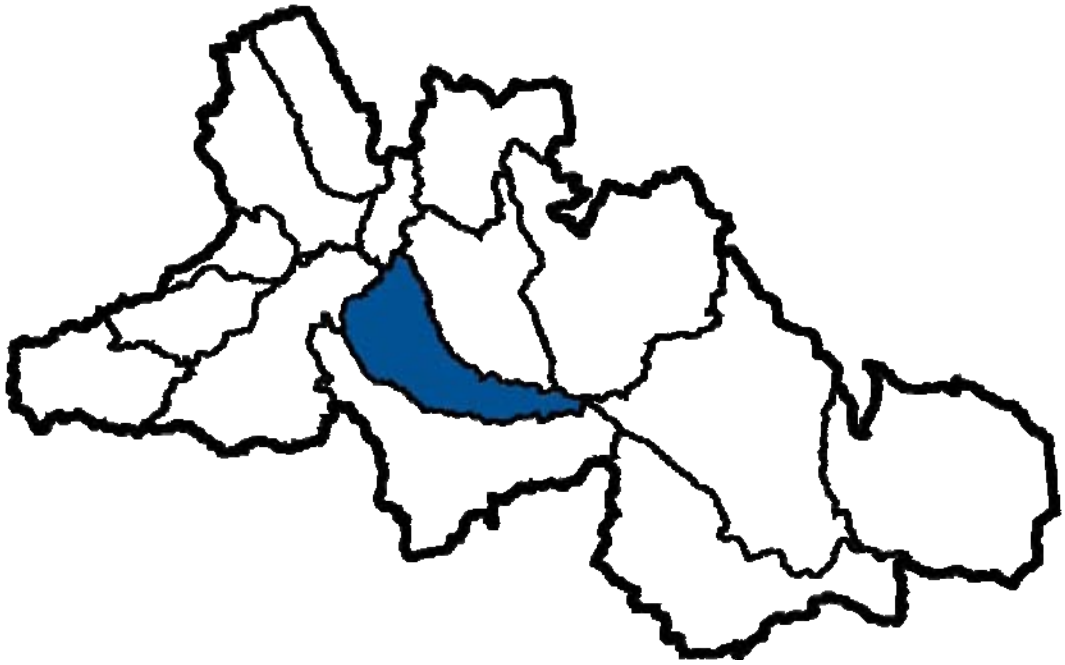
Kneehills Subwatershed



Red Deer River Watershed Alliance

State of the Watershed

4.10 Kneehills Creek Subwatershed

4.10.1 Watershed Characteristics

The Kneehills Creek subwatershed encompasses about 273,487 ha and is located in the Counties of Kneehill, Mountain View and Red Deer and the Municipal District of Rocky View No. 44 (Figure 278).

The Kneehills Creek subwatershed is located in the central region of the Red Deer River watershed. The subwatershed lies in the Central Parkland, Foothill Fescue and Northern Fescue Subregions (Figure 229). The Central Parkland Subregion is dominated by grassland with groves of aspen (*Populus* spp.), with the grassland vegetation being dominated by rough fescue (*F. campestris*). The Foothills Fescue Subregion is dominated by rough fescue (*F. campestris*), Idaho fescue (*F. idahoensis*) and oat grass (*Trisetum* spp.), where as the Northern Fescue Subregion is dominated by rough fescue (*F. campestris*) (Heritage Community Foundation, 2008).

The geology of the Kneehills Creek subwatershed is dominated by the Paskapoo Formation in addition to localized deposits belonging to the Scollard and Horseshoe Canyon 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, Upper Paskapoo, consists of diverse sandstones and siltstone/mudstones and minor shale deposits. The Scollard Formation (Paleocene and Upper Cretaceous) consists of sandstone, mudstone and thick coal deposits. The Horseshoe Canyon Formation (Upper Cretaceous) consists of sandstones, mudstones, shales, ironstone, bentonite and minor limestone deposits (Alberta Geological Survey, 2006).

The climate of the Kneehills Creek subwatershed is continental, with mean annual temperatures ranging from 2-4 °C and mean May-September temperatures ranging from 11-14 °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.

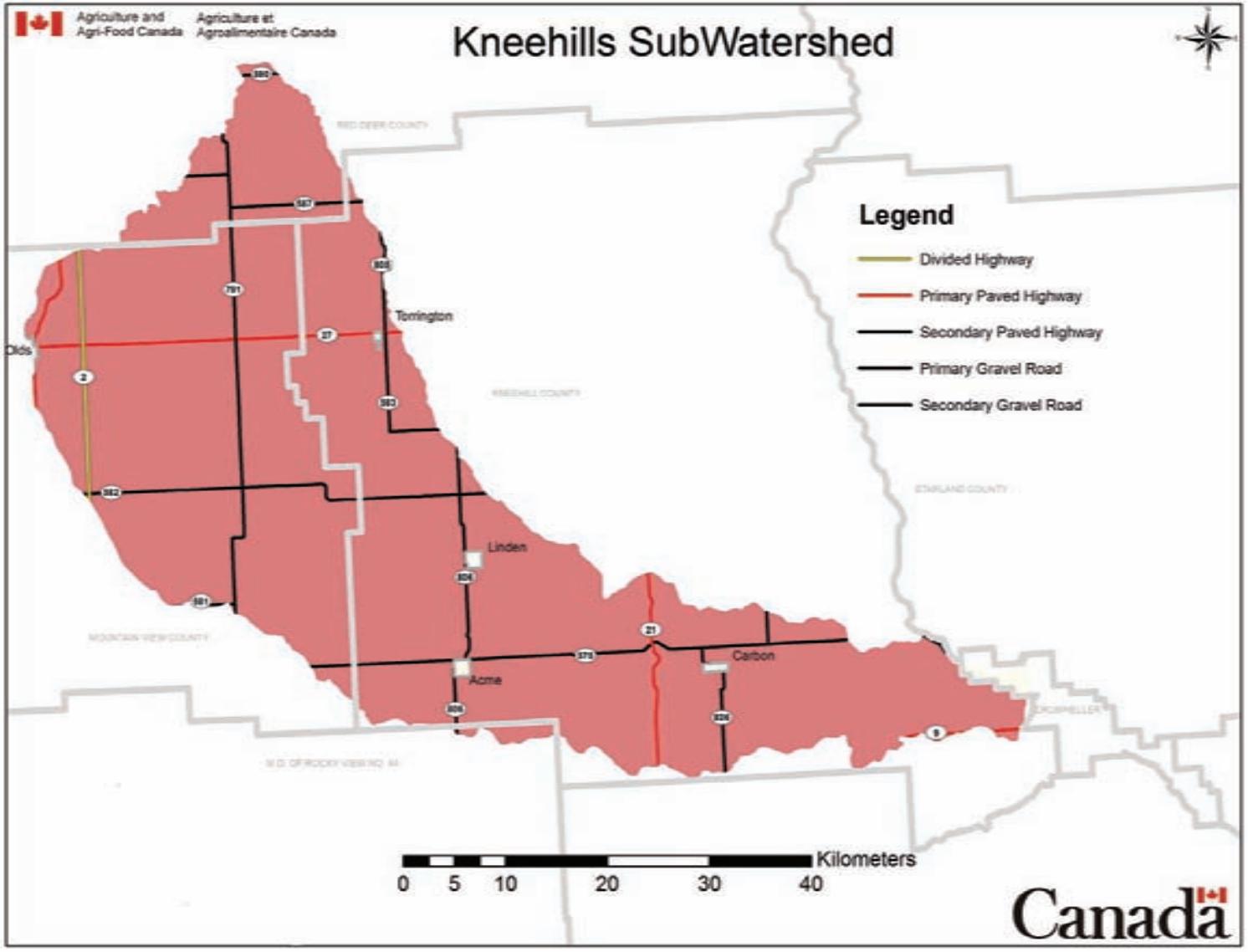


Figure 278. Location of the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

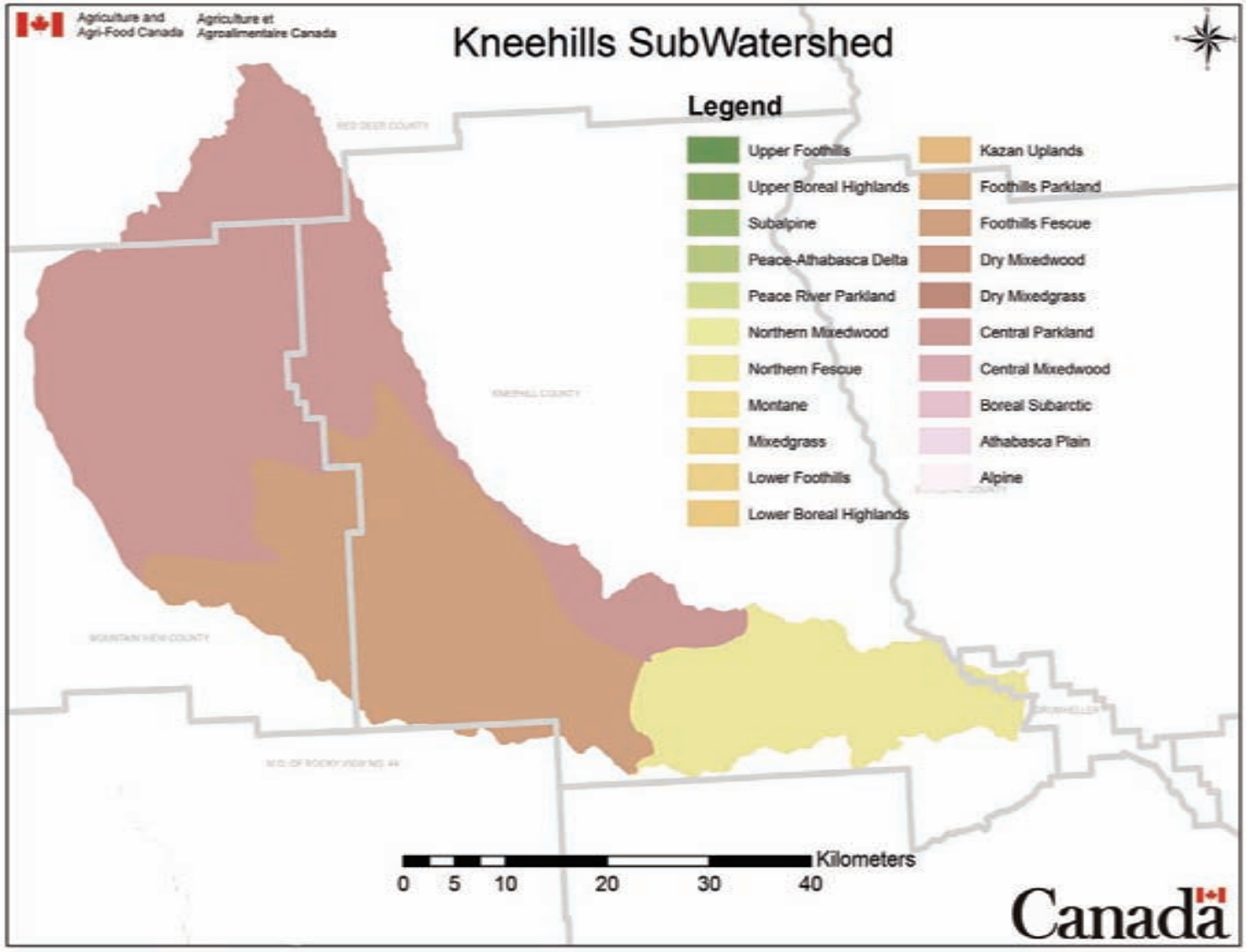


Figure 279. Natural subregions of the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

4.10.2 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.

