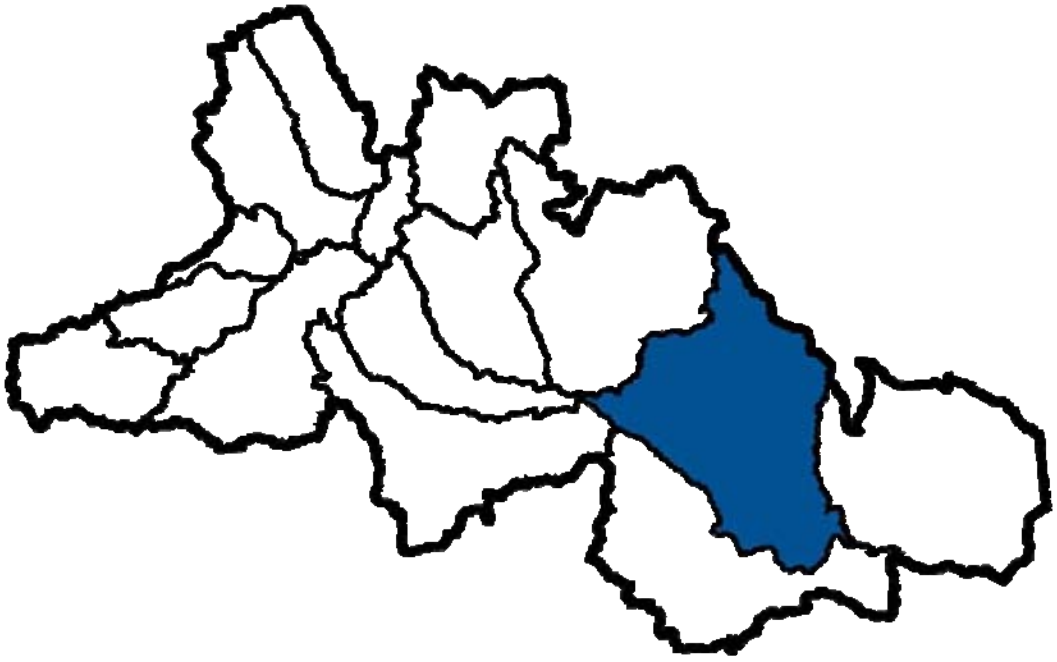
Berry Subwatershed



Red Deer River Watershed Alliance

State of the Watershed

4.13 Berry Creek Subwatershed

4.13.1 Watershed Characteristics

The Berry Creek subwatershed encompasses about 694,114 ha and is located in Paintearth and Starland Counties and Special Areas 2 and 3 (Figure 333).

The Berry Creek subwatershed is located in the east-central region of the Red Deer River watershed. The subwatershed lies in the Northern Fescue, Dry Mixedgrass and Mixedgrass Subregions (Figure 334). The Northern Fescue Subregion occurs in the north-western areas of the subwatershed and is dominated by rough fescue (*F. campestris*). The Dry Mixedgrass Subregion is predominant throughout the subwatershed and is dominated by spear grass (*Piptochaetium* spp.), blue grama (*B. gracilis*), western wheat grass (*P. smithii*) and northern wheat grass (*E. lanceolatus*). The vegetation of the Mixedgrass Subregion, occurring only south of Little Fish Lake, is similar to the Dry Mixedgrass Subregion; however, it is characterized by greater biomass production and a greater abundance of species that tend to favour cooler and moister sites. The majority of Mixedgrass vegetation is dominated by spear grass (*Piptochaetium* spp.), western porcupine grass (*H. spartea*), western wheat grass (*P. smithii*) and northern wheat grass (*E. lanceolatus*). Although much of the natural vegetation has been replaced by agricultural crops in the latter two Subregions, extensive areas of native rangeland remain, which are managed primarily for grazing by domestic livestock (Heritage Community Foundation, 2008).

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

The climate of the Berry Creek subwatershed is continental, with mean annual temperatures ranging from 3-5 °C, and mean May-September temperatures ranging from 11-15 °C. The mean annual precipitation ranges from 350-500 mm, with the May-September precipitation averaging 280-300 mm (Environment Canada, 2006).

