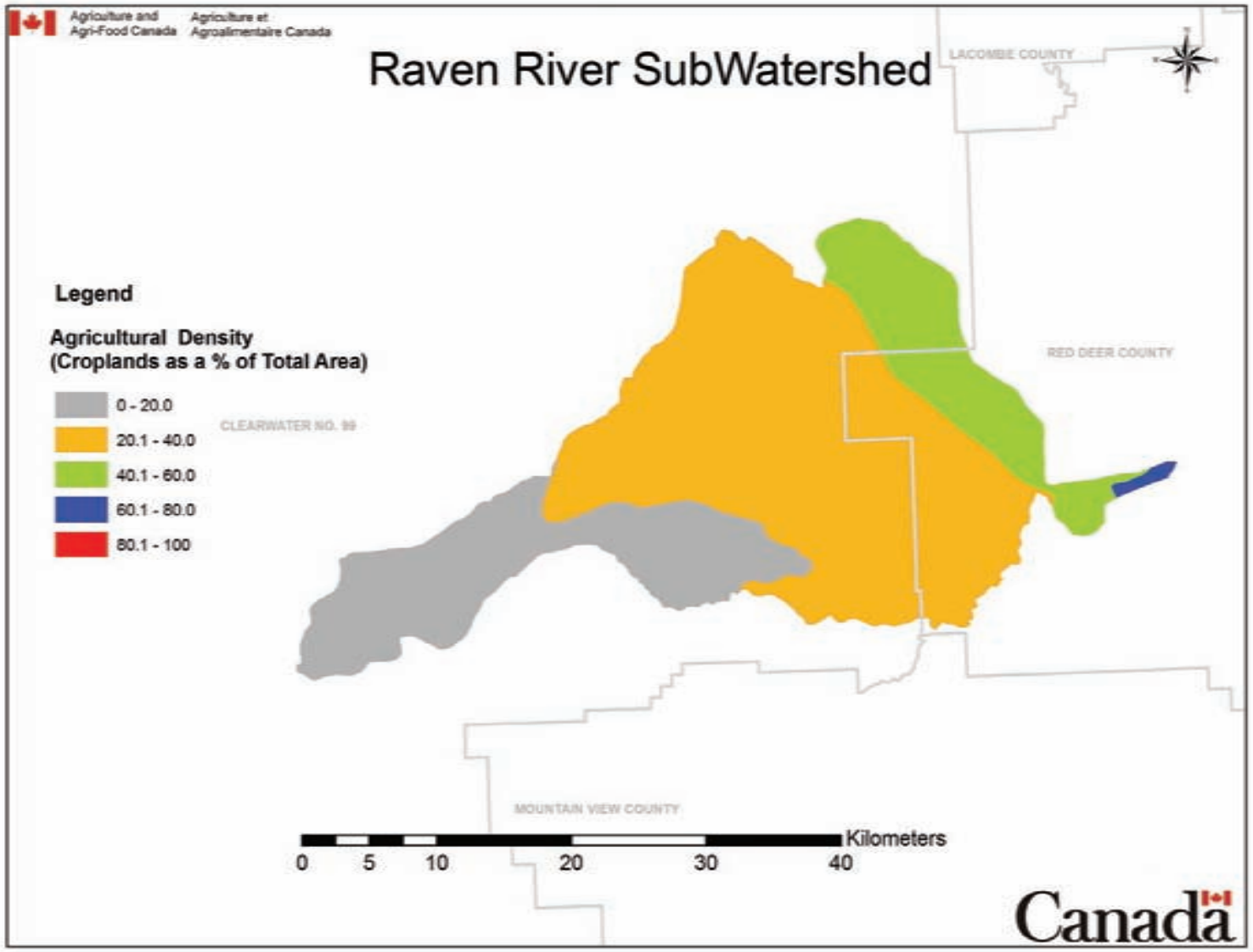


Figure 96. Agricultural intensity (% cropland) in the Raven River subwatershed (AAFC-PFRA, 2008).

4.3.2.4 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 subwatershed include the Village of Caroline and the hamlets of Butte, Crammond, Kevisville, Raven and Stauffer (Government of Canada, 2006). There are four recreational facilities in the subwatershed, three Provincial Recreation Areas (PRA) and one Provincial Natural Area (PNA) (Table 45) (Alberta Tourism, Parks and Recreation, 2008b).

Table 45. Recreational facilities in the Raven River subwatershed (Alberta Tourism, Parks and Recreation, 2008b).

Facility	Characteristics
Butcher Creek PNA	• 205 ha • day use sites
Dickson Dam-Dickson Point PRA	• 40.38 ha on Gleniffer Lake Reservoir • 25 unit campgrounds
Dickson Dam-North Valley PRA	• 21.02 ha on Gleniffer Lake Reservoir • day use sites
Raven PRA	• 1.11 ha on the Raven River • 8 unit campgrounds

Note: 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 97). For those years with available data, the average number of visitors per year was 618 in Dickson Dam-Dickson Point PRA and 114 in Raven PRA. An average 546 visitors have used these two recreation facilities annually from 1994-2003 (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).

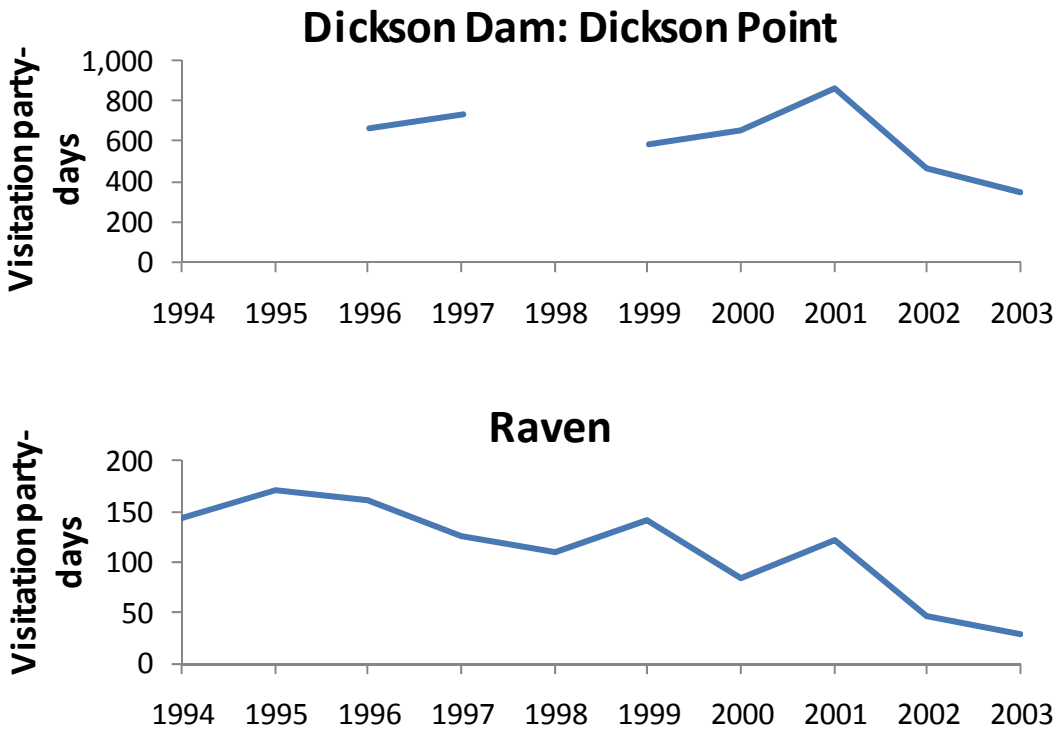


Figure 97. Visitation statistics for two recreation facilities in the Raven River subwatershed (Alberta Tourism, Parks and Recreation, 2008b).

4.3.2.5 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 Raven River subwatershed are urban and rural roads, which have a total length of 1,345 km and cover 21.52 km^2 of the subwatershed's landbase. Other major linear developments include pipelines and cutlines/trails (Table 46). In total, all linear developments cover an area of 50.9 km^2, or 4.6% of the total area of the subwatershed (Figure 98) (AAFC-PFRA, 2008).

In addition to linear developments, the Raven River subwatershed has 57 bridges that cross waterbodies, mostly streams and creeks, or culverts that connect waterbodies (Figure 99) (AAFC-PFRA, 2008). These are primarily associated with the Raven River and the North Raven River. The majority of pipeline crossings in the Raven River subwatershed are located in the south-central area of the subwatershed south of the Raven River. There are no pipeline crossings over any waterbodies in the headwaters of the Raven River (Figure 100) (AAFC-PFRA, 2008).

Table 46. Linear developments in the Raven River 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	1,345	16	21.52	42.3
Cutlines/trails	1,770	6	10.62	20.9
Pipelines	1,050	15	15.75	31.0
Powerlines	100	30	3.00	5.9
Railways	0	15	0	0
Total	**4,265**		**50.89**	

4.3.2.6 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 Raven River subwatershed has an average well density of 1.15 wells/km^2. About 64% of all wells are active, with the majority being oil wells, followed by gas and unspecified wells (Table 47). Wells are distributed throughout the entire subwatershed; however, there are fewer wells in the headwaters of the Raven River (Figure 101) (AAFC-PFRA, 2008).

Table 47. Number of known active and abandoned oil, gas, water and other wells in the Raven River subwatershed (AAFC-PFRA, 2008).

Well type	Quantity
Wells – active *	204
Wells – abandoned *	230
Total	**434**
Gas wells – active	324
Gas wells – abandoned	58
Total	**382**
Oil wells – active	285
Oil wells – abandoned	154
Total	**439**
Water wells – active	8
Water wells – abandoned	14
Total	**22**
Total active wells in subwatershed	**821**
Total abandoned wells in subwatershed	**456**
Total wells in subwatershed	**1,277**

* 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.