4.10.2.1 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 1,840 ha of wetlands (0.67% of the total subwatershed area) in the Kneehills 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 Parkland Natural Region (in the Central Parkland Subregion) and the Grassland Natural Region (in the Northern Fescue and Foothills Fescue Subregions) from 1985-2001 (Watmough and Schmoll, 2007). In Alberta, the Parkland Natural Region has lost 7% of its total wetland area and 8% of its total number of wetlands due to anthropogenic disturbances in that 16-year period. Comparatively, losses in wetland area have been lower in the Grassland Natural Region (1-4%; range based on the two Subregions that fall within the Kneehills Creek subwatershed), but losses in the number of wetlands have been similar (5-9%; range based on the two Subregions that fall within the Kneehills Creek subwatershed). 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 Parkland Natural Region and none in the other Natural Region and its two Subregions in this subwatershed (Watmough and Schmoll, 2007).

4.10.2.2 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.

The riparian health has been assessed in one waterbody in the Kneehills Creek subwatershed: an intermittent creek near Lonepine Creek (N 14-31-27-W 4) (Anon., 2002k). Its riparian health was assessed as healthy with problems due to an abundance of noxious weeds, disturbance-caused vegetation and unrestricted access of livestock to the creek. Livestock have been grazing on desirable woody plants and caused minor pugging and hummocking along the streambank. It was recommended to fence off the creek, thereby restricting access of livestock to the creek and reducing structural damage to the creek bank. In addition, weeds should be controlled to reduce competition with native plants species and more desirable woody plants should be planted along the creek.

4.10.2.3 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 over 100 feedlots/intensive livestock operations in the Kneehills Creek subwatershed, concentrated most heavily in the Linden/Acme area (Figure 280) (AAFC-PFRA, 2008). Most feedlots finish cattle/cows, swine and poultry, while some are cattle and swine rearing and feeding operations.

Cattle density ranges from 0-0.20 cattle/ha in the southeast to 0.21-0.40 cattle/ha along the Red Deer River to 0.41-0.60 cattle/ha in the northern and western areas of the subwatershed. Cattle density is greatest in the central interior area of the subwatershed, ranging from 0.80-1.00 cattle/ha (Figure 281) (AAFC-PFRA, 2008). Manure production ranges from 5.1-7.5 tonnes manure/ha throughout most of the subwatershed, although it is lower in the headwaters of Kneehills Creek and near Spruce Creek (2.6-5.0 tonnes/manure/ha) and west of Drumheller (0.2-2.5 tonnes manure/ha) (Figure 282) (AAFC-PFRA, 2008). Overall, manure production is considered medium for the Kneehills Creek subwatershed relative to the remainder of the Red Deer River watershed.

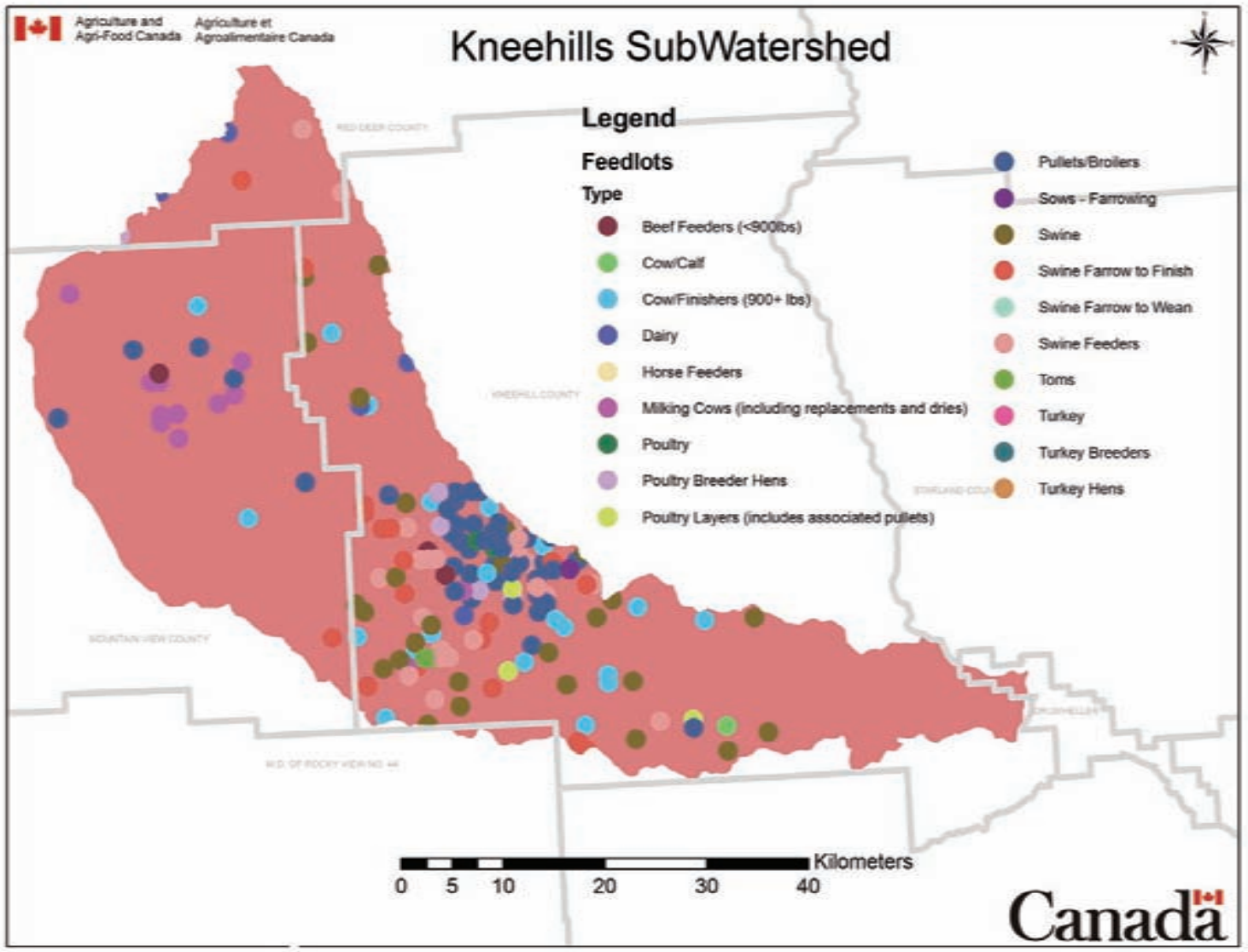


Figure 280. Feedlots and intensive livestock operations in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

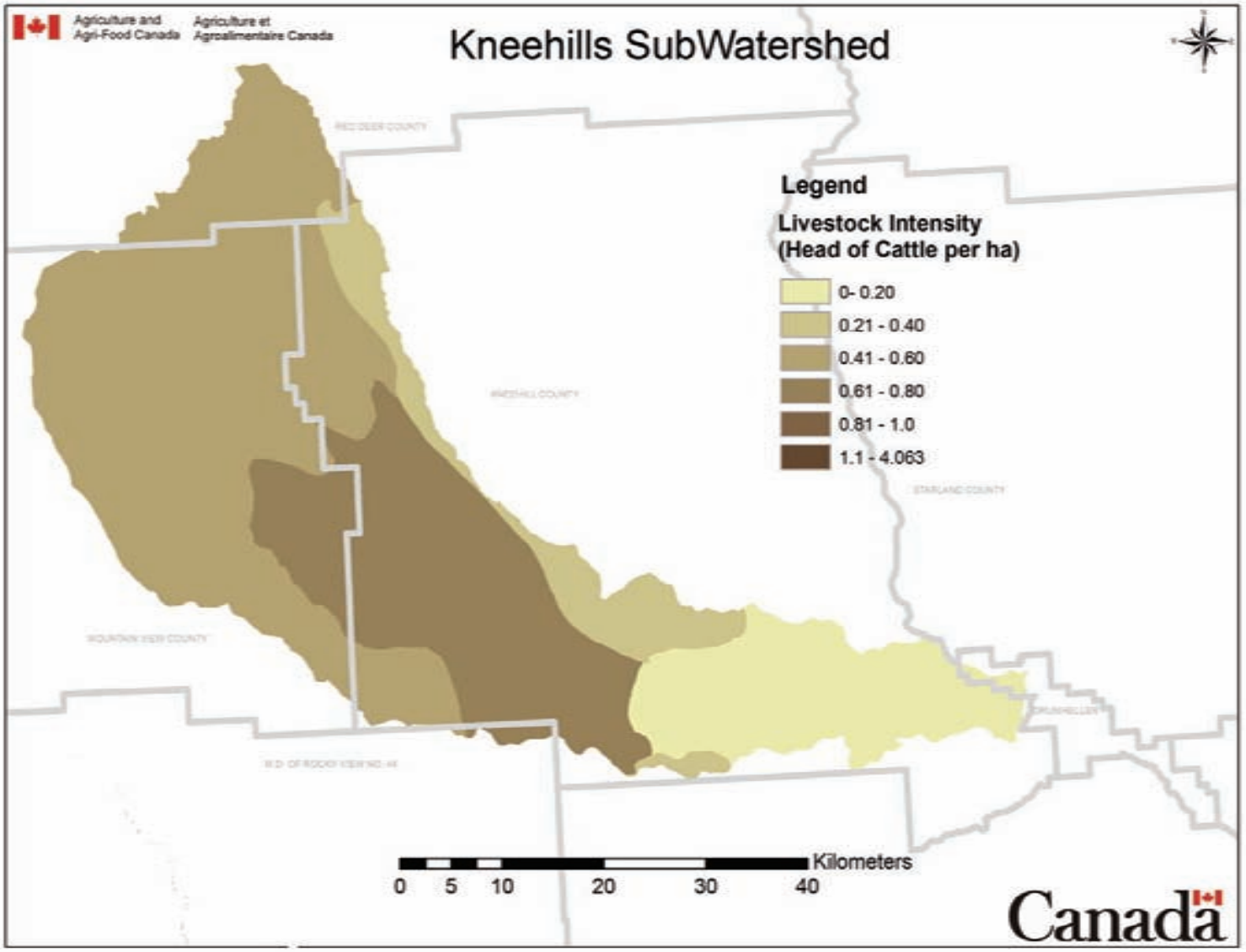


Figure 281. Cattle density (cattle/ha) in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