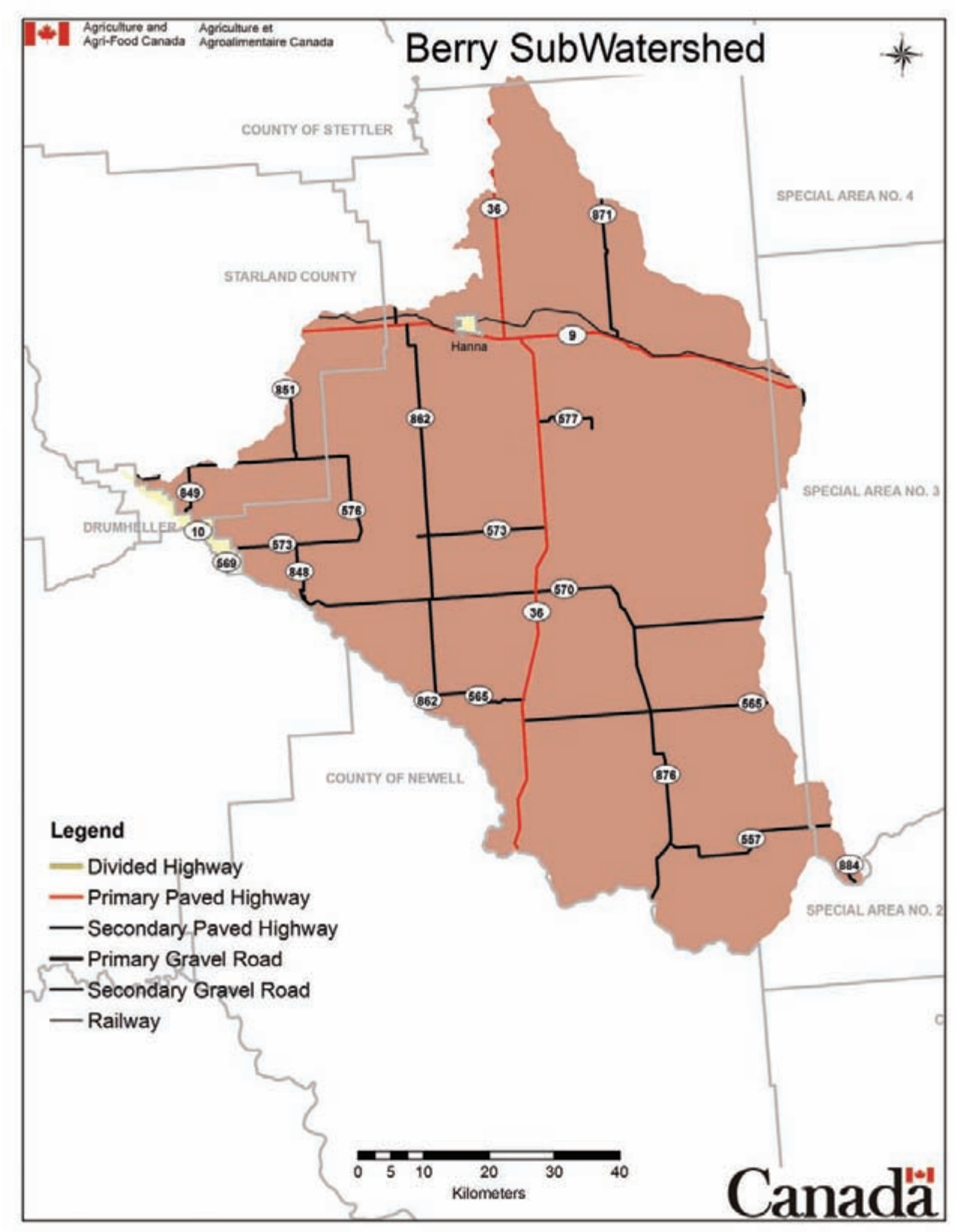


Figure 333. Location of the Berry Creek subwatershed (AAFC-PFRA, 2008).

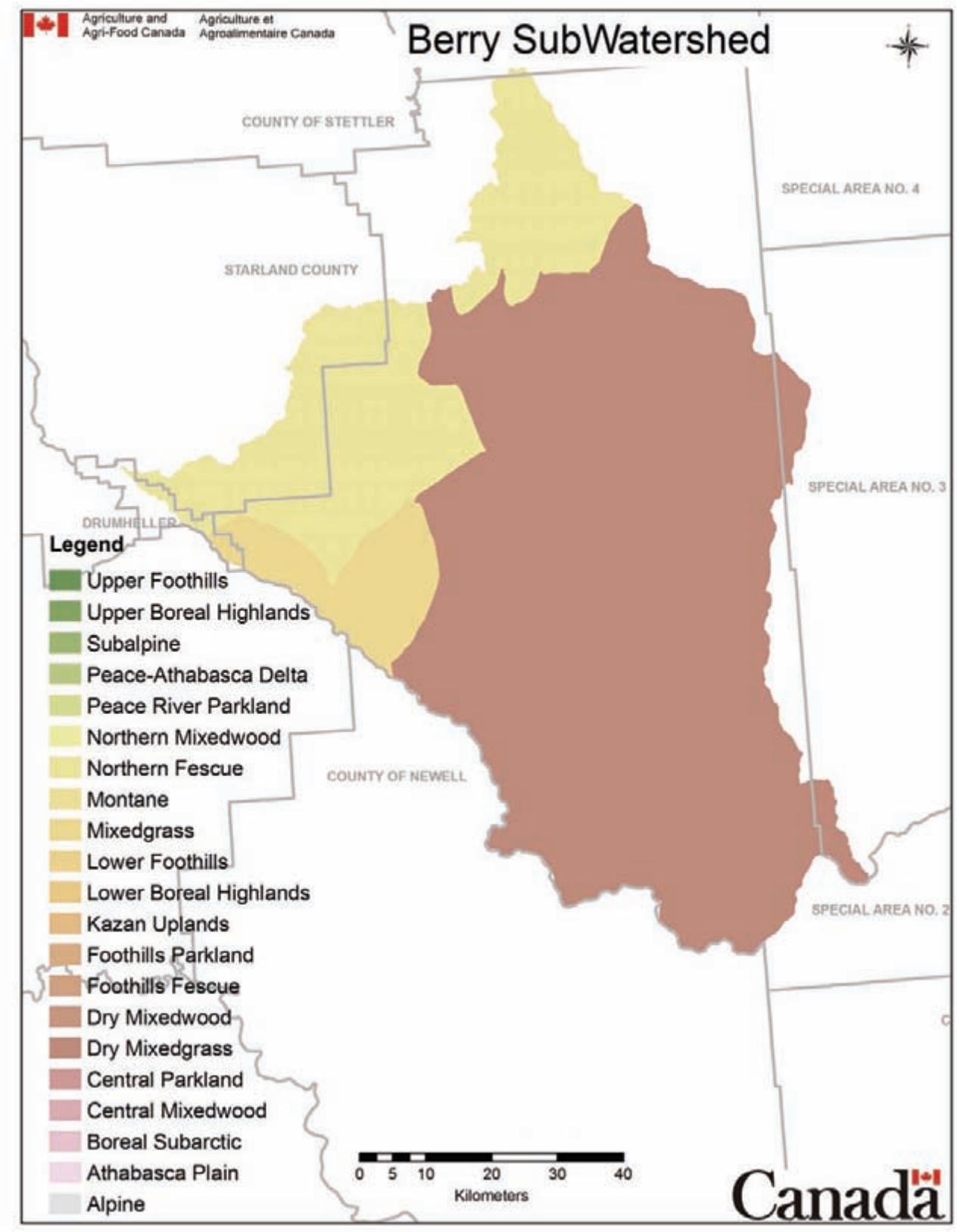


Figure 334. Natural subregions of the Berry Creek subwatershed (AAFC-PFRA, 2008).