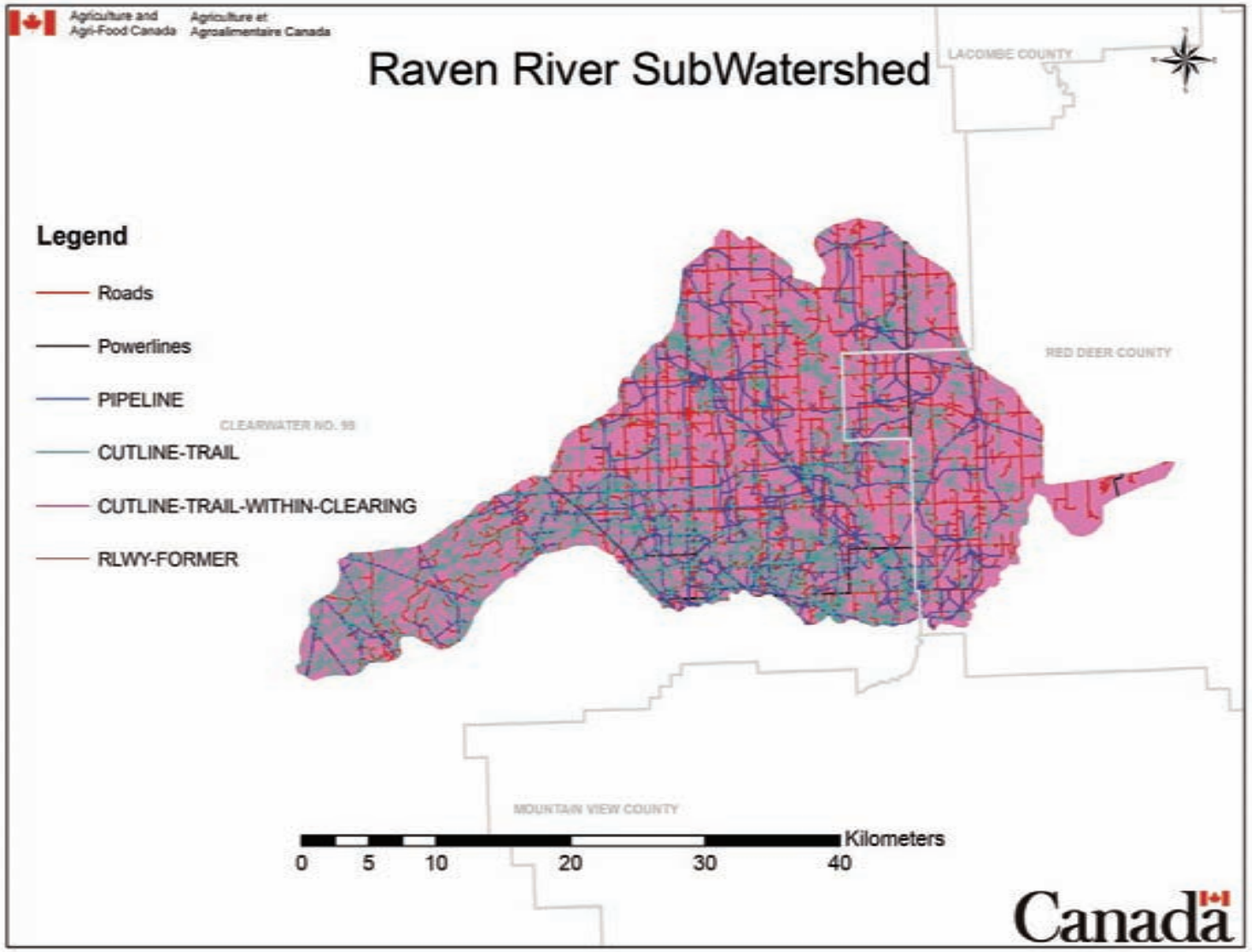


Figure 98. Linear developments in the Raven River subwatershed (AAFC-PFRA, 2008).

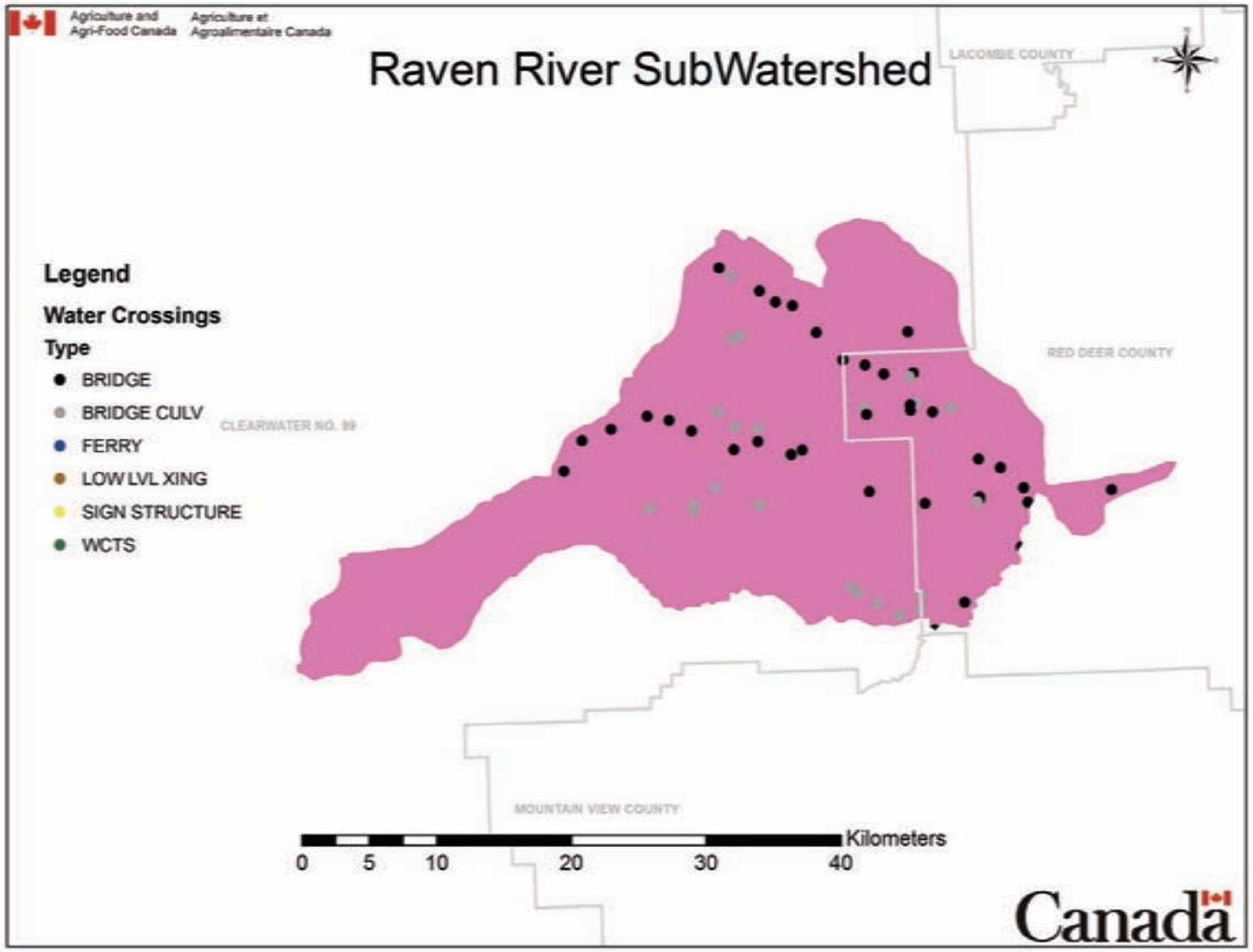


Figure 99. Waterbody crossings in the Raven River subwatershed (AAFC-PFRA, 2008).