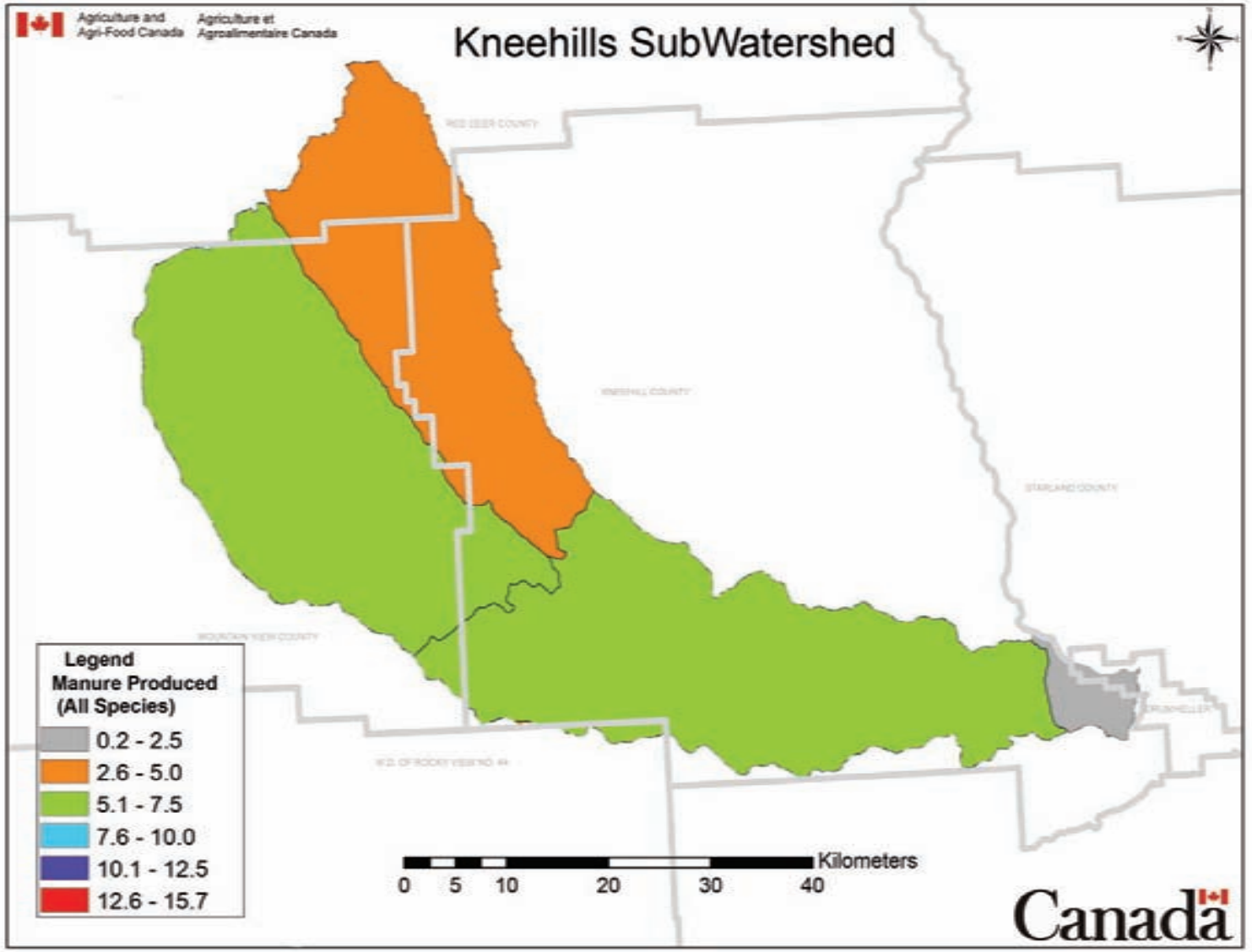


Figure 282. Manure production (tonnes/ha) in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

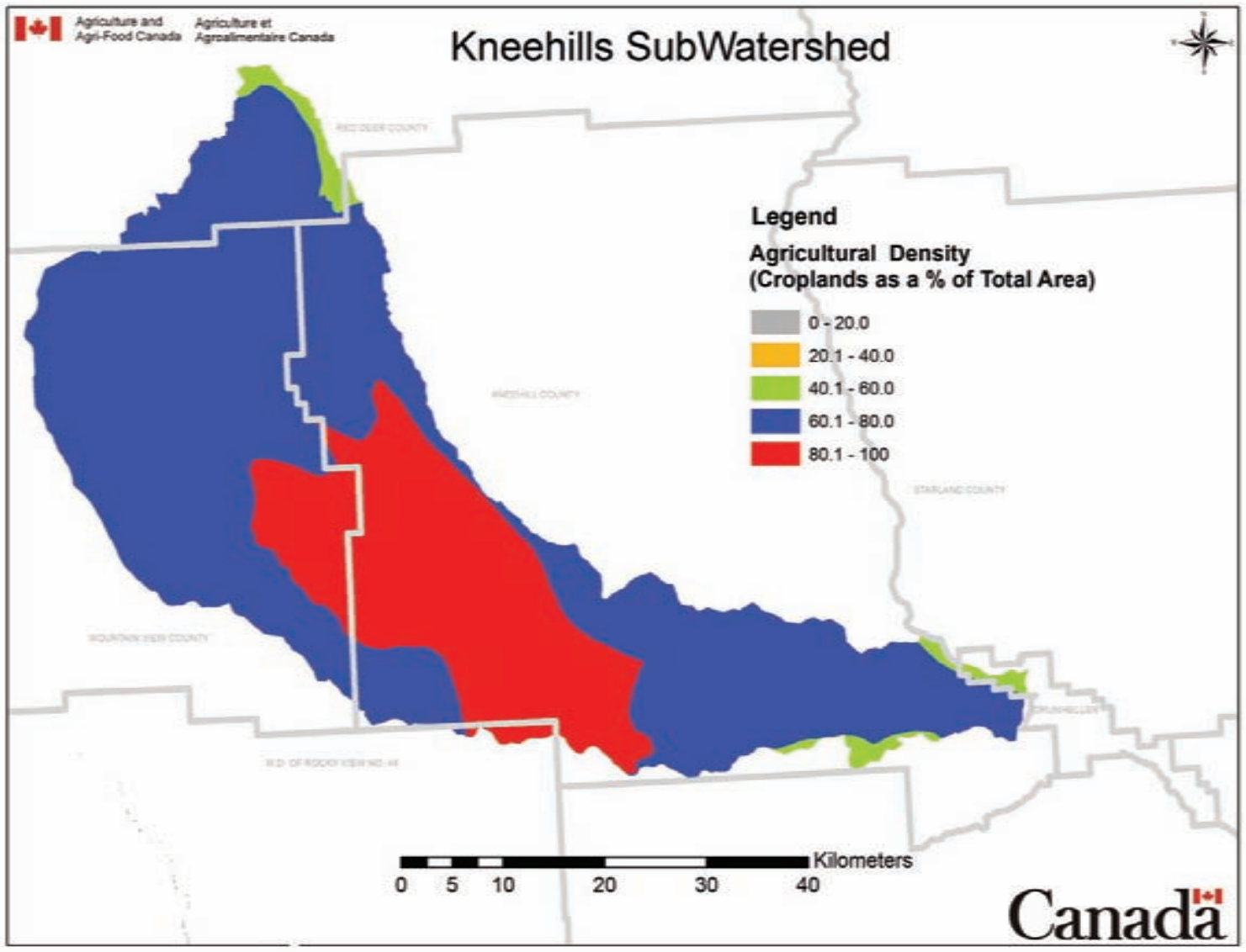


Figure 283. Agricultural intensity (% cropland) in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

Agricultural intensity, expressed as the percent land cover used as croplands, ranges from 80-100% in the central area and from 60-80% throughout most of the remainder of the subwatershed (Figure 283) (AAFC-PFRA, 2008).

4.10.2.4 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 Kneehills Creek subwatershed include the Villages of Acme, Carbon and Linden and numerous hamlets, including Allingham, Bargrave, Bircham, Buoyant, Cosway, Dunphy, Entice, Gatine, Grainger, Hesketh, Horseshoe Lake, Kirkpatrick, Knee Hill Valley, Mayton, Nacmine, Neapolis, Nisbet, Sharples, Stirlingville, Sunnyslope, Swalwell, Torrington and Wimborne (Government of Canada, 2006). Aside from campgrounds, there are no provincial parks, recreational areas or natural areas in the subwatershed (Alberta Tourism, Parks and Recreation, 2008b).

4.10.2.5 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 Kneehills Creek subwatershed are urban and rural roads, which have a total length of 3,000 km and cover48.0 km^2 of the subwatershed's landbase. Other major linear developments include pipelines (Table 113). In total, all linear developments cover an area of 74.9 km^2, or 2.7% of the total area of the subwatershed (Figure 284) (AAFC-PFRA, 2008).

Table 113. Linear developments in the Kneehills 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	3,000	16	48.00	64.1
Cutlines/trails	600	6	3.60	4.8
Pipelines	1,300	15	19.50	26.0
Powerlines	48	30	1.44	1.9
Railways	155	15	2.32	3.1
Total	**5,103**		**74.86**	

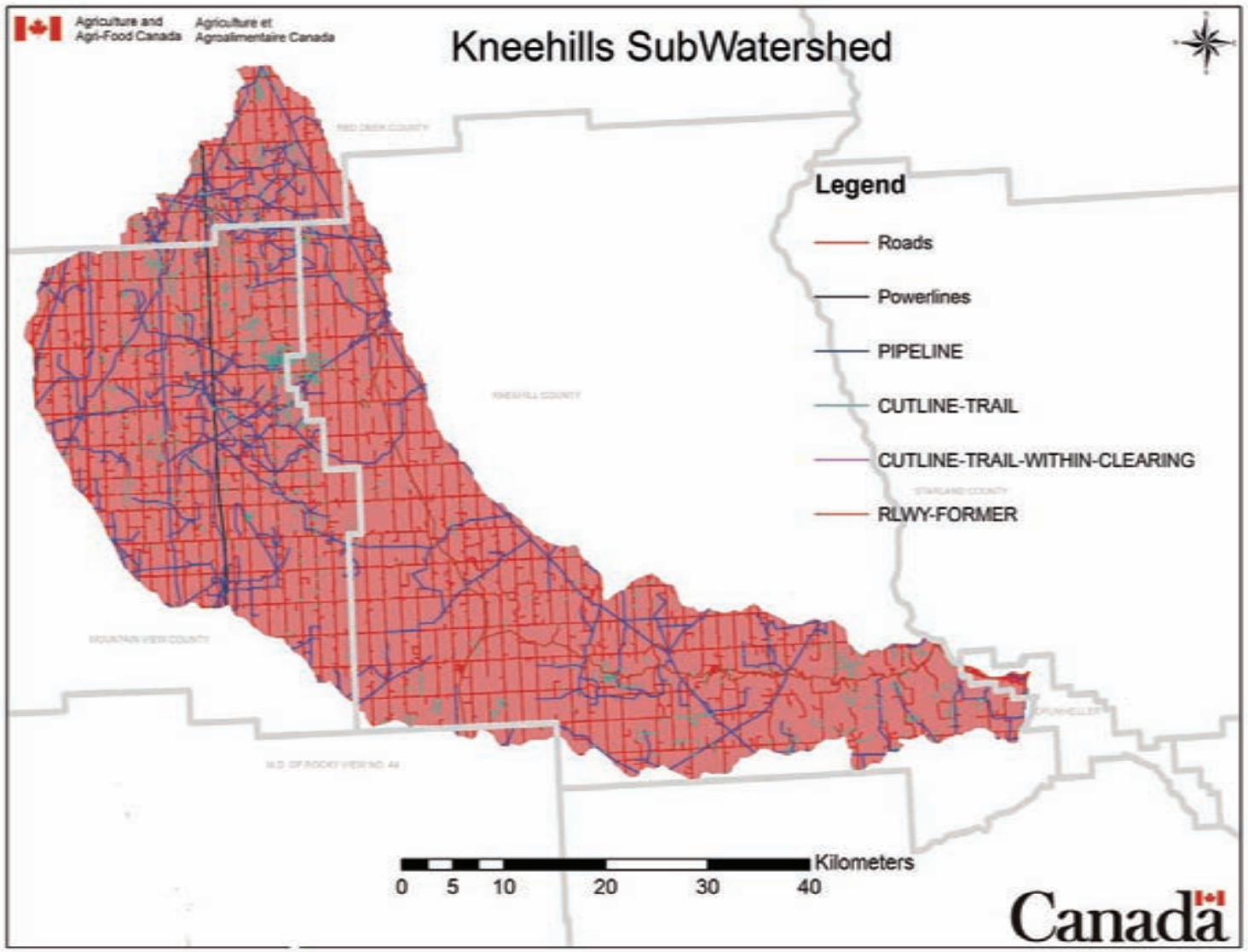


Figure 284. Linear developments in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