4.13.2 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.

4.13.2.1 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 22,659 ha of wetlands (3.26% of the total subwatershed area) in the Berry Creek subwatershed (AAFC-PFRA, 2008). Patterned and non-patterned open fens occur near upper Willow Creek (Twp. 56, Rge. 23, W 5) (Sweetgrass Consultants Ltd., 1994; Geowest Environmental Consultants Ltd., 1995). There are no data on any other classes, forms and types of wetlands (*sensu* National Wetlands Working Group, 1997) within the subwatershed; however, given the presence of lentic (lakes) and lotic (streams and rivers) systems, marshes and shallow open water wetlands are likely also present in the subwatershed. In addition, ephemeral, temporary, seasonal and semi-permanent wetlands (*sensu* Stewart and Kantrud, 1971) are likely present in the subwatershed as well.

The Prairie Habitat Joint Venture program (a partnership between federal and provincial governments, organizations and conservation groups in Manitoba, Saskatchewan and Alberta) has assessed the loss of wetlands in the Grassland Natural Region (in the Dry Mixedgrass Subregion, the dominant Subregion in the Berry Creek watershed) from 1985-2001 (Watmough and Schmoll, 2007). In Alberta, the Grassland Natural Region has lost 7% of its total wetland area and 9% of its total number of wetlands due to anthropogenic disturbances in that 16-year period. There appears to be no change in the rate of wetland loss in the Prairie Parkland Region over the past 50-70 years. Caution must be taken when extrapolating these data to the entire subwatershed, since the Prairie Habitat Joint Venture program has

assessed wetland losses along only one transects in the Grassland Natural Region and none in the less prominent Parkland Natural Region in this subwatershed (Watmough and Schmoll, 2007).

4.13.2.2 Riparian Health

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

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

4.13.2.3 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 five feedlots/intensive livestock operations in the Berry Creek subwatershed, located primarily in the Dorothy-Hanna corridor (Figure 335) (AAFC-PFRA, 2008). The feedlots rear and/or finish swine and poultry.

Cattle density ranges from 0-0.20 cattle/ha throughout most of the subwatershed but increases to 0.21-0.40 cattle/ha in the southwestern area of the subwatershed and east of Sullivan and Dowling Lakes (Figure 336) (AAFC-PFRA, 2008). Manure production ranges from 0.2-2.5 tonnes manure/ha throughout the entire subwatershed (Figure 337) (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, ranges from 0-20% for most of the subwatershed and increases to primarily 20-40% only in the northern and north-western areas of the subwatershed. It peaks at 60-80% east of Drumheller (Figure 338) (AAFC-PFRA, 2008).

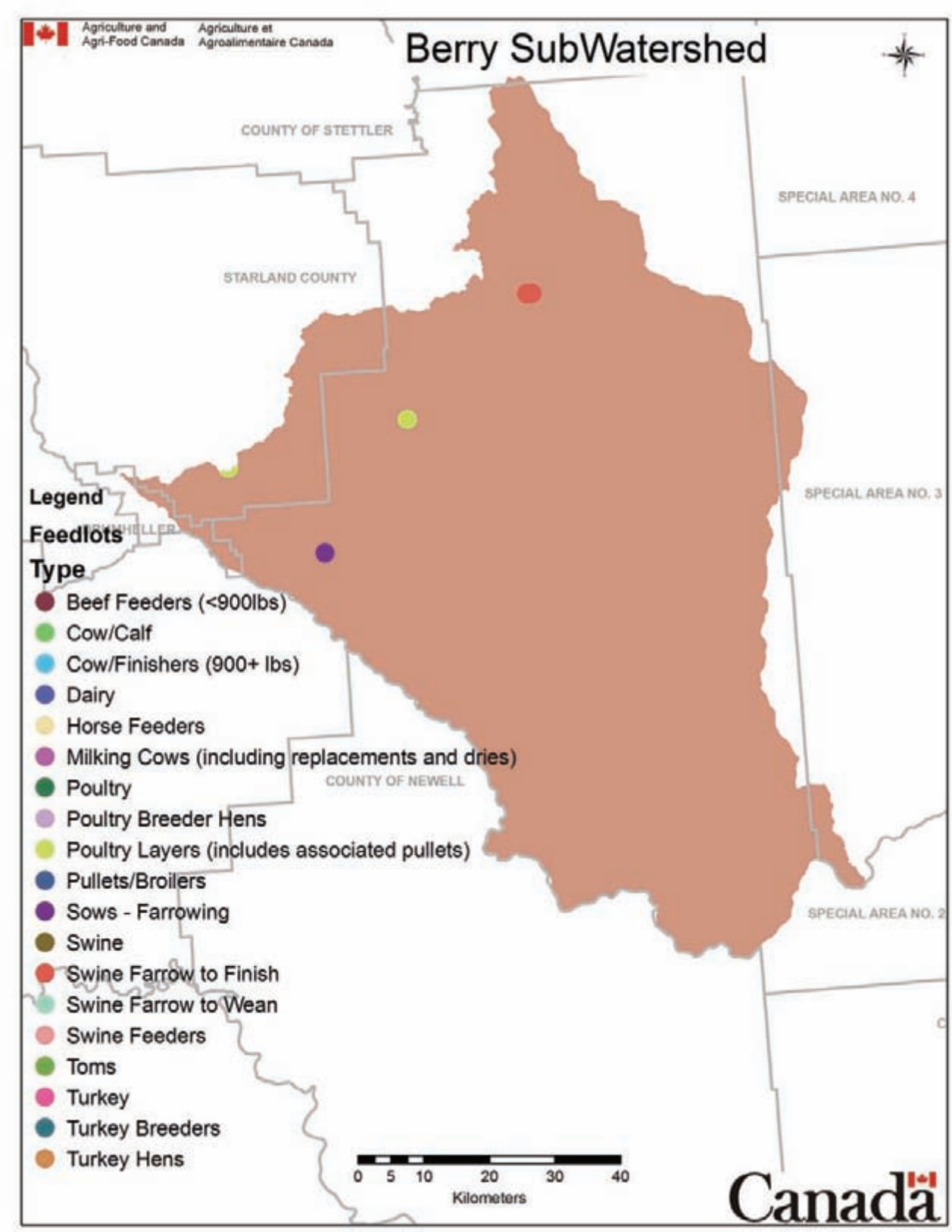


Figure 335. Feedlots and intensive livestock operations in the Berry Creek subwatershed (AAFC-PFRA, 2008).