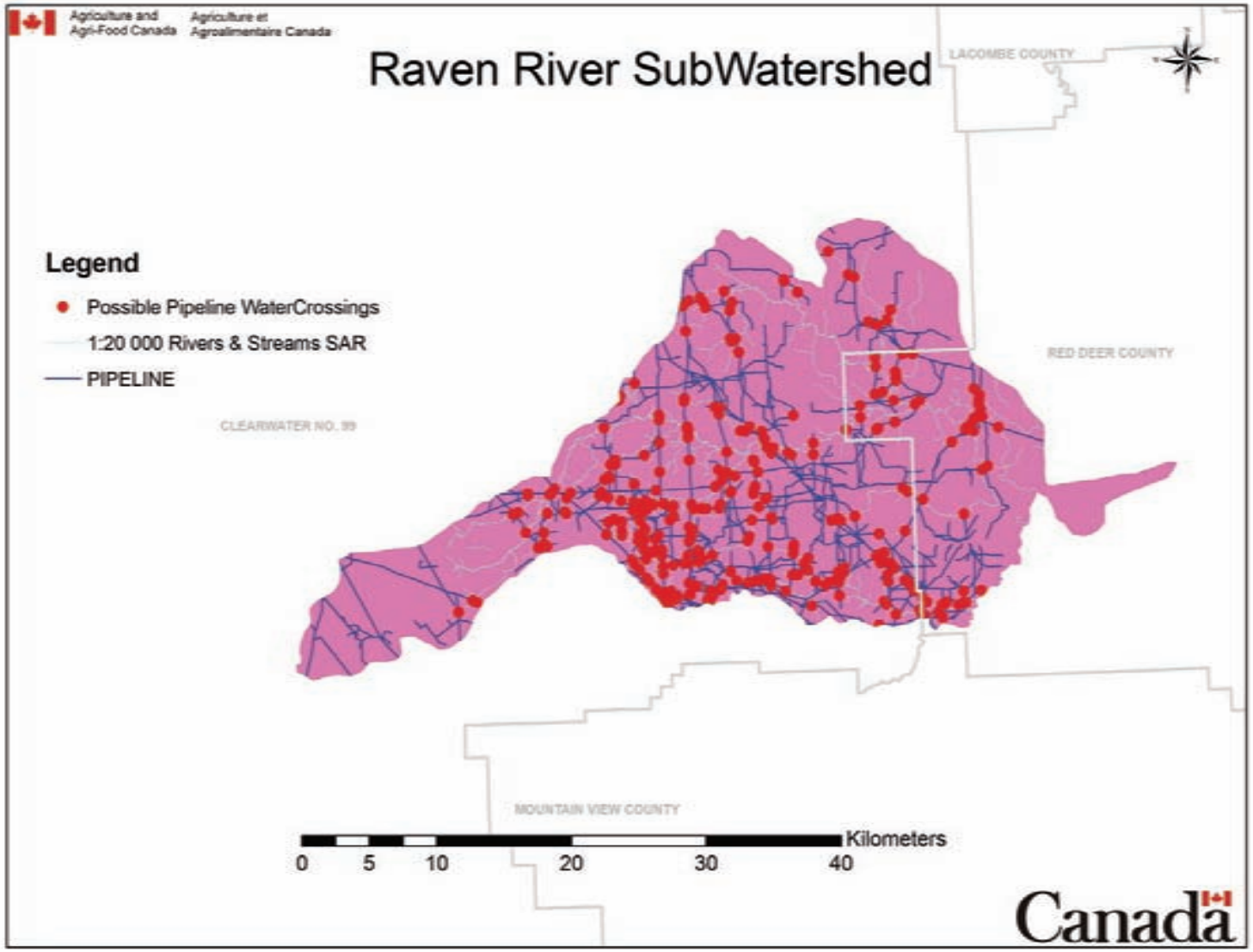


Figure 100. Pipeline crossings over waterbodies in the Raven River subwatershed (AAFC-PFRA, 2008).

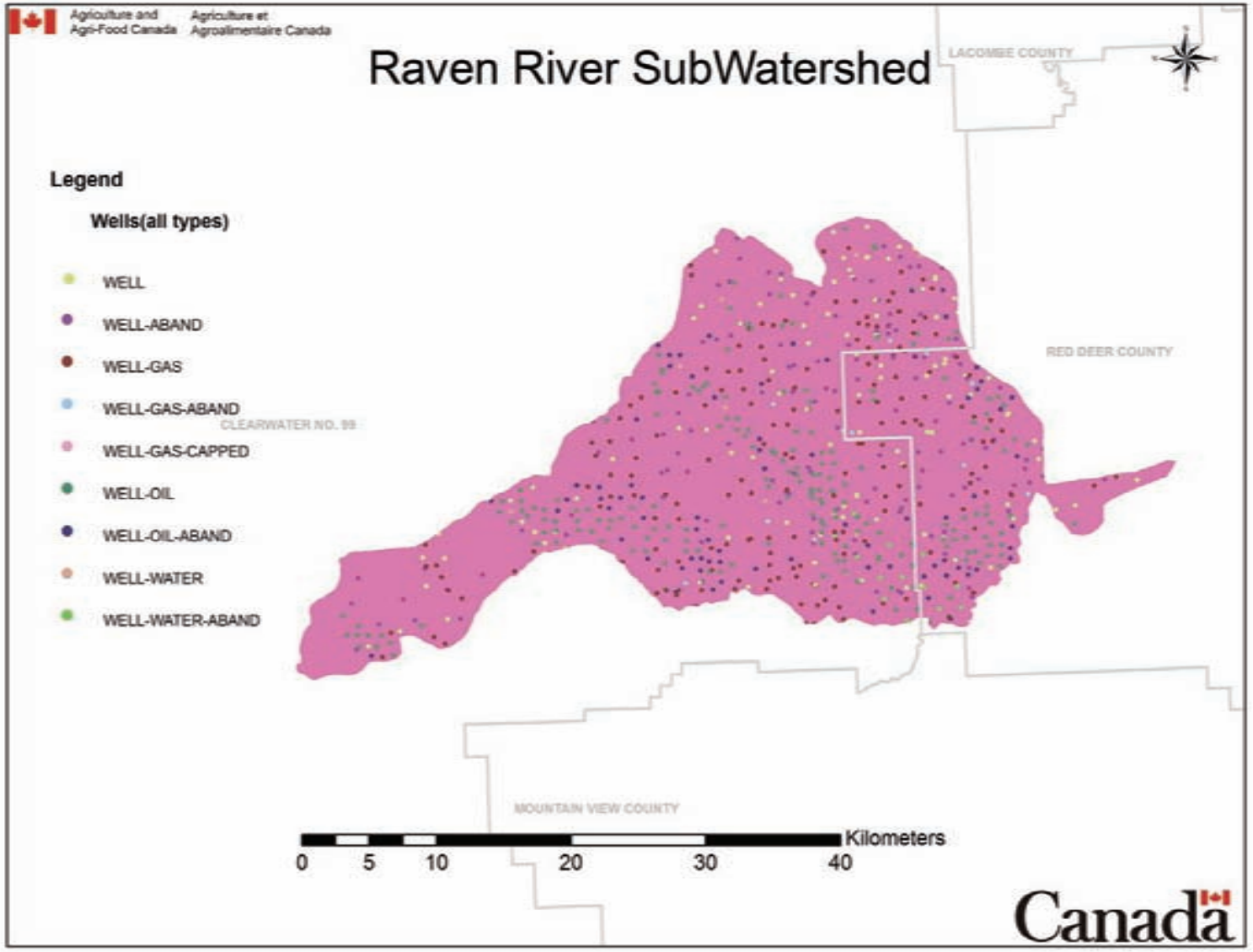


Figure 101. Known active and abandoned oil, gas, water and other wells in the Raven River subwatershed (AAFC-PFRA, 2008).

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).

4.3.3 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.

4.3.3.1 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.

Water quality has been assessed only once in the Raven River subwatershed (in the North Raven River in 1991). At that time, none of the water quality parameters examined exceeded ASWQ and/or CCME PAL guidelines; however, sample analyses were restricted to a small number of parameters (Table 48).

Table 48. Water quality in the North Raven River. Data are values from a single sample collected September 1991 (data from Alberta Environment, 2008). n = sample size. All concentrations in mg/L unless otherwise noted.

Parameter *	Mean	n
TP	0.028	1
TDP	---	---
TN	0.560	1
NO_3^--NO_2^-	0.240	1
NH_3	0.028	1
DO	---	---
Chl. *a* (µg/L)	---	---
pH	8.1	1
Specific Conductivity (µS/cm)	534	1
TDS	309	1

* Variable abbreviations as in Table 10.

4.3.3.2 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* are 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.

Bacterial data were not located for any waterbody in the Raven River subwatershed.

4.3.3.3 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 Raven River subwatershed.

4.3.3.4 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 Raven River subwatershed.

4.3.3.5 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.

There are no waste water treatment facilities or stormwater outfalls located in the Raven River subwatershed. At least 21 upstream oil/gas facilities, one oil/gas refining/storage facility and one power generating facility have released pollutants continuously or sporadically into the air since 2002. These pollutants include sulphur dioxide (SO_2), nitrous oxide (N_2O), carbon monoxide (CO) and particulate matter < 10 µm in size. A hydrocarbon, 1,2,4-thrimethylbenzene, was released from the power generating facility while storing or handling in 2002 (NPRI, 2008). No pollutants were released directly into aquatic ecosystems according to the National Pollution Release Inventory. The Village of Caroline has an outfall into the Raven River; however, there are no data on release quantities or quality.

4.3.4 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.

4.3.4.1 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 length of all water courses in the Raven River subwatershed total about 450 km in length (Figure 102) (AAFC-PFRA, 2008). The major streams in the subwatershed include the Raven River, North Raven River (a.k.a. Stauffer Creek), Beaver Creek, Crooked Creek and Schrader Creek. In addition, there are numerous small creeks and sloughs in the subwatershed (Government of Canada, 2006).

Alberta Environment has been monitoring water discharge rates below the confluence of the Raven River and the North Raven River (real-time active, 05CB004). There is one discontinued water discharge monitoring site in the Red Deer River below the confluence with Schrader Creek (05CB003) (Government of Alberta, 2008c). In the Raven River, average water discharge rates are very similar from April-October, ranging from 1-3 m^3/sec. Historical rates deviate from this range by maximally 1 m^3/sec. Water discharge rates were well above historical levels in the spring and early summer 2008, when they exceeded 30 m^3/sec (Figures 103) (Government of Alberta, 2008c).

One major dam is located in the Raven River subwatershed (Figure 104). It is Beaver Creek Dam on Beaver Creek, a tributary of the Raven River, south of Caroline. In addition, there are numerous smaller water infrastructures in the subwatershed, e.g., small dams, sluices, weirs and dykes, which control water flow.