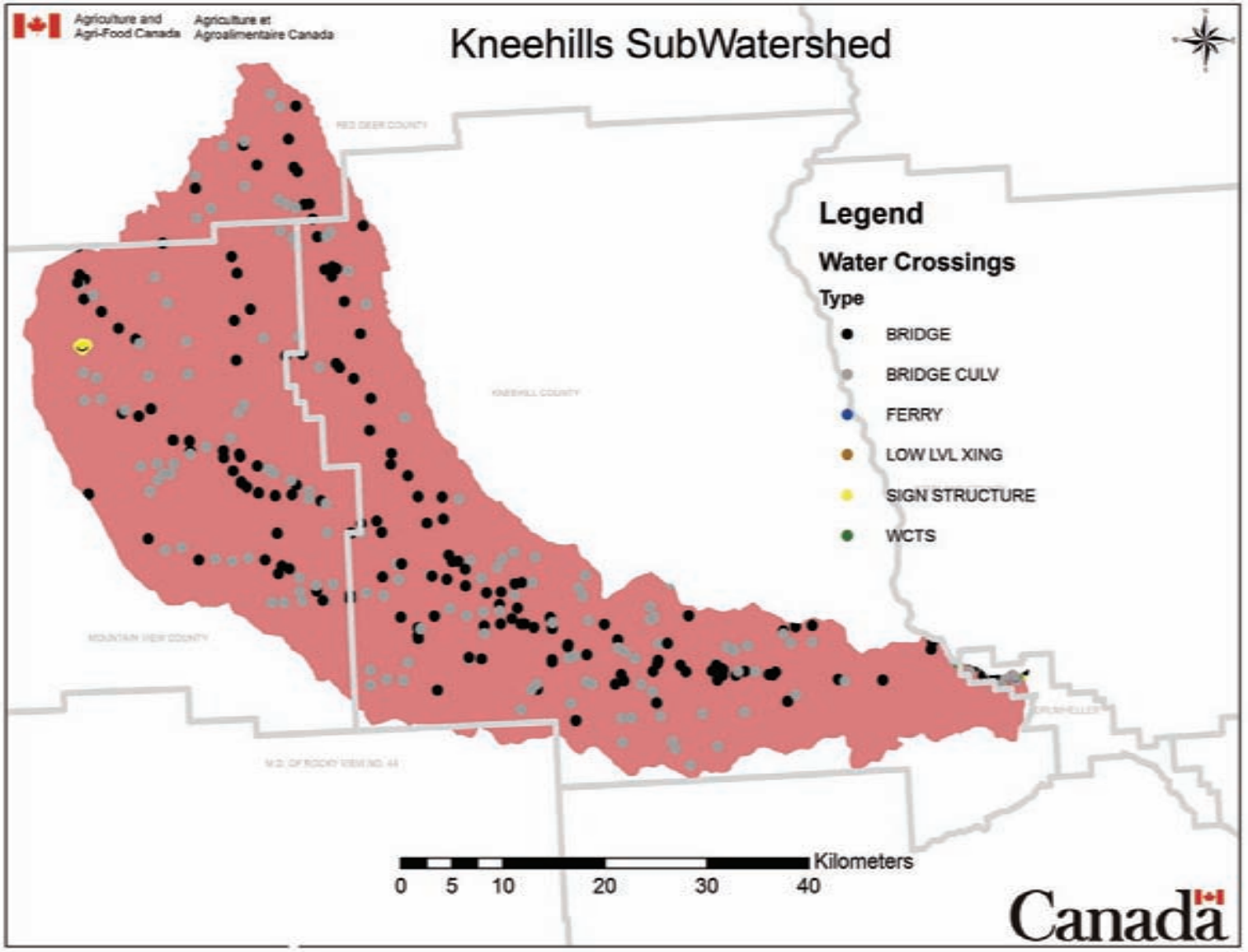


Figure 285. Waterbody crossings in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

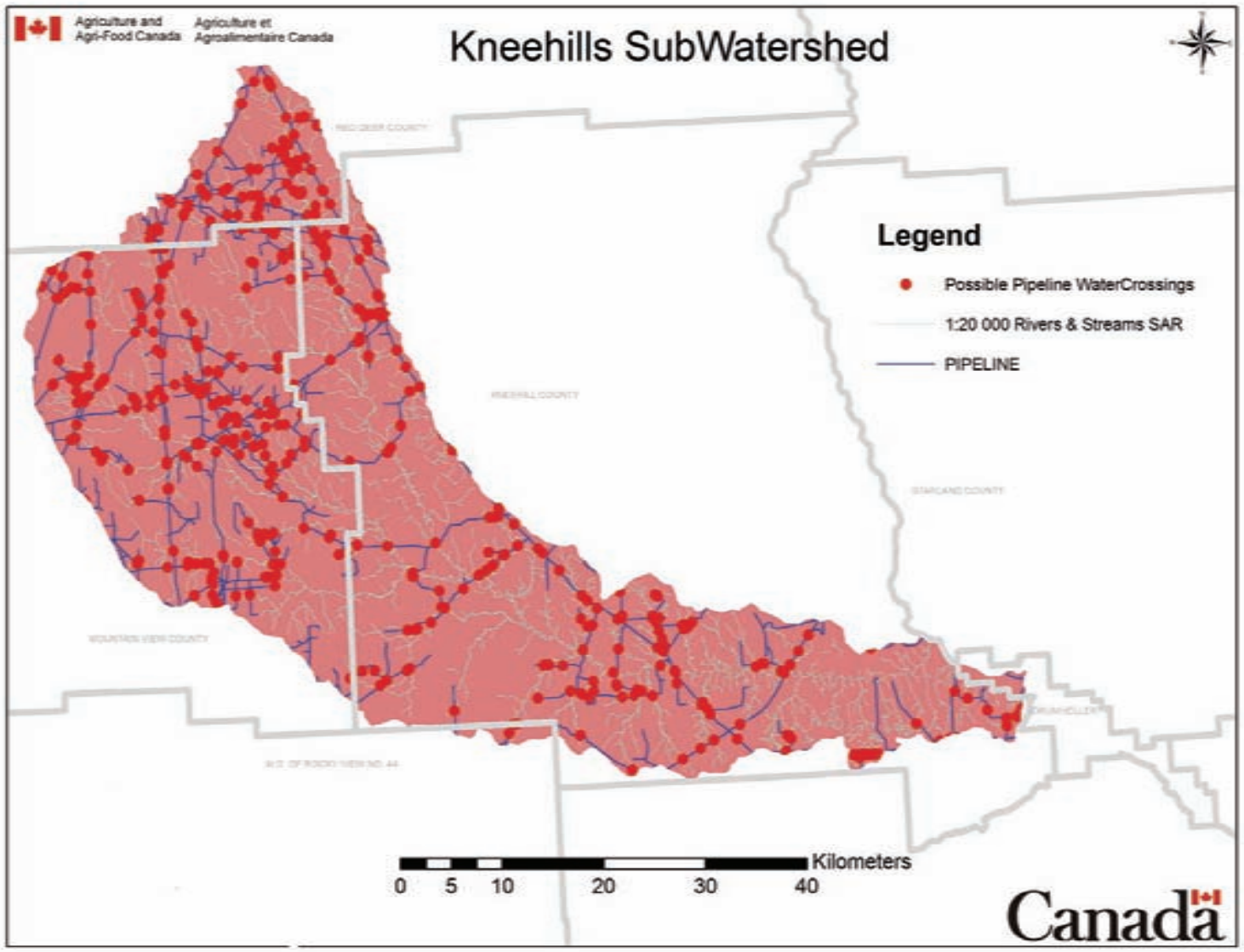


Figure 286. Pipeline crossings over waterbodies in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

In addition to linear developments, the Kneehills Creek subwatershed has 320 bridges that cross waterbodies, mostly streams and creeks, or culverts that connect waterbodies. These are primarily associated with Kneehills Creek and Lonepine Creek (Figure 285) (AAFC-PFRA, 2008). The majority of pipeline crossings in the Kneehills Creek subwatershed are located in the north-western area of the subwatershed in the headwaters of Kneehills Creek and Lonepine Creek and in the east-central area of the subwatershed near Carbon (Figure 286) (AAFC-PFRA, 2008).

4.10.2.6 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 Kneehills Creek subwatershed has an average well density of 1.87 wells/km^2; however, the well density increases up to 5 wells/km^2 south of Kneehills Creek and reaches up to 10 well/km^2 near Carbon, Gatine and Dunphy near the confluence of Kneehills Creek with the Red Deer River (Figure 287). About 79% of all wells are active, with the majority being unspecified wells, followed by gas and oil wells (Table 114) (AAFC-PFRA, 2008).

Table 114. Number of known active and abandoned oil, gas, water and other wells in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

Well type	Quantity
Wells – active *	2,509
Wells – abandoned *	819
Total	**3,328**
Gas wells – active	1,341
Gas wells – abandoned	134
Total	**1,475**
Oil wells – active	160
Oil wells – abandoned	118
Total	**278**
Water wells – active	17
Water wells – abandoned	3
Total	**20**
Total active wells in subwatershed	**4,027**
Total abandoned wells in subwatershed	**1,074**
Total wells in subwatershed	**5,101**

* 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.