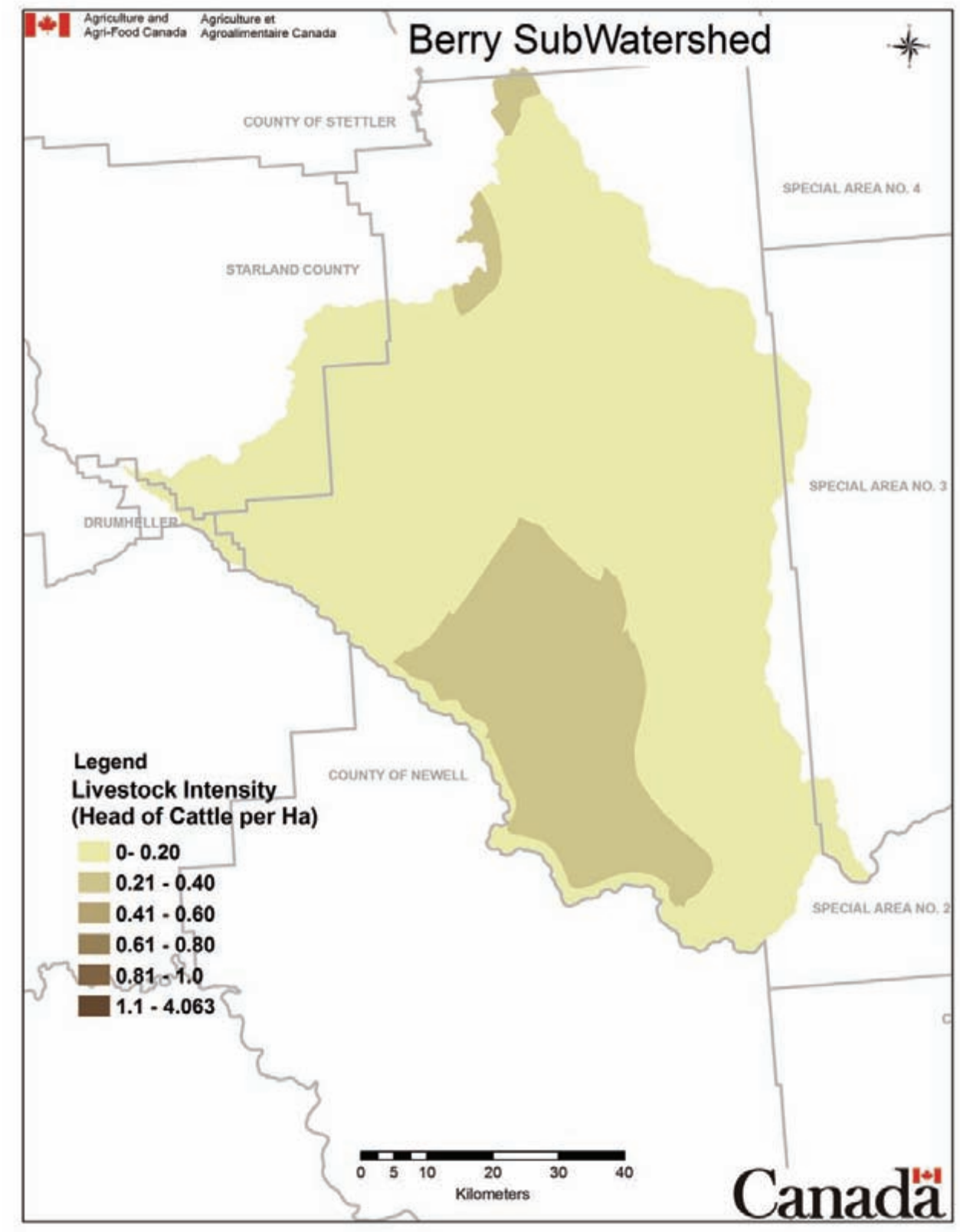


Figure 336. Cattle density (cattle/ha) in the Berry Creek subwatershed (AAFC-PFRA, 2008).