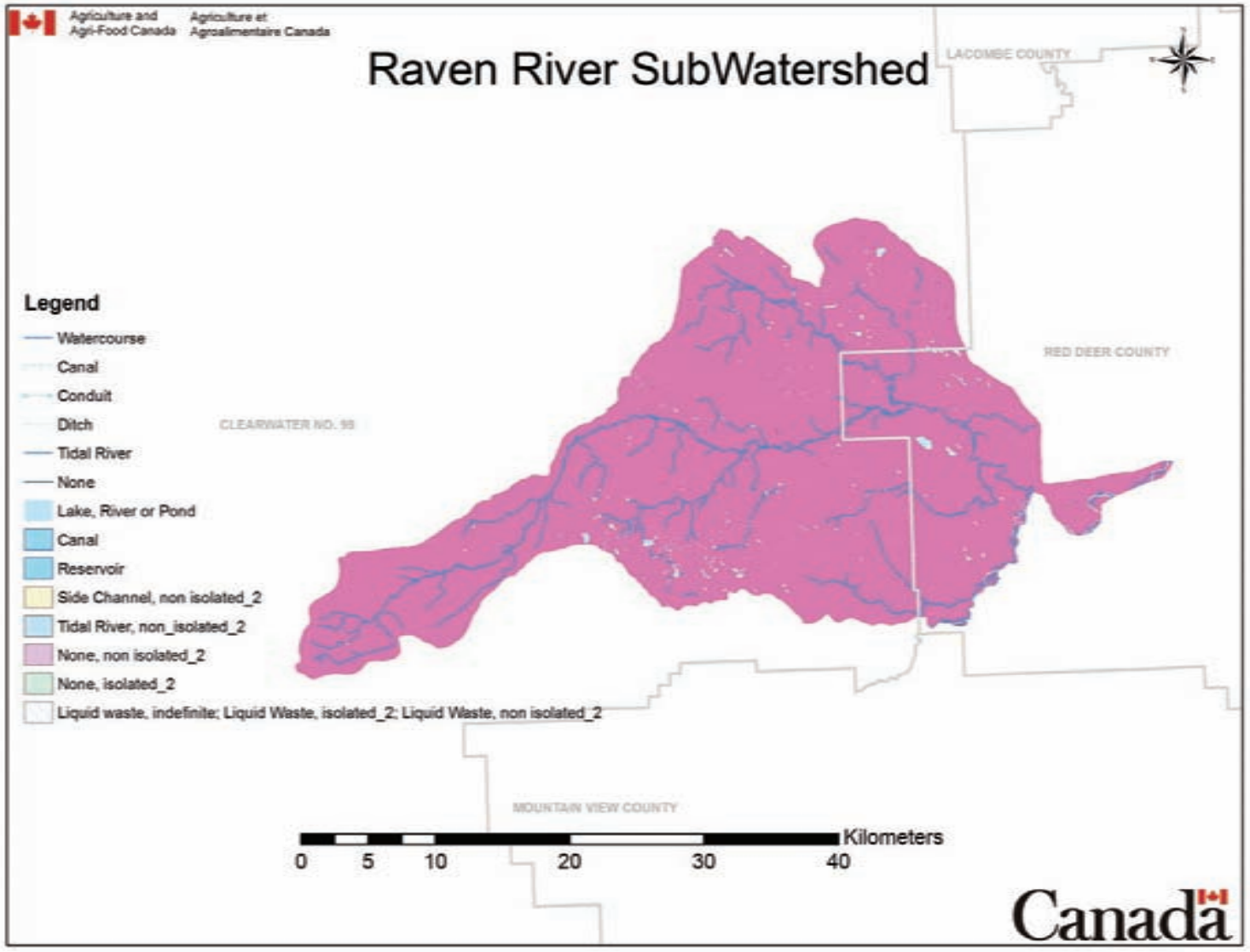


Figure 102. Waterbodies in the Raven River subwatershed (AAFC-PFRA, 2008).

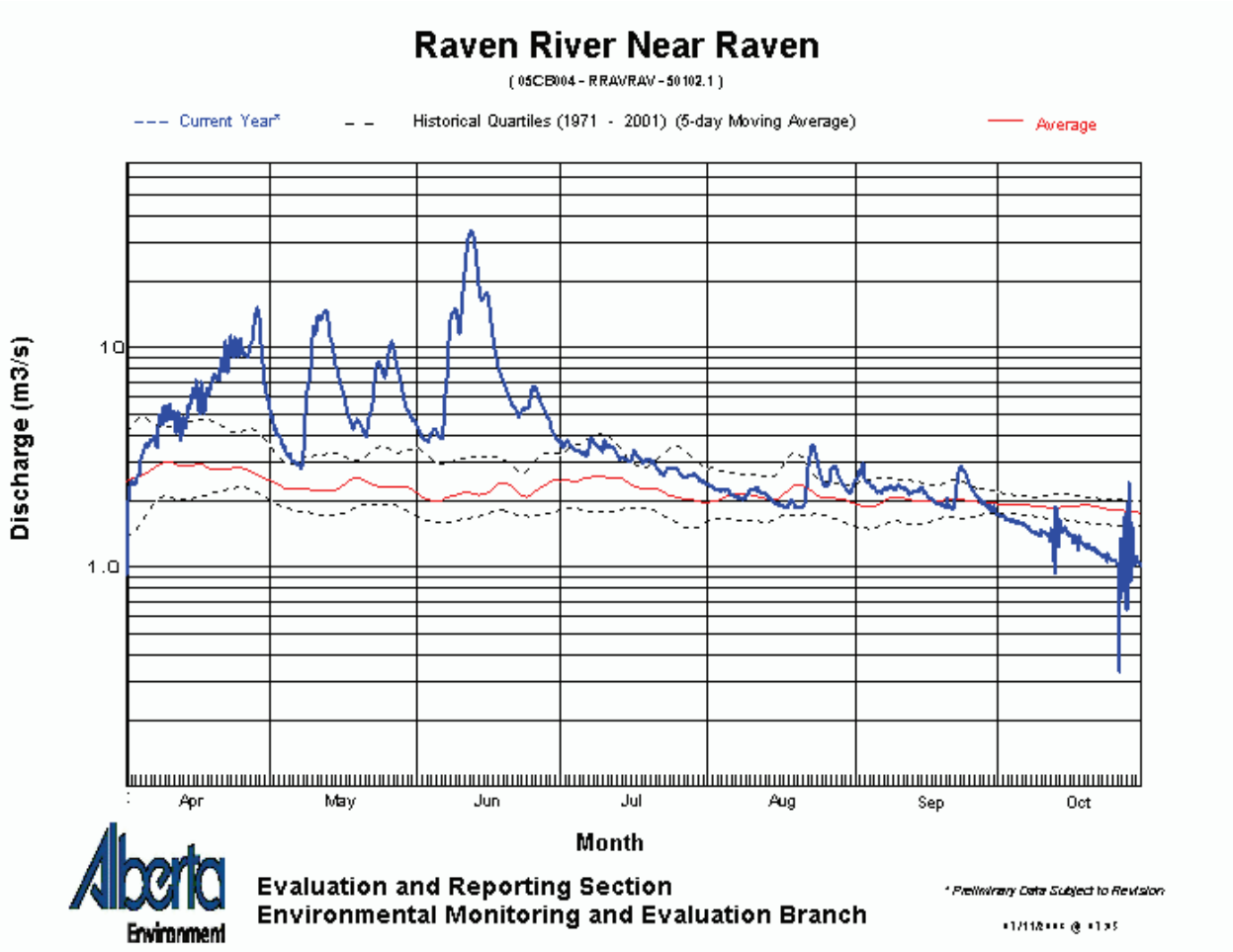


Figure 103. Discharge rates of the Raven River near Raven (Government of Alberta, 2008c). "Current year" indicates water discharge rates in 2008.