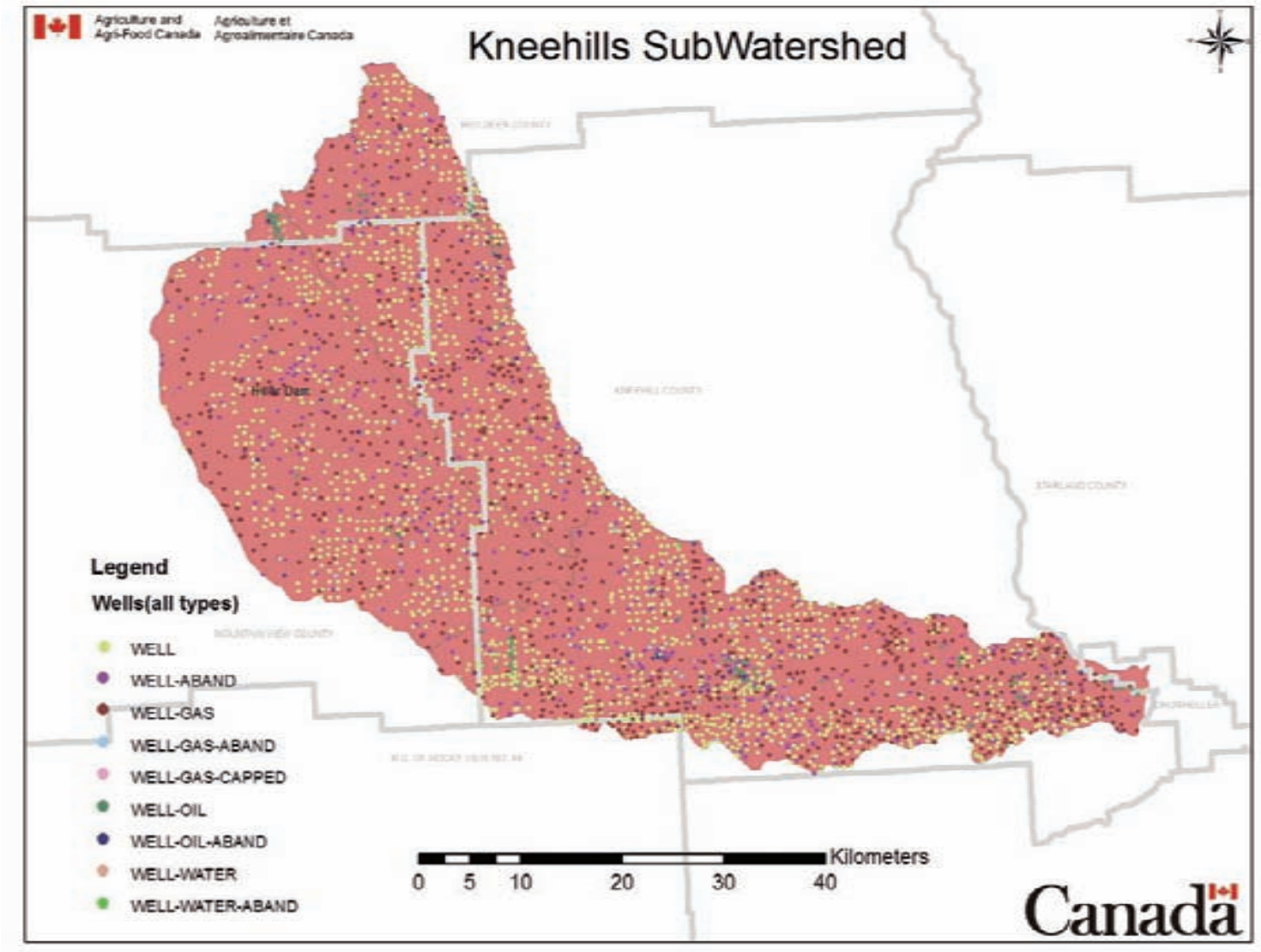


Figure 287. Known active and abandoned oil, gas, water and other wells in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

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).

4.10.3 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.

4.10.3.1 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 assessments have been carried out in Kneehills Creek sporadically from 1983-1995. TP and TN concentrations in Kneehills Creek and Lonepine Creek exceeded CCME PAL guidelines (0.05 mg/L and 1.0 mg/L, respectively) (Table 115). 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 Kneehills Creek subwatershed and may contribute to the nutrient loading of both creeks.

4.10.3.2 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.

Total coliform and fecal coliform bacterial concentrations have been assessed in Kneehills Creek and Lonepine Creek, and fecal and total coliform bacterial concentrations have considerably exceeded CCME Agriculture/Irrigation guidelines in the former creek (Table 115). Sources of these bacteria likely include livestock and agricultural operations throughout the subwatershed, which occur in medium to high densities compared to Alberta. Coliform concentrations were below CCME Agriculture/Irrigation guidelines in Lonepine Creek.

Table 115. Water quality in the Kneehills Creek subwatershed. n= sample size. All concentrations in mg/L unless otherwise noted. Concentrations exceeding water quality guidelines are highlighted *.

Parameter	Kneehills Creek		Lonepine Creek	
	Mean	n	Mean	n
TP	0.327	39	0.126	8
TDP	0.045	10	0.042	1
TN	1.802	39	1.408	8
NO_3^--NO_2^-	0.176	39	0.108	8
NH_3	0.091	39	0.103	8
DO	9.02	38	7.83	8
Chl. *a* (µg/L)	---	---	---	---
pH	8.29	39	8.03	8
Specific Conductivity (µS/cm)	1255	39	780	8
TDS	656	5	---	---
Total coliforms (CFU/100 mL)	294	31	6	7
Fecal coliforms (CFU/100 mL)	358	34	3	7

* TN from ASWQG PAL chronic exposure guideline; fecal and total coliforms from CCME-Agriculture/Irrigation guideline; all others from CCME PAL. In Kneehills creek, water samples were collected April 1983-February 1995, October 1992, and July to August 1998; in Lonepine Creek, water samples were collected June 1984-February 1985 (data from Alberta Environment). Variable abbreviations as in Table 10.

4.10.3.3 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 Kneehills Creek subwatershed.

4.10.3.4 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 Kneehills Creek subwatershed.

4.10.3.5 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.

About 40 upstream oil/gas facilities, two oil/gas refining/storage facilities, three commercial facilities and one chemical manufacturing facility have released pollutants continuously or sporadically into the air in the Kneehills Creek subwatershed since 1994. Pollutants from the upstream oil/gas facilities and the oil/gas refining/storage facilities include carbon monoxide (CO), nitrous oxide (N_2O) and particulate matter < 10 µm in size and volatile organic compounds (VOCs). The chemical manufacturing facility has released isopropyl alcohol into the air or incinerated it and disposed of it off-site since 1994. The three commercial facilities have released N_2O, particulate matter < 10 µm in size, VOCs, hydrochloric acid (HCl), sulphuric acid (H_2SO_4) and Cu- and Zn-containing compounds into the air (NPRI, 2008). No pollutants were released directly into aquatic ecosystems according to the National Pollution Release Inventory.

4.10.4 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.

4.10.4.1 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 watercourses in the Kneehills Creek subwatershed is about 1,764 km (Figure 288) (AAFC-PFRA, 2008). The major streams in the subwatershed are Kneehills Creek, Lonepine Creek, Spruce Creek and Ten Mile Creek. Beveridge Lake, Burns Lake, Davey Lake, Keiver's Lake and Stewart Lake are the largest waterbodies in the subwatershed. In addition, there are numerous small creeks and sloughs in the subwatershed (Government of Canada, 2006).

Alberta Environment has been monitoring water discharge rates in Kneehills Creek near Drumheller (real-time active, 05CB002), in Lonepine Creek above the confluence with Kneehills Creek (discontinued, 05CE013) and in Kneehills Creek above the confluence with Lonepine Creek (discontinued, 05CE016) (Government of Alberta, 2008c).

In Kneehills Creek near Drumheller, water discharge rates are highest in April (1-2 m^3/sec) and the decrease throughout the remainder of the year (0.01-1.0 m^3/sec). The hydrograph is characterized by sporadic, sudden increases in water discharge rates, particularly in the months of August, September and October. Historically, water discharge rates have reached maxima of 9-10 m^3/sec, particularly in April, and minima of near 0 m^3/sec during the summer and fall months. Water discharge rates were above average levels for most of the year, exceeding 10 m^3/sec once in June and remaining near 0.1 m^3/sec (Figure 289) (Government of Alberta, 2008c).