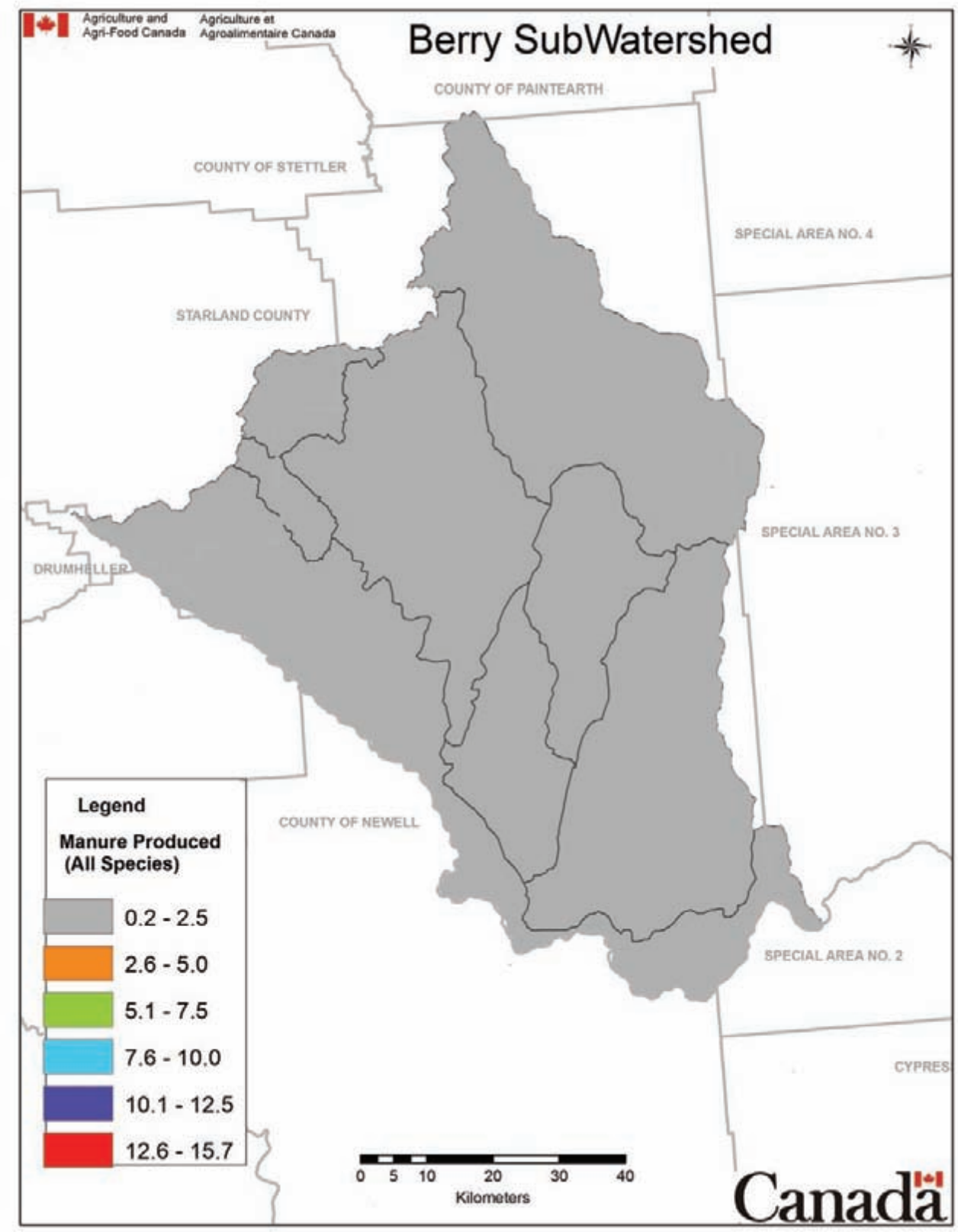


Figure 337. Manure production (tonnes/ha) in the Berry Creek subwatershed (AAFC-PFRA, 2008).

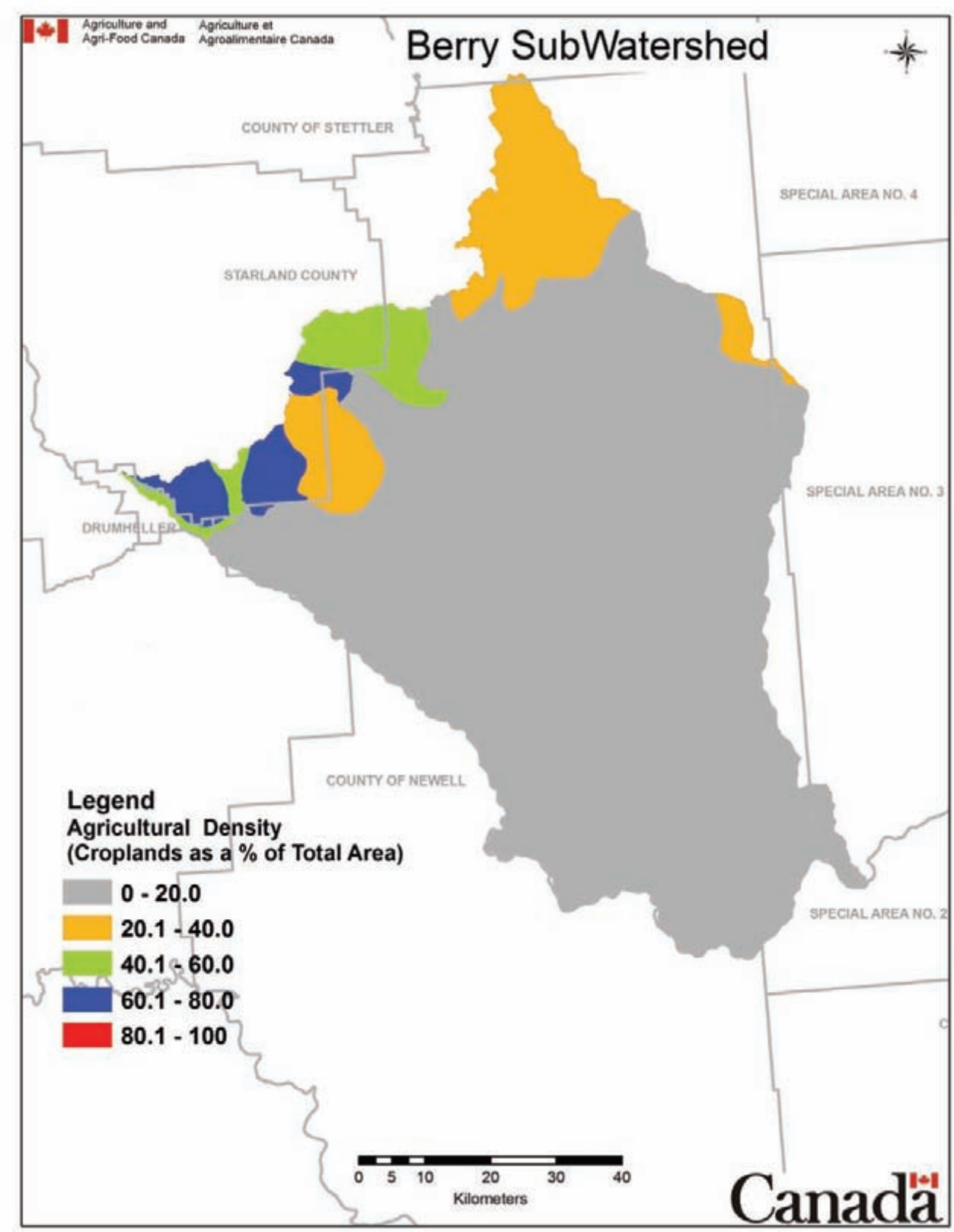


Figure 338. Agricultural intensity (% cropland) in the Berry Creek subwatershed (AAFC-PFRA, 2008).