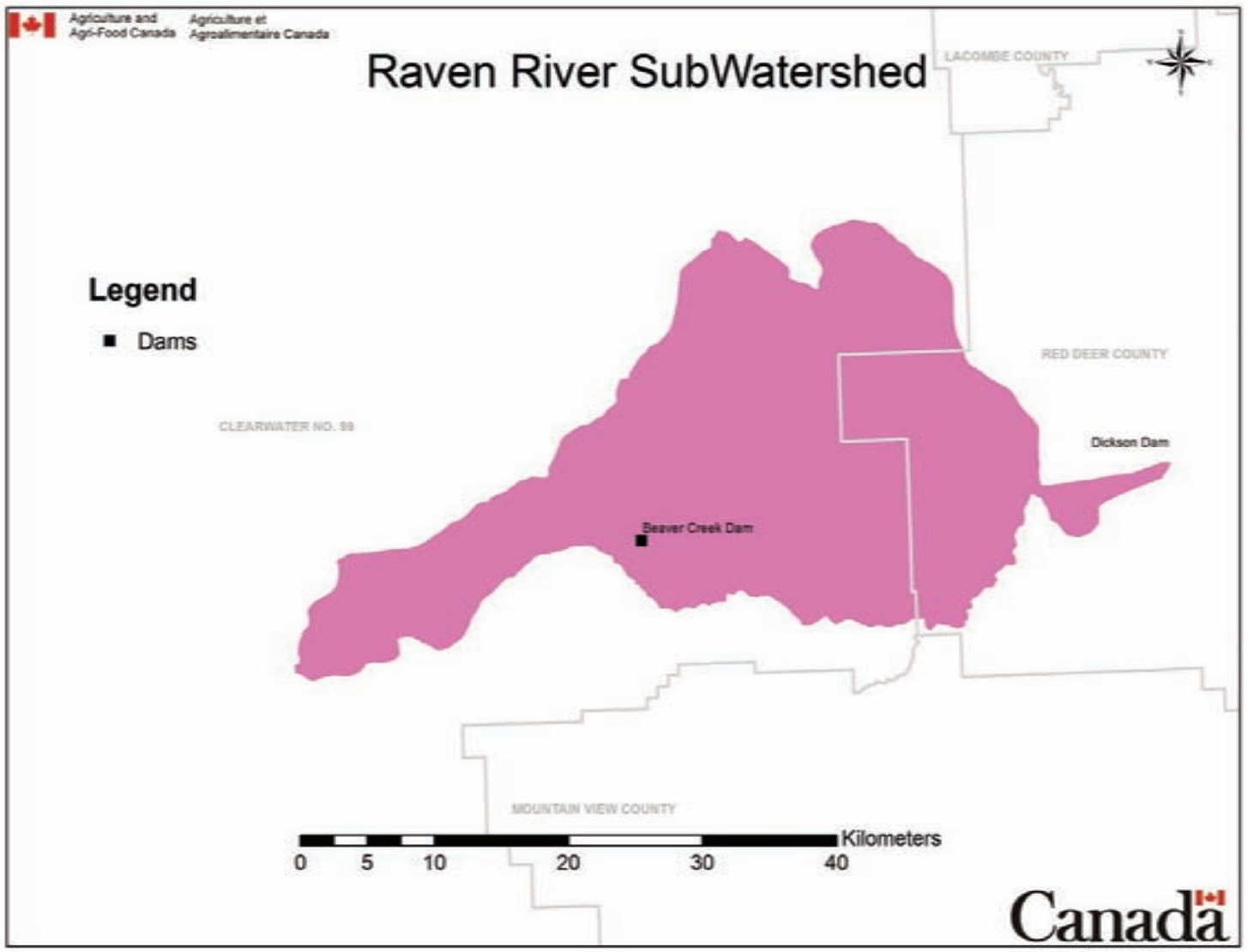


Figure 104. Major dams in the Raven River subwatershed (AAFC-PFRA, 2008).

4.3.4.2 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 Raven River subwatershed.

4.3.4.3 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 Raven River subwatershed, 4,152 ha (or 4.4% of the total area of the subwatershed) of land do not contribute to the drainage of the subwatershed (Figure 105), owing to the steep slopes prevalent throughout the majority of the subwatershed (Figure 106). The areas that do not contribute to the drainage in the subwatershed are located east of Burnstick Lake, between Spruce View and Stauffer and southeast of the confluence of the Raven River and the North Raven River (AAFC-PFRA, 2008).

The Raven River has had several high streamflow advisories since 2001 in response to snow melt early in the year and high precipitation events throughout the summer months (May-September) (Table 49) (Alberta Environment, 2008c).

Table 49. Advisories and warnings in the Raven River subwatershed since 2001 (Alberta Environment, 2008c).

Advisory	Waterbody	Date
High streamflow	Raven River	June 17, 2005 June 23, 2005 August 23, 2005 September 10, 2005 June 15, 2006 September 15, 2006 May 01, 2007

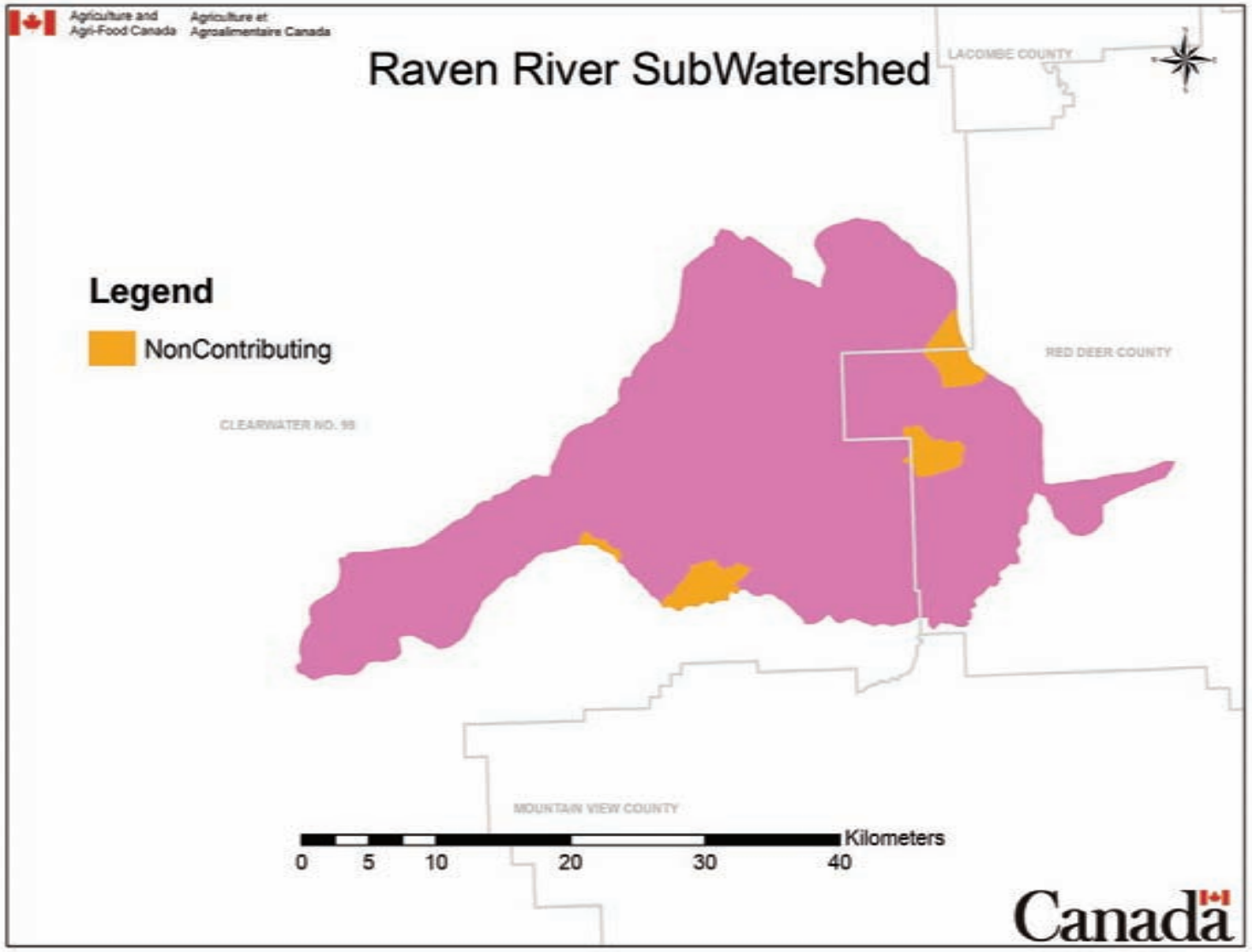


Figure 105. Non-contributing drainage area in the Raven River subwatershed (AAFC-PFRA, 2008).

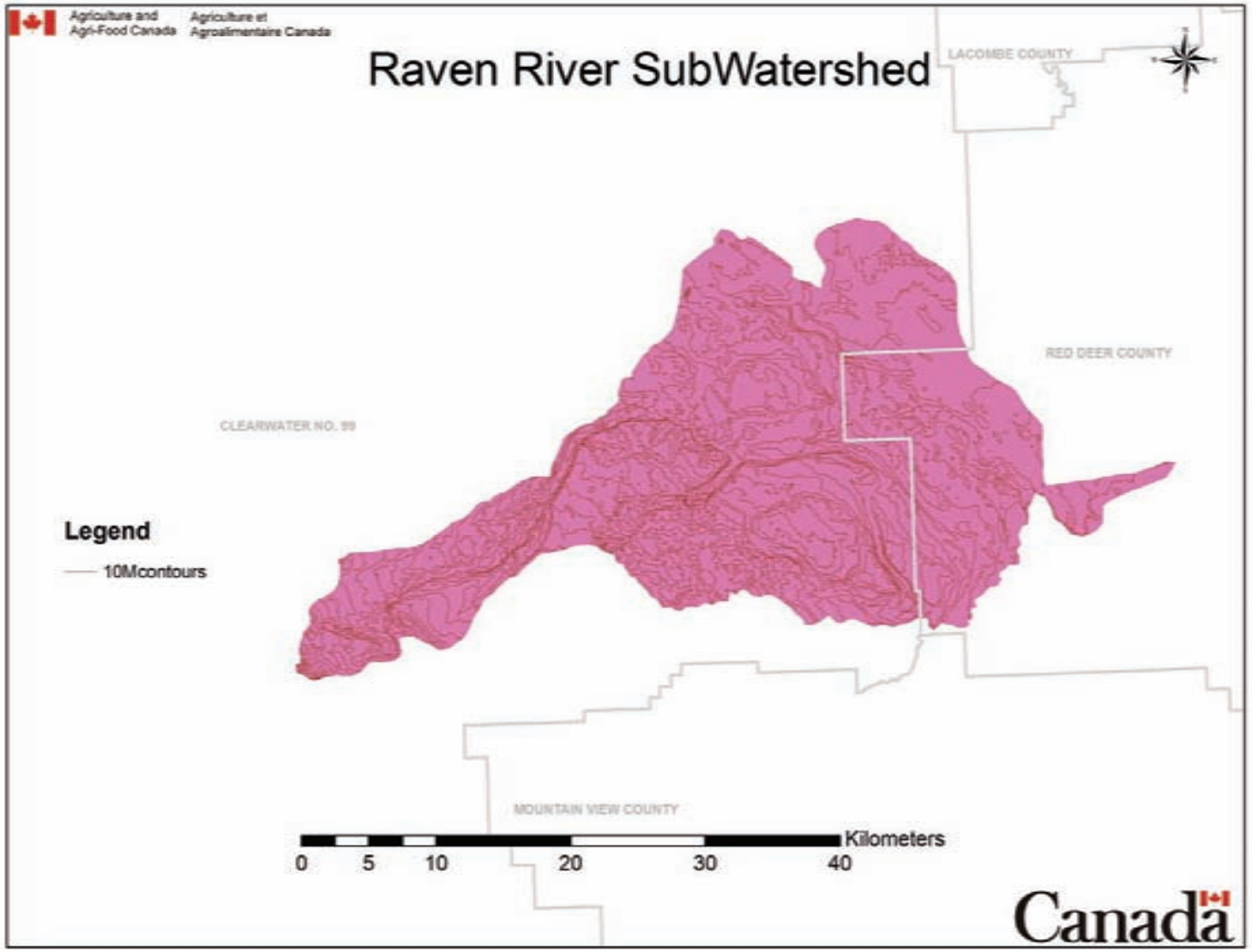


Figure 106. Topography (10-m contour intervals) of the Raven River subwatershed (AAFC-PFRA, 2008).