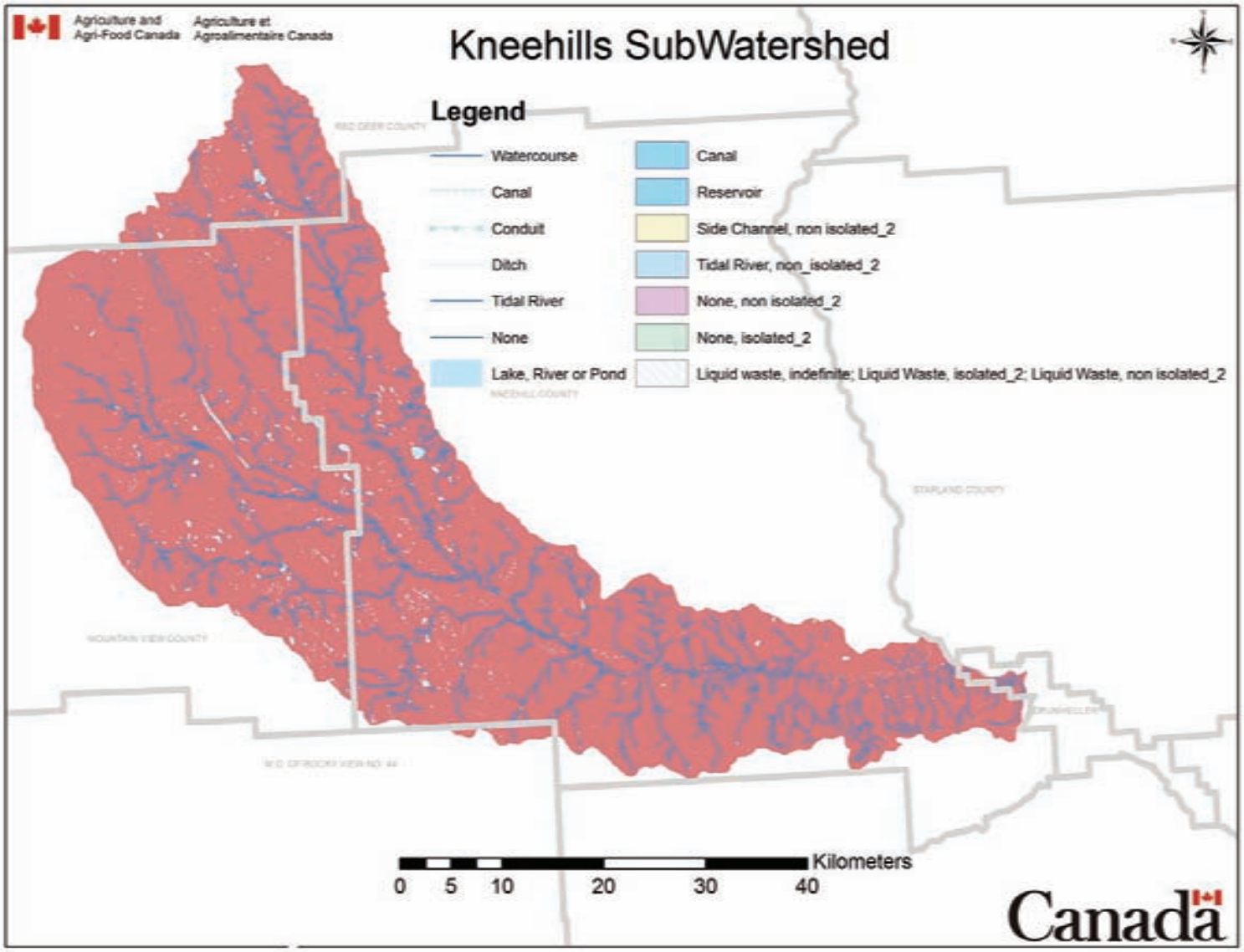


Figure 288. Waterbodies in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

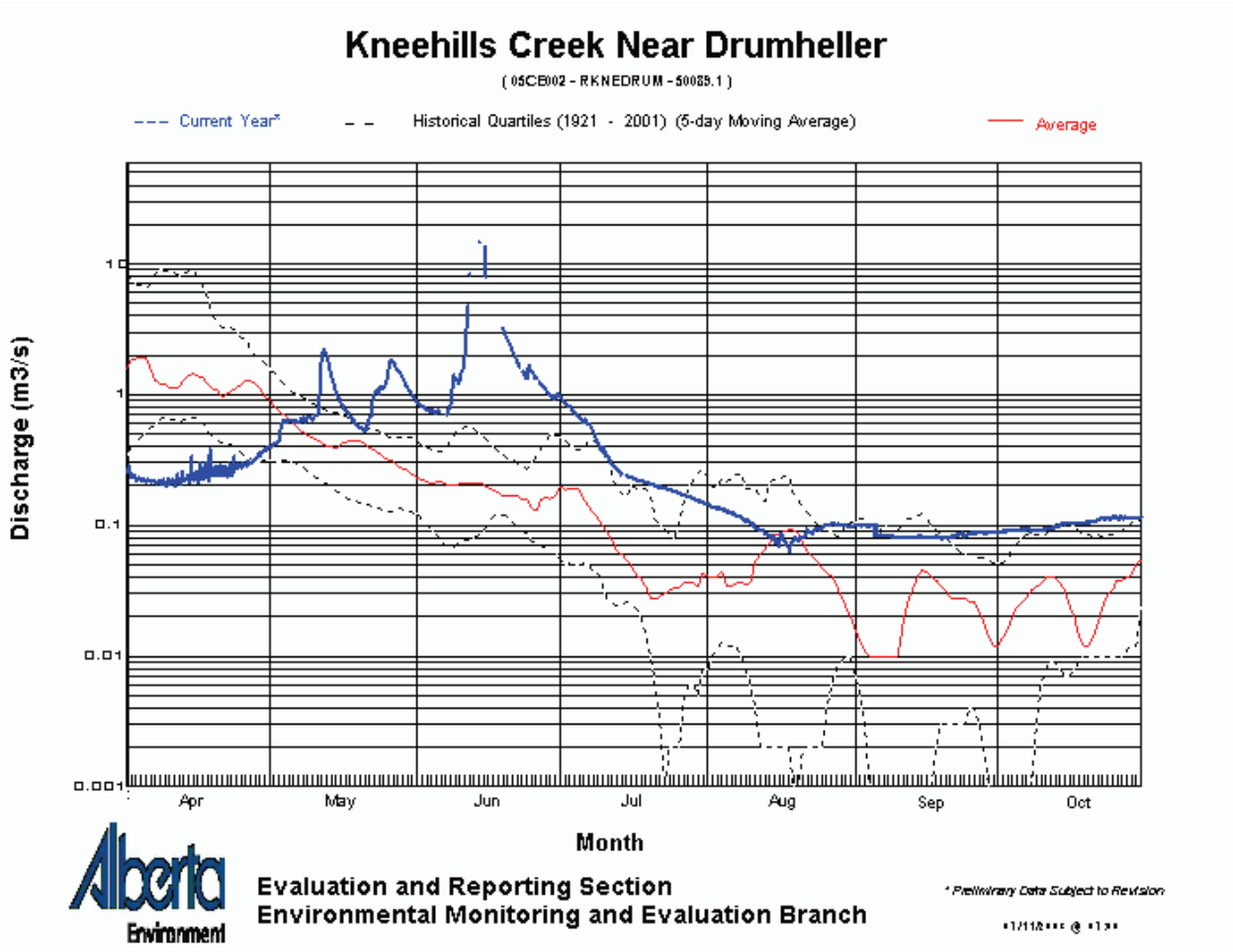


Figure 289. Discharge rates in Kneehills Creek near Drumheller (Government of Alberta, 2008c). "Current year" indicates water discharge rates in 2008.

There are two major dams in the Kneehills Creek subwatershed (Figure 290). Hiller Dam is located on a small tributary of Lonepine Creek in the northwestern area of the subwatershed. Grainger Dam is located east of Linden, and Fyten Reservoir is located south-west of Swalwell on a tributary of Kneehills Creek. A flood control feature is located on Kneehill Creek east of Carbon. In addition, there are numerous smaller water infrastructures in the subwatershed, e.g., small dams, sluices, weirs and dykes, which control water flow.

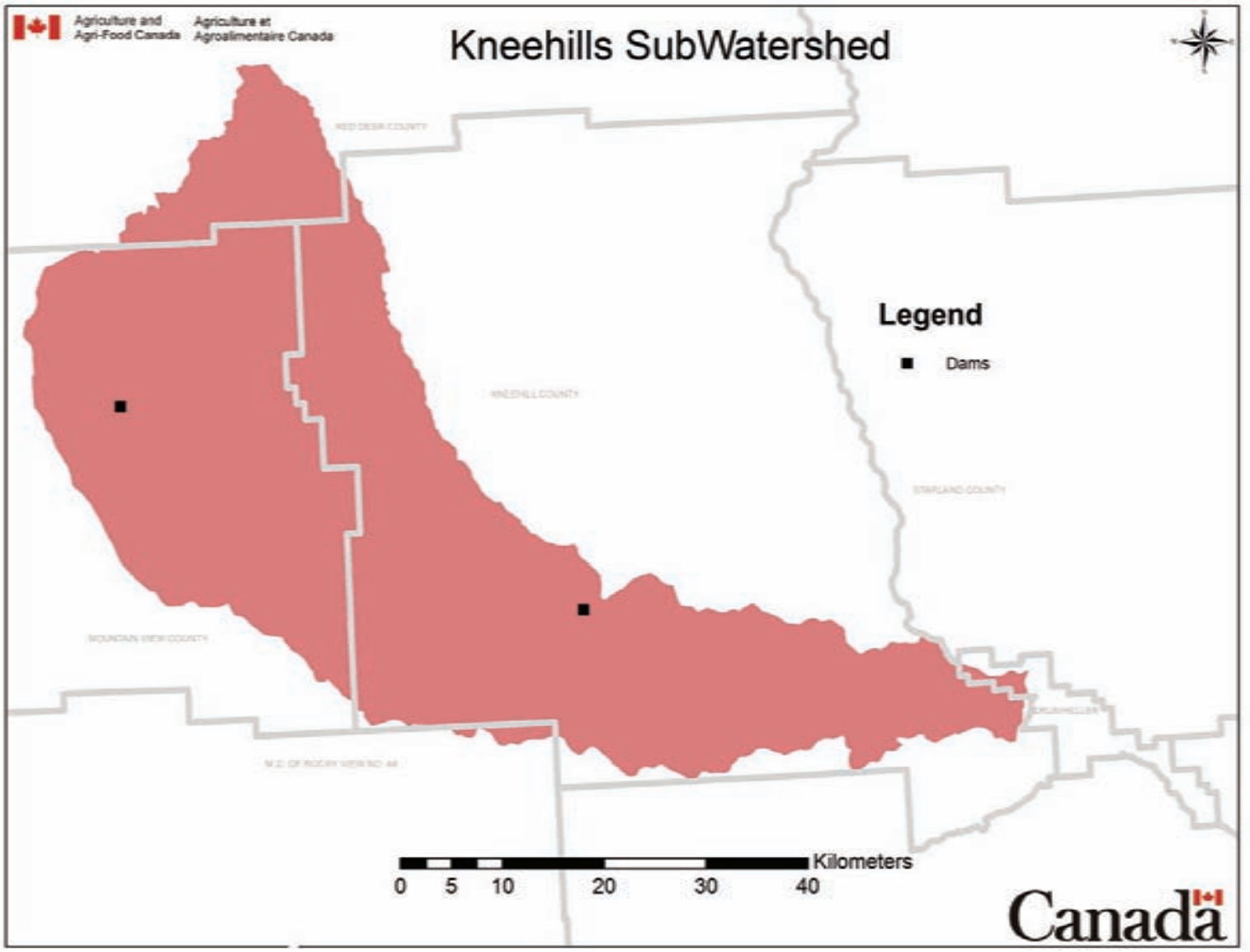


Figure 290. Major dams in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

4.10.4.2 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 Kneehills Creek subwatershed.

4.10.4.3 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 Kneehills Creek subwatershed, 46,530 ha (or 18.6% of the total area of the subwatershed) of land do not contribute to the drainage of the subwatershed (Figure 291). These areas are located primarily in the central and northwestern areas of the subwatershed, e.g., between the tributaries of Lonepine Creek and Kneehills Creek and between Lonepine and Kneehills Creeks, where the topography is generally flat (Figure 292) and precipitation does not run off into nearby waterbodies (AAFC-PFRA, 2008).

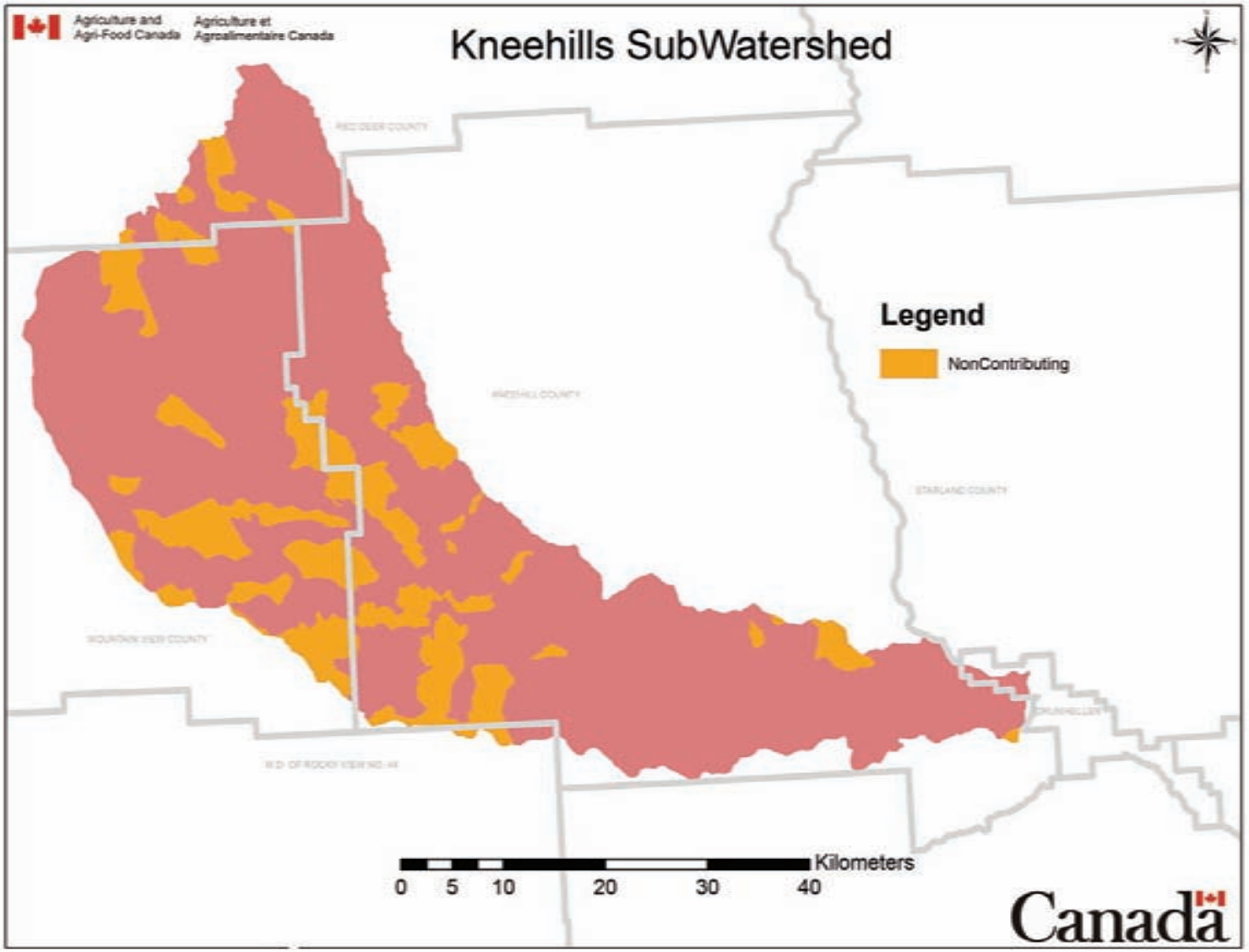


Figure 291. Non-contributing drainage area in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