4.13.2.4 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 Berry Creek subwatershed include Town of Hanna, the Village of Youngstown and numerous hamlets, including Aerial, Batter, Batter Junction, Bonar, Cessford, Clivale, Dorothy, East Coulee, Eladesor, Finnegan, Fish Creek, Galarneauville, Howie, Hutton, Lawsonburg, Lehigh, Lonebutte, Millerfield, Pollockville, Rainbow, Richdale, Rose Lynn, Scotfield, Sheerness, Stanmore, Sunnynook, Taplow, Togo Lake, Wardlow, Watts and Willow Creek (Government of Canada, 2006). There are two Provincial Parks (PP) in the subwatershed (Table 139) (Alberta Tourism, Parks and Recreation, 2008b).

Table 139. Recreational facilities in the Berry Creek subwatershed (Alberta Tourism, Parks and Recreation, 2008b).

Facility	Characteristics
Dinosaur PP	• 8085.96 ha on the Red Deer River • 126 unit campgrounds (59 with electrical hookups), 10 unit group campgrounds, visitor centre • UN World Heritage Site
Little Fish Lake PP	• 61.19 ha on Little Fish Lake • 14 unit campgrounds

Note: PP = provincial park.

Visitation statistics for Little Fish Lake PP indicate that the number of visitors to this recreation facility has been relatively consistent on an annual basis (Figure 339). For those years with available data, the average number of visitors per year was 753 from 1994-2003, with a peak of 1,063 visitors in 1996, although the number of visitors is likely substantially higher due to the absence of group camp data in 2000 and 2001 (Alberta Tourism, Parks and Recreation, 2008b).

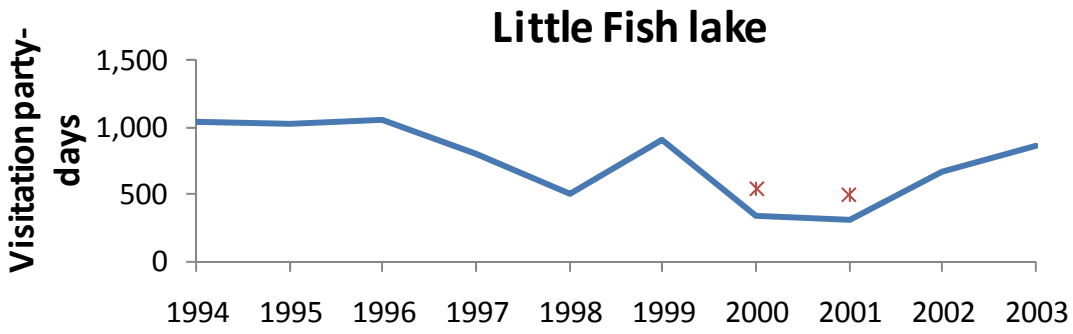


Figure 339. Visitation statistics for Little Fish Lake Provincial Park in the Berry Creek subwatershed (Alberta Tourism, Parks and Recreation, 2008b). Asterisks indicate years for which group camp data were not available.

4.13.2.5 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 Berry Creek subwatershed are urban and rural roads, which have a total length of 4,900 km and cover 78.4 km^2 of the subwatershed's landbase. Other major linear developments include pipelines and cutlines/trails (Table 140). In total, all linear developments cover an area of 159.7 km^2, or 2.3% of the total area of the subwatershed (Figure 340) (AAFC-PFRA, 2008).

Table 140. Linear developments in the Berry 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	4,900	16	78.40	49.1
Cutlines/trails	4,400	6	26.40	16.5
Pipelines	2,800	15	42.00	26.3
Powerlines	330	30	9.90	6.2
Railways	201.2	15	3.02	1.9
Total	**12,631**		**159.72**	

In addition to linear developments, the Berry Creek subwatershed has 342 bridges that cross waterbodies, mostly streams and creeks, or culverts that connect waterbodies. These are primarily associated with Berry Creek, East Berry Creek and Bullpound Creek (Figure 341) (AAFC-PFRA, 2008). Pipeline crossings are distributed throughout the Berry Creek subwatershed, although their density is lower north of Dinosaur Provincial Park and east of Cessford. The highest density of pipeline crossings occurs in the central area of the subwatershed, particularly south of Little Fish Lake and near Berry Creek and McBride Reservoirs (Figure 342) (AAFC-PFRA, 2008).