4.3.4.4 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 Raven River subwatershed, 818 surface water licenses and 434 groundwater licenses have been issued for water diversion projects (Figures 107, 108, respectively). Both surface water and groundwater licenses have been issued primarily for the central and eastern areas of the subwatershed. No groundwater licenses have been issued in the headwaters of the Raven River (AAFC-PFRA, 2008).

Nearly 2.95 million m^3 of surface and groundwater are diverted annually in the Raven River subwatershed (Government of Alberta, 2008d). The most prominent use of surface water is the management of the fisheries in a tributary of the Raven River (96% of total surface water diversions, Alberta Fisheries Management Division), while the most prominent users of groundwater are municipalities (46% of total groundwater diversions) and industry (35% of total groundwater diversions) (Table 50). The majority of water diverted in the entire subwatershed comes from surface water sources, e.g., lakes, streams and rivers (84%) (Government of Alberta, 2008d). Additional groundwater diversion information is provided in HCL (2004).

Table 50. Surface and groundwater diversions in the Raven 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^3/yr)	Groundwater (m^3/yr)
Agriculture	33,050	63,316
Commercial	6,000	18,615
Habitat enhancement	48,110	---
Industrial	---	164,091
Management of fisheries	2,393,830	---
Municipal	---	215,228
Recreation	---	7,400
Total	**2,480,990**	**468,650**
Grand total		**2,949,640**

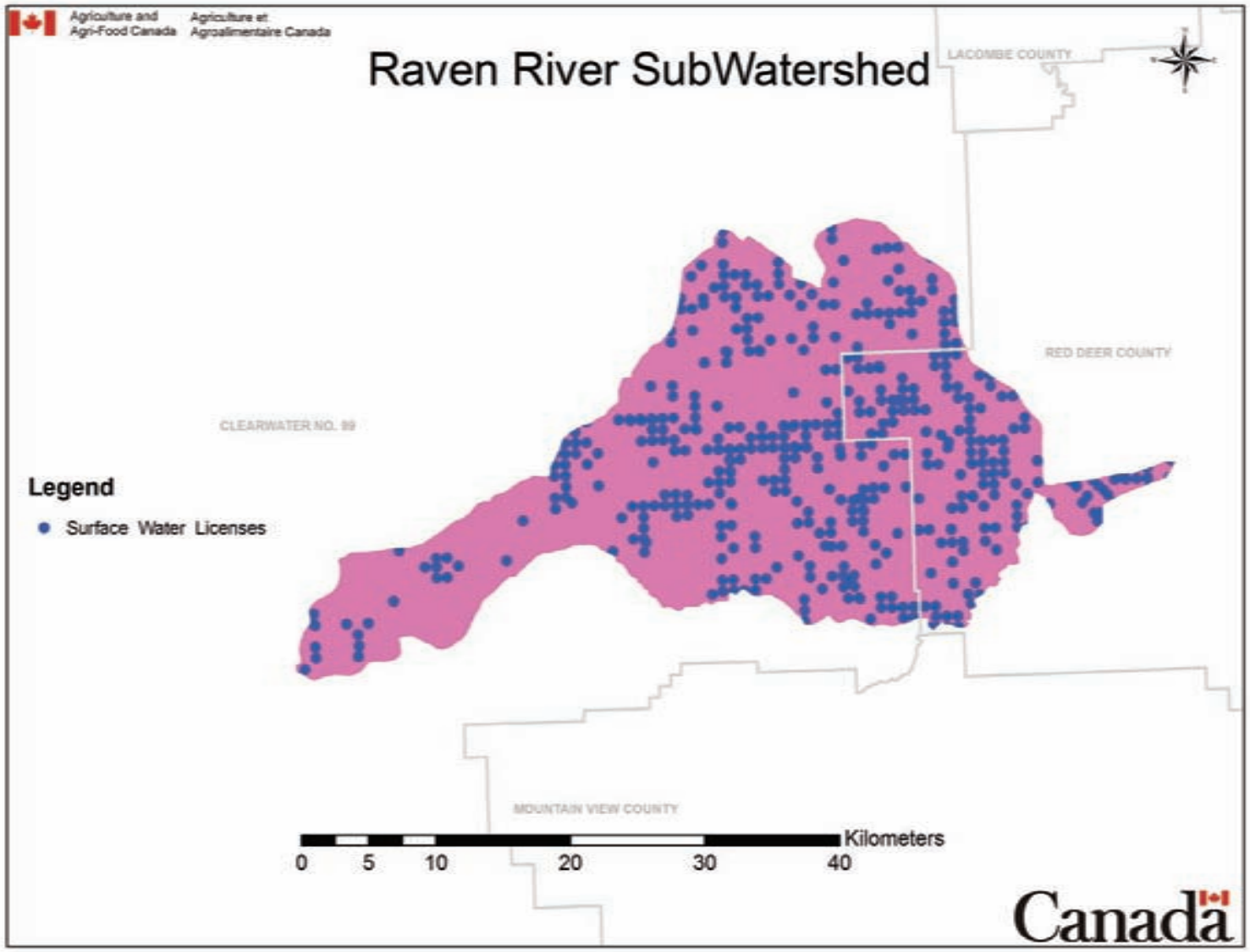


Figure 107. Surface water licenses in the Raven River subwatershed (AAFC-PFRA, 2008).

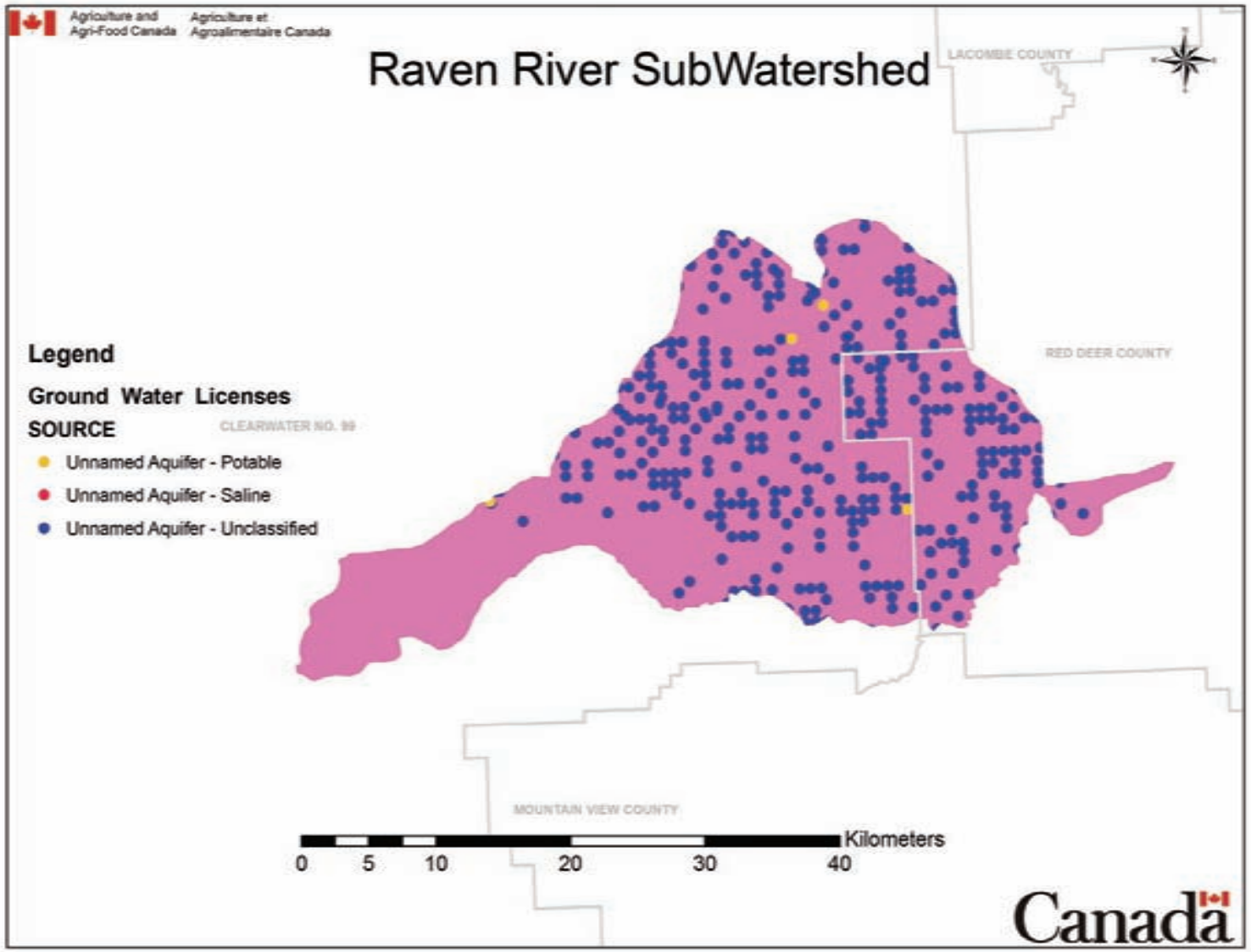


Figure 108. Groundwater licenses in the Panther River subwatershed (AAFC-PFRA, 2008).