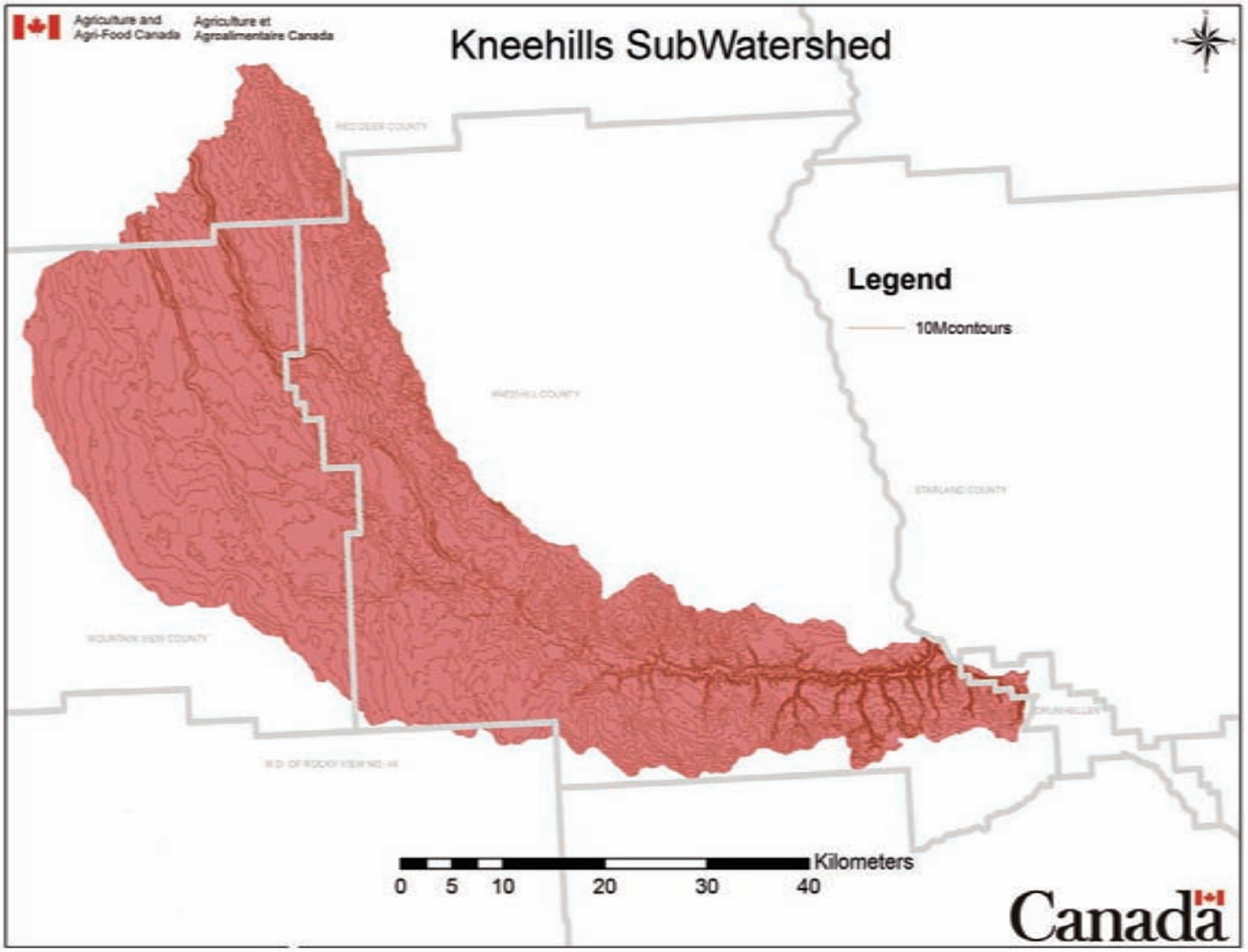


Figure 292. Topography (10-m contour intervals) of the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

4.10.4.4 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 Kneehills Creek subwatershed, 1,688 surface water licenses and 1,208 groundwater licenses have been issued for water diversion projects (Figures 293, 294, respectively) (AAFC-PFRA, 2008). They are distributed throughout the entire subwatershed.

About 4.87 million m^3 of surface and groundwater are diverted annually in the Kneehills Creek subwatershed (Government of Alberta, 2008d). The most prominent use of surface water is for irrigation (35% of total surface water diversions) and water management practices (26% of total surface water diversions), while the most prominent users of groundwater are agricultural operations (78% of total groundwater diversions) and municipalities (17% of total groundwater diversions) (Table 116). Nearly equal quantities of surface and groundwater are diverted in the subwatershed (49 and 51%, respectively) (Government of Alberta, 2008d). Additional groundwater diversion information is provided in HCL (2000a, 2002, 2005) and Stantec Consulting Ltd. (2005).

Table 116. Surface and groundwater diversions in the Kneehills 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	474,425	1,923,728
Commercial	18,051	51,800
Groundwater exploration	---	9,378
Habitat enhancement	207,220	---
Industrial	---	1,095
Irrigation	830,120	---
Management of fish	95,980	68,610
Municipal	---	419,649
Recreation	143,080	---
Water management	620,440	---
Total	**2,389,316**	**2,474,261**
Grand total		**4,863,576**

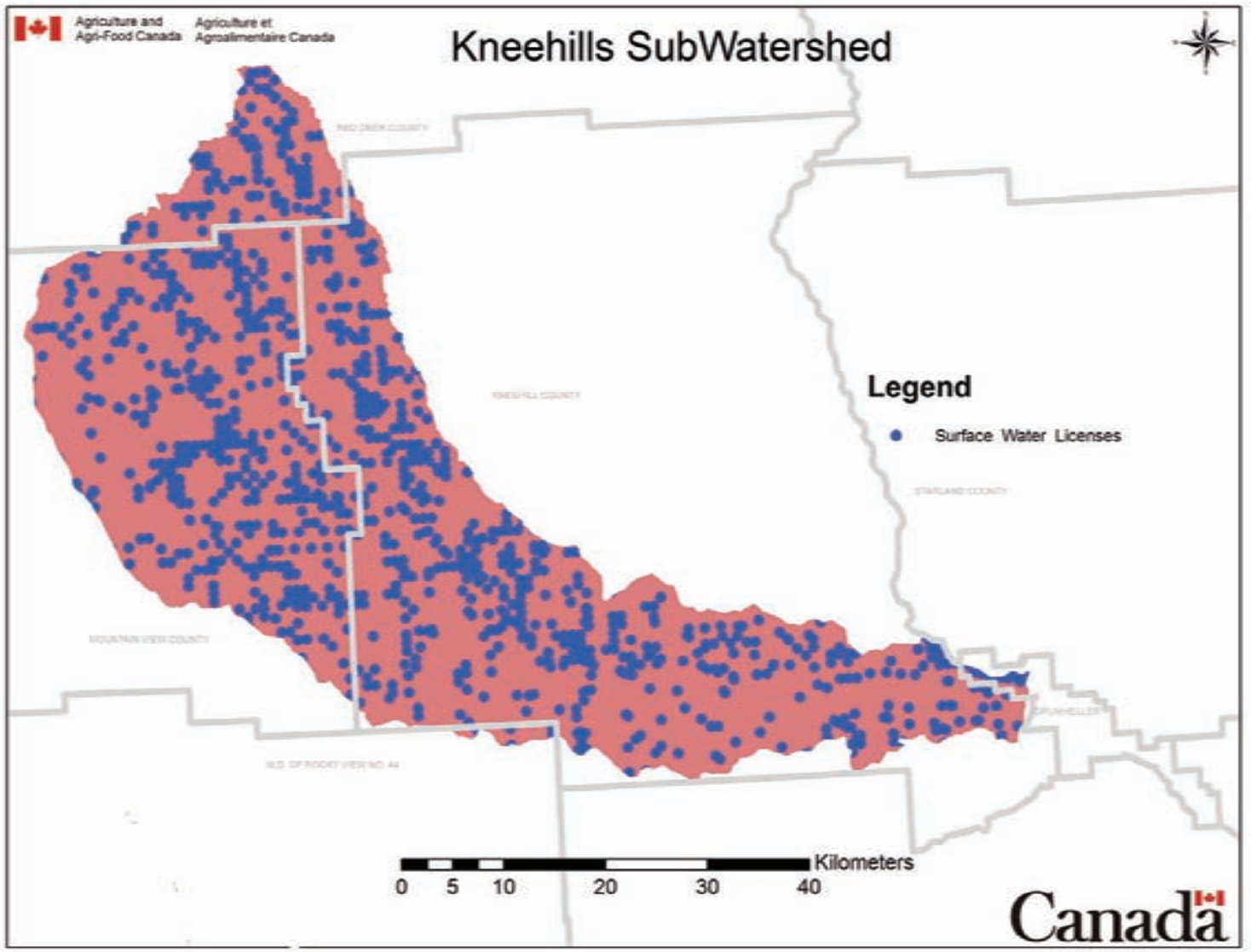


Figure 293. Surface water licenses in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

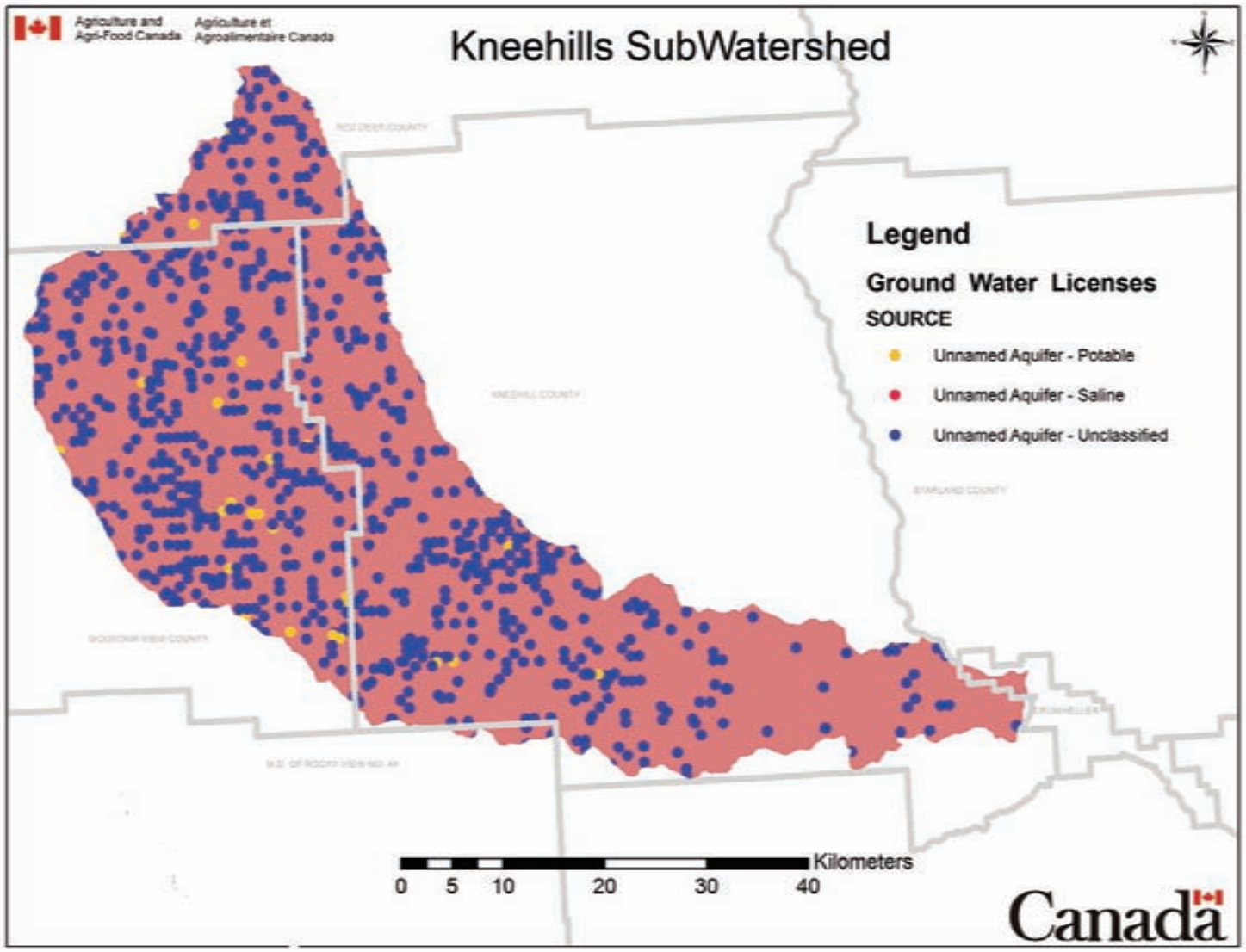


Figure 294. Groundwater licenses in the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