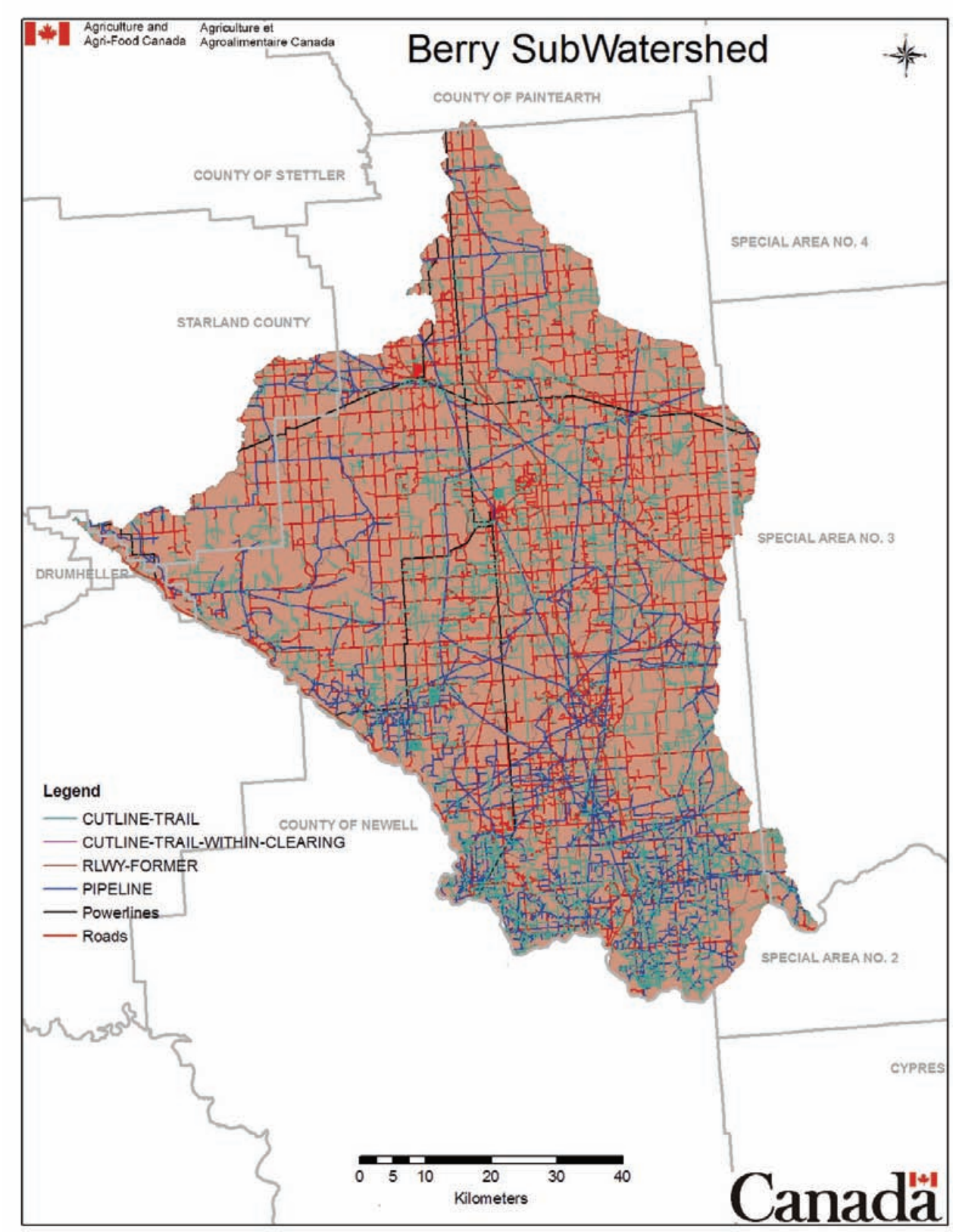


Figure 340. Linear developments in the Berry Creek subwatershed (AAFC-PFRA, 2008).

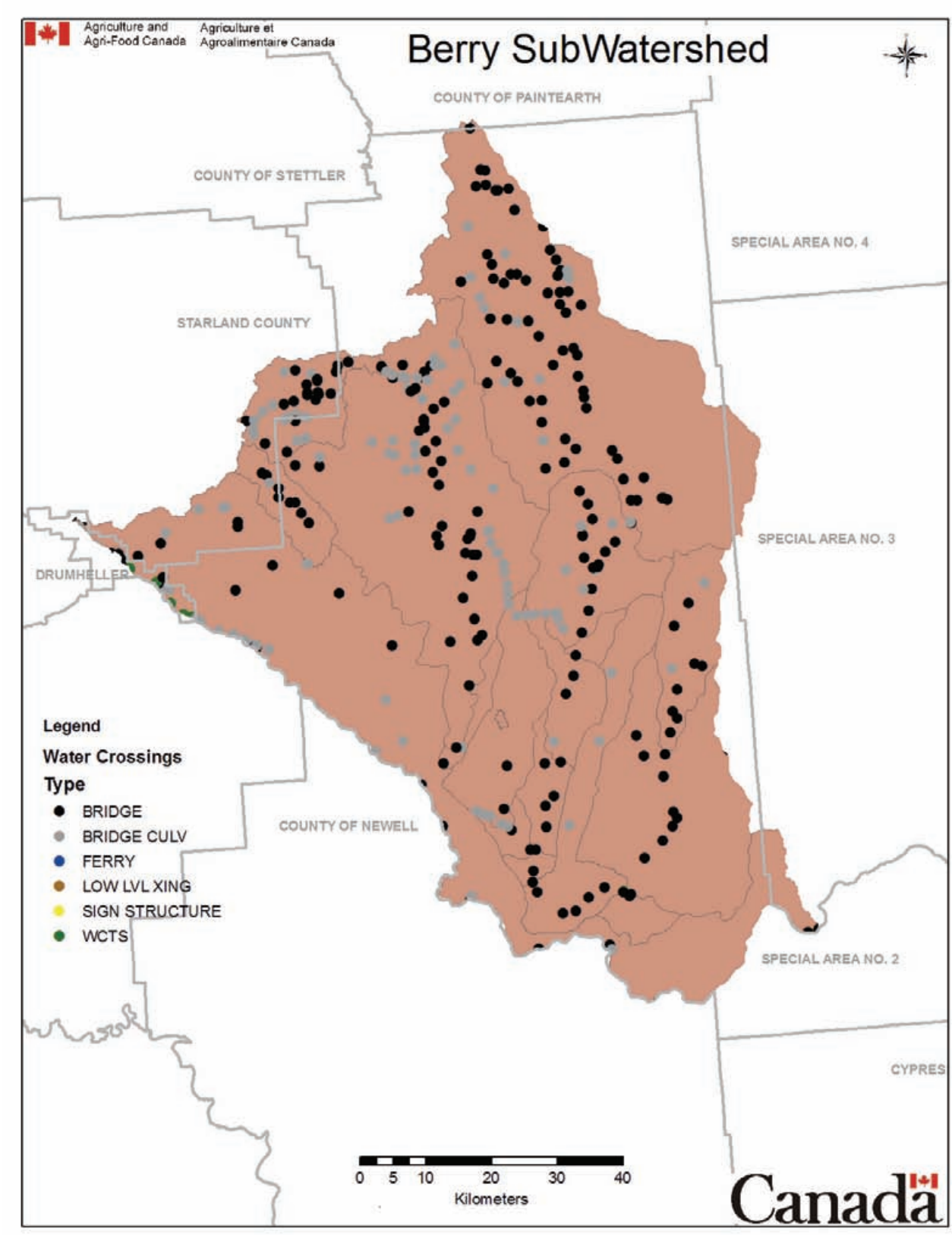


Figure 341. Waterbody crossings in the Berry Creek subwatershed (AAFC-PFRA, 2008).