4.3.4.5 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 Raven River subwatershed has about 30 freshwater springs, of which most are located in the headwaters of the Raven River near Caroline.

The majority of the Raven River subwatershed lies in Clearwater County, with only the eastern portions near Gleniffer Lake Reservoir being located in Red Deer County. Groundwater assessments have been conducted for both counties by HCL (2004). These assessments indicated that most of the Raven River subwatershed is a groundwater discharge area, i.e., water moves from groundwater reservoirs and discharges to the surface. 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 (2004).

4.3.5 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.

4.3.5.1 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 Raven River subwatershed.

4.3.5.2 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.

Fish populations have been assessed in two streams in the Raven River subwatershed: North Raven River and Beaver Creek. The predominant species in the North Raven River are brown trout, brook trout, white sucker and longnose sucker. There have been significant decreases in the populations of the brook trout ($p = 0.008$) and brown trout ($p = 0.02$) over the sampling period. Brown trout was the only species that has been captured consistently over the sampling period (Figure 109).

The North Raven River (a.k.a. Stauffer Creek) has undergone shoreline restoration and clearing and beaver dams have been removed to improve fish habitat and access for sport fishermen to the creek. These projects are ongoing and have been carried out by Trout Unlimited Canada in conjunction with Golder Associates, the Alberta Conservation Association and the Alberta Sustainable Resources Fisheries Management Division.

The predominant species in Beaver Creek are white sucker and brook trout. There have not been any significant changes in the populations of these species over the sampling period ($p > 0.7$ and 0.5, respectively). The brook trout is also the species that is the most consistently found during the sampling period (Figure 110).

Brown trout prefers cold, well-oxygenated upland waters, especially large streams in mountainous areas. Cover is important to them, and they are more likely to be found where there are submerged rocks, undercut banks and overhanging vegetation. Brown trout are active both by day and by night and are opportunistic feeders. While in fresh water, the diet will frequently include invertebrates from the streambed, small fish, frogs and insects flying near the water's surface. The high dietary reliance upon insect larvae, pupae, nymphs and adults is what allows trout to be a favoured target for fly fishing (Nelson and Paetz, 1992; Scott and Crossman, 1998).

Brook trout is native to small streams, creeks, lakes and spring ponds. It prefers cool, clear waters of high purity and a narrow pH range in lakes, rivers and streams, being sensitive to poor oxygenation, pollution and changes in pH caused by environmental effects, such as acid rain. Its diverse diet includes crustaceans, frogs and other amphibians, insects, molluscs, smaller fish, and even small aquatic mammals, such as voles, worms and flies (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).

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).

4.3.5.3 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 Raven River subwatershed is covered by coniferous forests (31%) and perennial croplands/pastures (29%). The age structure of forest stands in this subwatershed has been altered due to timber harvesting activities, i.e., forest stands tend to be younger than in non-harvested forest stands. There are very few exposed or developed lands, shrublands or mixed forests (Figure 111, Table 51) (AAFC-PFRA, 2008).

Table 51. Land cover in the Raven River subwatershed (AAFC-PFRA, 2008). The most prominent land cover types are highlighted.

Land cover type	Area (ha)	Proportion of subwatershed area (%)
Waterbodies	1,411	1.27
Exposed land	315	0.28
Developed land	390	0.35
Shrubland	287	0.26
Wetland	1,123	1.01
Grassland	5,417	4.87
Annual cropland	15,034	13.50
Perennial cropland/pastures	32,042	28.78
Coniferous forests	34,963	31.40
Deciduous forests	3814	3.43
Mixed forests	285	0.26
No data	16,257	14.60
Total	**111,337**	

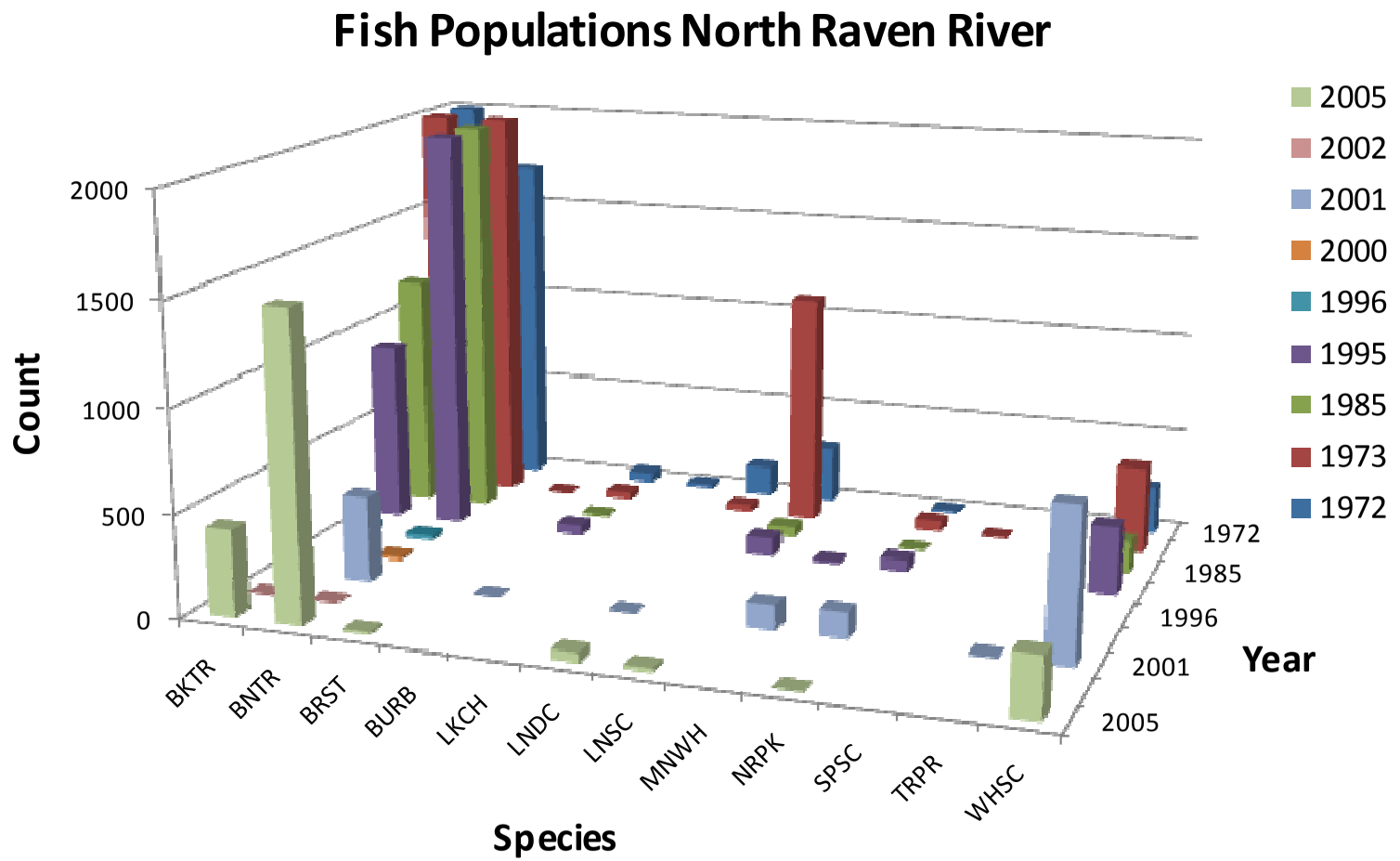


Figure 109. Fish populations in the North Raven River (a.k.a. Stauffer Creek) in 1972-1973, 1985, 1995-1996, 2000-2002 and 2005 (data from Alberta Sustainable Resource Development, 2008). The y-axis has been modified for better data representation. For full species names, please refer to Table 23.