4.10.4.5 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 Kneehills Creek subwatershed has < 10 freshwater springs, the least of any of the 15 subwatersheds of the Red Deer River watershed. The freshwater springs are dispersed throughout the entire subwatershed. Consequently, there are no areas of high density of springs similar to other subwatersheds, e.g., the Threehills Creek subwatershed.

The Kneehills Creek subwatershed lies in the Counties of Kneehill, Mountain View and Red Deer and the Municipal District of Rocky View No. 44, for which groundwater assessments have been conducted by Stantec Consulting Ltd. (Kneehill County; 2005) and HCL (the remaining municipalities; 2000a, 2002, 2005). The assessments indicated that the area in the headwaters of Kneehills Creek and Lonepine Creek consists of similar proportions of groundwater recharge (i.e., water moves from the surface into groundwater reservoirs) discharge areas (i.e., water moves from groundwater reservoirs to the surface). In the lower reach of Kneehills Creek towards the Red Deer River, the area consists primarily of groundwater discharge areas. 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 (2000a, 2002, 2005) and Stantec Consulting Ltd. (2005).

4.10.5 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.

4.10.5.1 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 Kneehills Creek subwatershed.

4.10.5.2 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 population data were not located for any waterbody in the Kneehills Creek subwatershed.

4.10.5.3 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.

Table 117. Land cover in the Kneehills Creek subwatershed (AAFC-PFRA, 2008). The most prominent land cover types are highlighted.

Land cover type	Area (ha)	Proportion of subwatershed area (%)
Waterbodies	1,023	0.37
Exposed land	2,200	0.80
Developed land	2,262	0.83
Shrubland	2,840	1.04
Wetland	1,840	0.67
Grassland	10,447	3.82
Annual cropland	172,733	63.16
Perennial cropland/pastures	55,032	20.12
Coniferous forests	671	0.25
Deciduous forests	1,469	0.54
Mixed forests	2	0.00
No data	22,969	8.40
Total	**273,487**	

The majority of the land base of the Kneehills Creek subwatershed is covered by annual and perennial croplands/pastures (63% and 20%, respectively). The remaining land cover types cover < 5% individually (Figure 295, Table 117) (AAFC-PFRA, 2008).

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

4.10.5.4 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 Kneehills Creek subwatershed is home to one endangered species (piping plover, *C. melodus circumcinctus*), three threatened species (loggerhead shrike, *L. ludovicianus excubitorides*; peregrine falcon, *F. peregrinus anatum*; Sprague's pipit, *A. spragueii*) and three species of special concern (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.

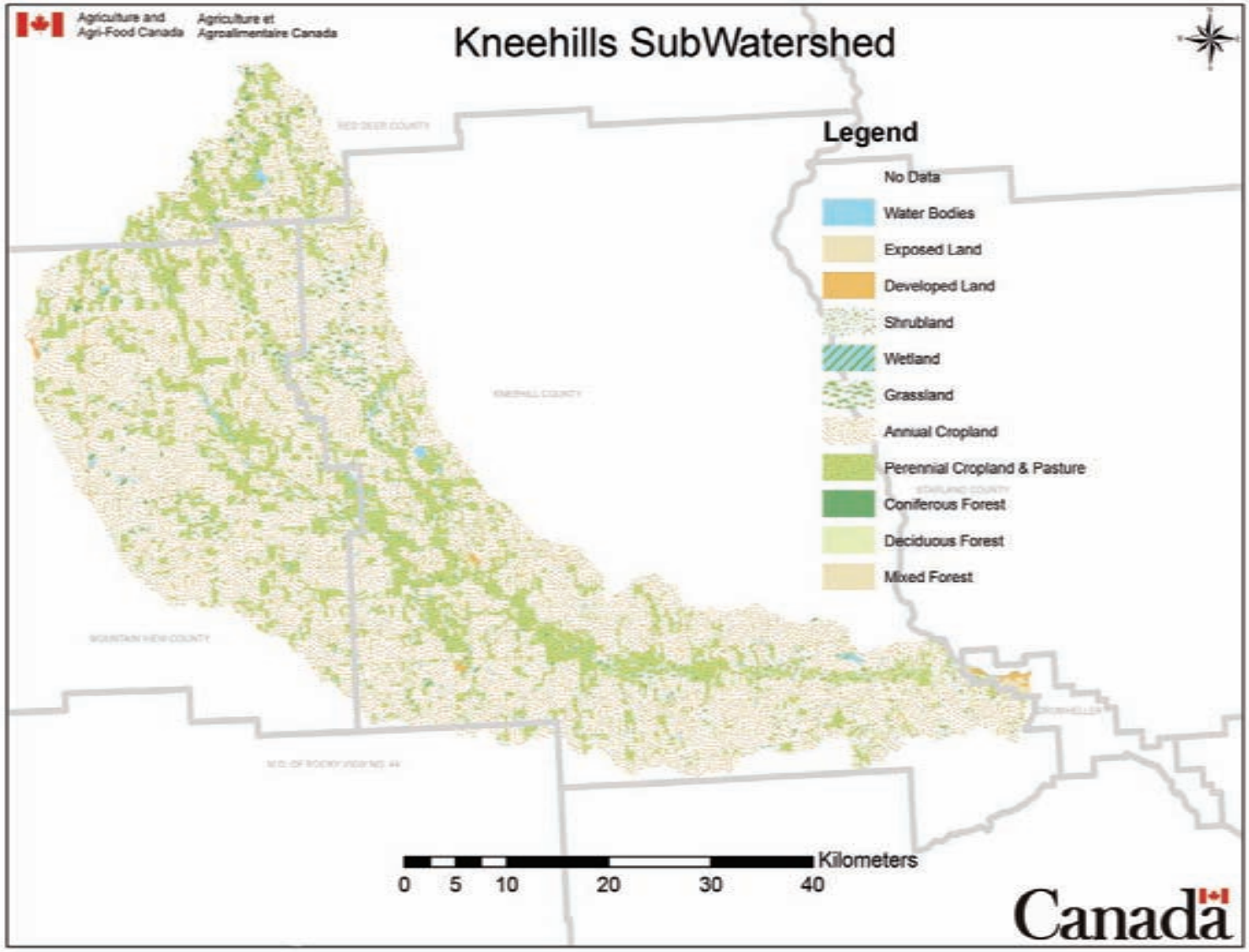


Figure 295. Land cover of the Kneehills Creek subwatershed (AAFC-PFRA, 2008).

4.10.6 Subwatershed Assessment

The Kneehills Creek subwatershed lies in the Central Parkland, Foothill Fescue and Northern Fescue Subregions and is characterized by medium to high livestock intensity and high to very high agricultural intensity relative to the Alberta average. There are over 100 feedlots in the subwatershed, located primarily in the Acme and Linden area. Resource exploration and extraction activities have contributed to a complex network of linear development (mostly roads) and the establishment of 4,027 wells (mostly for unspecified purposes). These land use practices have contributed to the deterioration of riparian zones and water quality. For example, TN and TP concentrations in Kneehills and Lonepine Creeks frequently exceed CCME PAL guidelines. Moreover, fecal coliform bacterial concentrations frequently exceed CCME Agriculture/Irrigation guidelines in Kneehills Creek. No parasite and pesticide data were located for any waterbody in the Kneehills Creek subwatershed. The only riparian health assessment for a small tributary stream of Kneehills Creek indicated a healthy with problem rating, which is likely indicative of other riparian zones in the subwatershed as well. Stream discharge rates range from 1-10 m^3/sec following the spring freshet. For the remainder of the year, discharge rates decrease substantially. Water resources are used primarily for agricultural practices, i.e., irrigation. In total, 2,896 water diversion licenses have been issued in the Kneehills Creek subwatershed, which permit the diversion of 4.86 million m^3 of water annually. Most of the watershed is covered by annual croplands, and although no biodiversity assessment and fish community data have been located, it is home to one endangered species, three threatened species and three species of special concern.

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 scientific 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 Kneehills Creek subwatershed receives a rating of “poor” for the condition indicators and a rating of “medium” for the risk indicators (Tables 118, 119). Overall, this subwatershed receives a ranking of “C”. There are substantial data gaps, and several of the condition rankings are based on limited data. Consequently, it is recommended to implement a detailed water quality sampling program, conduct a wetland inventory and regularly monitor riparian health conditions along the major waterbodies in the subwatershed. Of particular concern are (1) nutrient and fecal coliform 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, (3) the conversion of the landbase from its

natural state into annual and perennial croplands and pastures and (4) the high oil/gas well density, which represents a substantial risk to aquatic resources and habitats.

Table 118. Condition and risk indicator summary for the Kneehills Creek subwatershed. Gray logos indicate data gaps.

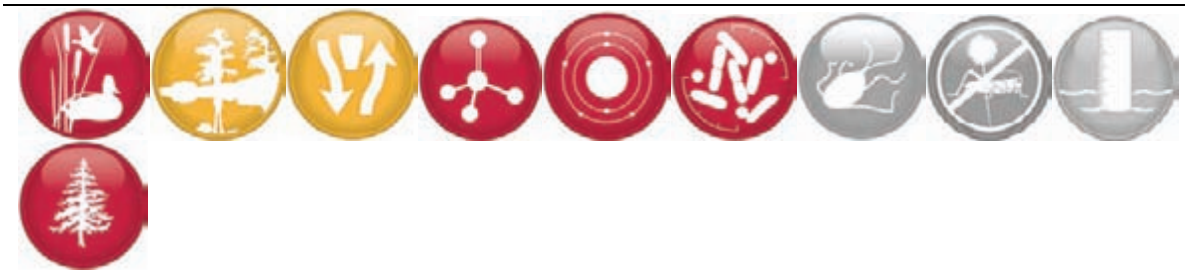
Condition Indicators

Risk Indicators


Table 119. Condition and risk assessments of the Kneehills Creek subwatershed. Indicators with a "poor" or "high" ranking are highlighted.

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