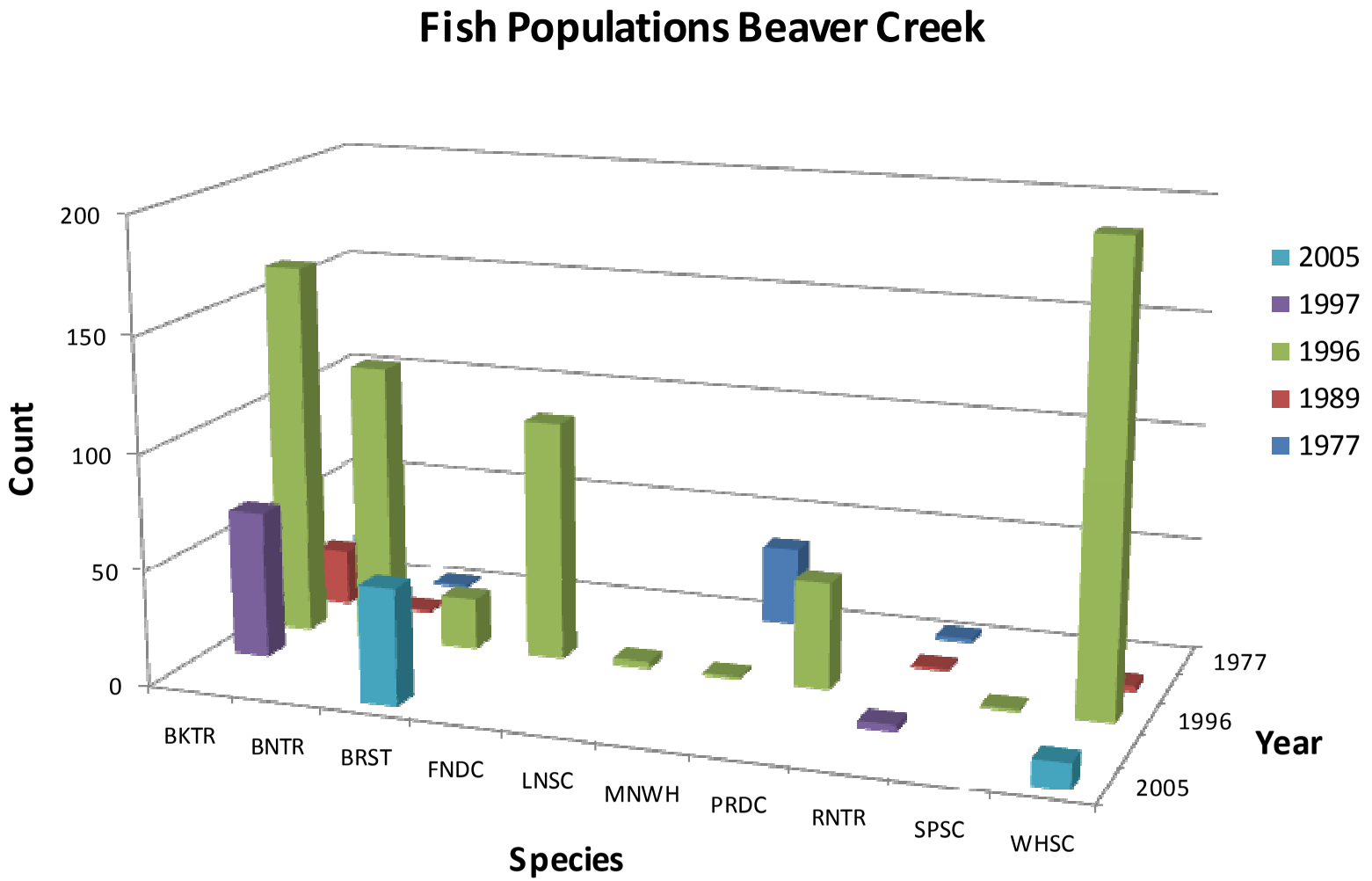


Figure 110. Fish populations in Beaver Creek in 1977, 1989, 1996-1997 and 2005 (data from Alberta Sustainable Resource Development, 2008). The y-axis has been modified for better data representation. For full species names, please refer to Table 23.

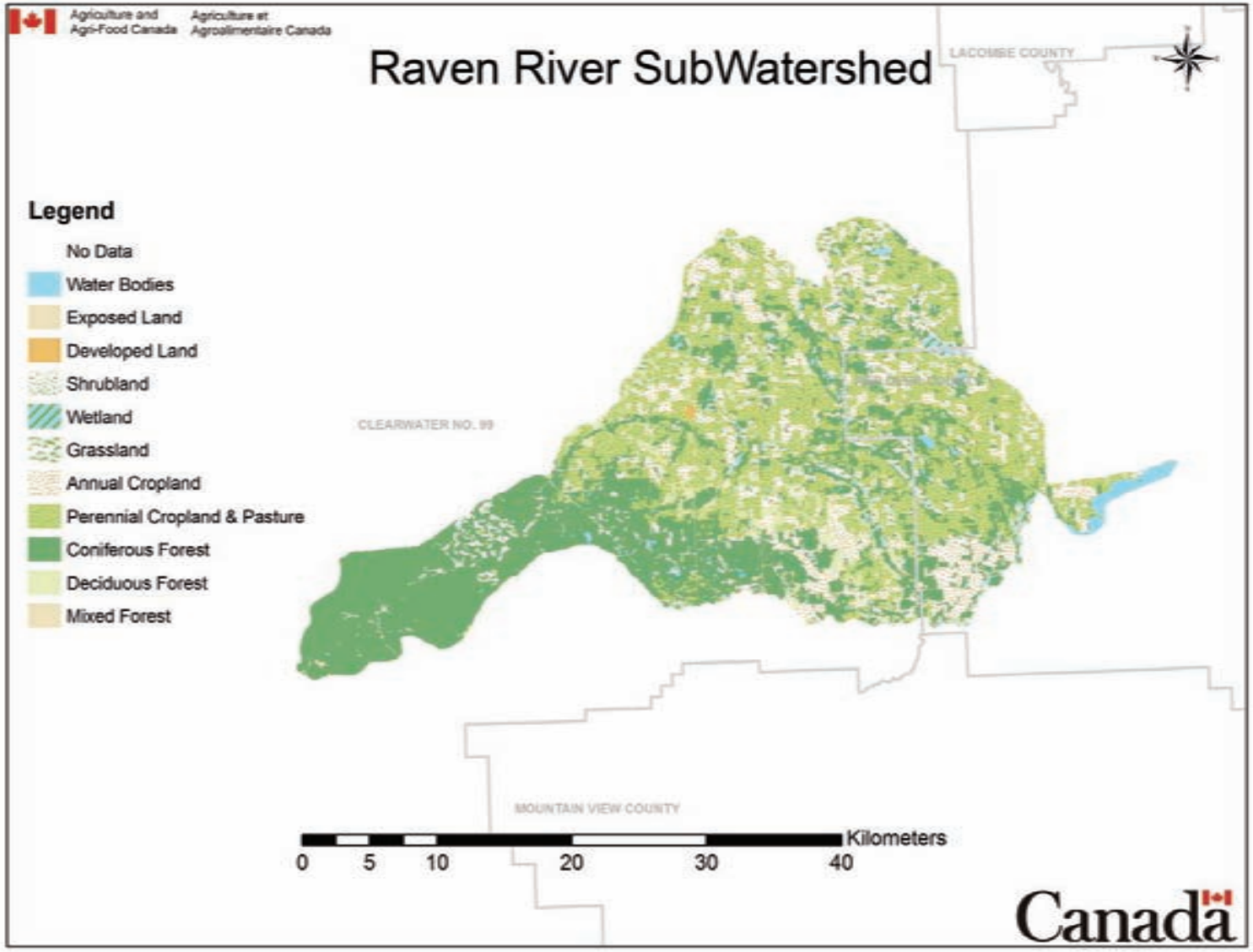


Figure 111. Land cover in the Raven River subwatershed (AAFC-PFRA, 2008).

One Ecologically Significant Area has been identified in the Raven River subwatershed: Raven River (Twp. 35-37, Rge. 46-7, W 5) (Alberta Environmental Protection, 1997). It is located in Red Deer County and Clearwater County and covers an area of 4,497 ha. The following factors make the Raven River a provincially significant area:

- a provincially-renowned trout fishery
- clear spring-fed stream and adjacent aspen, spruce and pine woodland on uplands; some areas with clearing to edge of stream
- spawning, rearing and overwintering areas for a variety of fish
- brown trout, rainbow trout, northern pike, mountain whitefish, walleye, eastern brook trout, cutthroat trout, goldeye, and mooneye fishery
- spawning, rearing and overwintering areas for brown trout, rainbow trout, northern pike, mountain whitefish and burbot
- key moose and deer habitat
- includes some of Alberta's larger springs, one of which is now used for a fish hatchery

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

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

4.3.6 Subwatershed Assessment

The Raven River subwatershed is located in the Upper and Lower Foothills and Dry Mixedwood Subregions in the headwaters of the Red Deer River, contributing to the complex biogeophysical composition of the subwatershed. Agricultural and livestock operations occur at a low to medium intensity relative to the Alberta average, and resource exploration and extraction endeavors have

resulted in an extensive network of linear disturbances (primarily roads). In all, there are 821 active wells in the subwatershed; most are natural gas wells. The Village of Caroline and several hamlets and recreational facilities exists in the subwatershed. The impacts of these land use activities on aquatic ecosystems are largely unknown due to the scarcity of water quality data. The data that exist indicate a high water quality, with no variables exceeding CCME PAL guidelines. Bacteria, parasite or pesticide data were not located for any waterbody in the Raven River subwatershed. The Raven and North Raven Rivers are the primary waterbodies in the subwatershed. Discharge rates in these rivers approach 10-20 m^3/sec following the spring freshet and heavy precipitation events, which has resulted in several High Water Level advisories in the Raven River. A total of 1,252 water licenses have been issued, which divert 2.95 million m^3 of water annually for primarily fisheries management purposes. Brown trout, brook trout and white sucker are the predominant fish species in the subwatershed, and an extensive sport fishery centres on particularly the trout species. Biodiversity assessment data have not been located for this coniferous forest and perennial cropland/pastures-dominated subwatershed; however, three SARA species of special concern inhabit 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 Raven River subwatershed receives a rating of “good” for the condition indicators and a rating of “low” for the risk indicators (Tables 52, 53). 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 is the extensive network of linear developments (roads and cutlines), primarily due to natural resource exploration and extraction activities throughout the subwatershed.

Table 52. Condition and risk indicator summary for the Raven River subwatershed. Gray logos indicate data gaps.

Condition Indicators

Risk Indicators


Table 53. Condition and risk assessments of the Raven River subwatershed. Indicators with a "poor" ranking are highlighted.

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