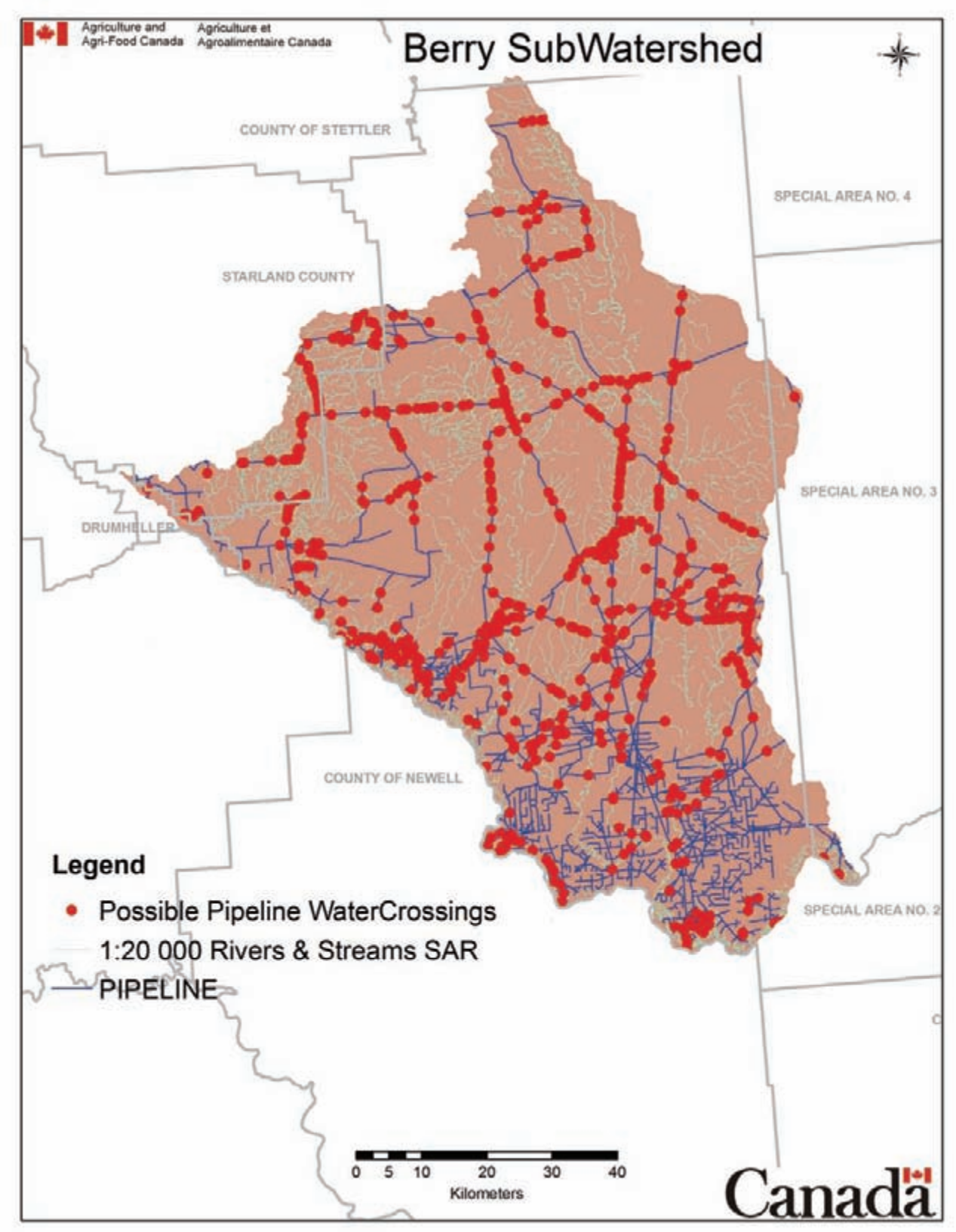


Figure 342. Pipeline crossings over waterbodies in the Berry Creek subwatershed (AAFC-PFRA, 2008).

4.13.2.6 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 Berry Creek subwatershed has an average well density of 1.98 wells/km^2; however, well density increases up to 10 wells/km^2 south-east of Drumheller and in the Cessford-Pollickville-Sunnynook area. Well densities are highest near Cessford and north of Pollickville, where they reach up to 40 wells/km^2 (Figure 343). About 72% of all wells are active, with the majority being gas wells, followed by unspecified and oil wells (Table 141) (AAFC-PFRA, 2008).

Table 141. Number of known active and abandoned oil, gas, water and other wells in the Berry Creek subwatershed (AAFC-PFRA, 2008).

Well type	Quantity
Wells – active *	1,201
Wells – abandoned *	2,629
Total	**3,830**
Gas wells – active	7,855
Gas wells – abandoned	866
Total	**8,721**
Oil wells – active	724
Oil wells – abandoned	384
Total	**1,108**
Water wells – active	61
Water wells – abandoned	33
Total	**94**
Total active wells in subwatershed	**9,841**
Total abandoned wells in subwatershed	**3,912**
Total wells in subwatershed	**13,753**

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

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

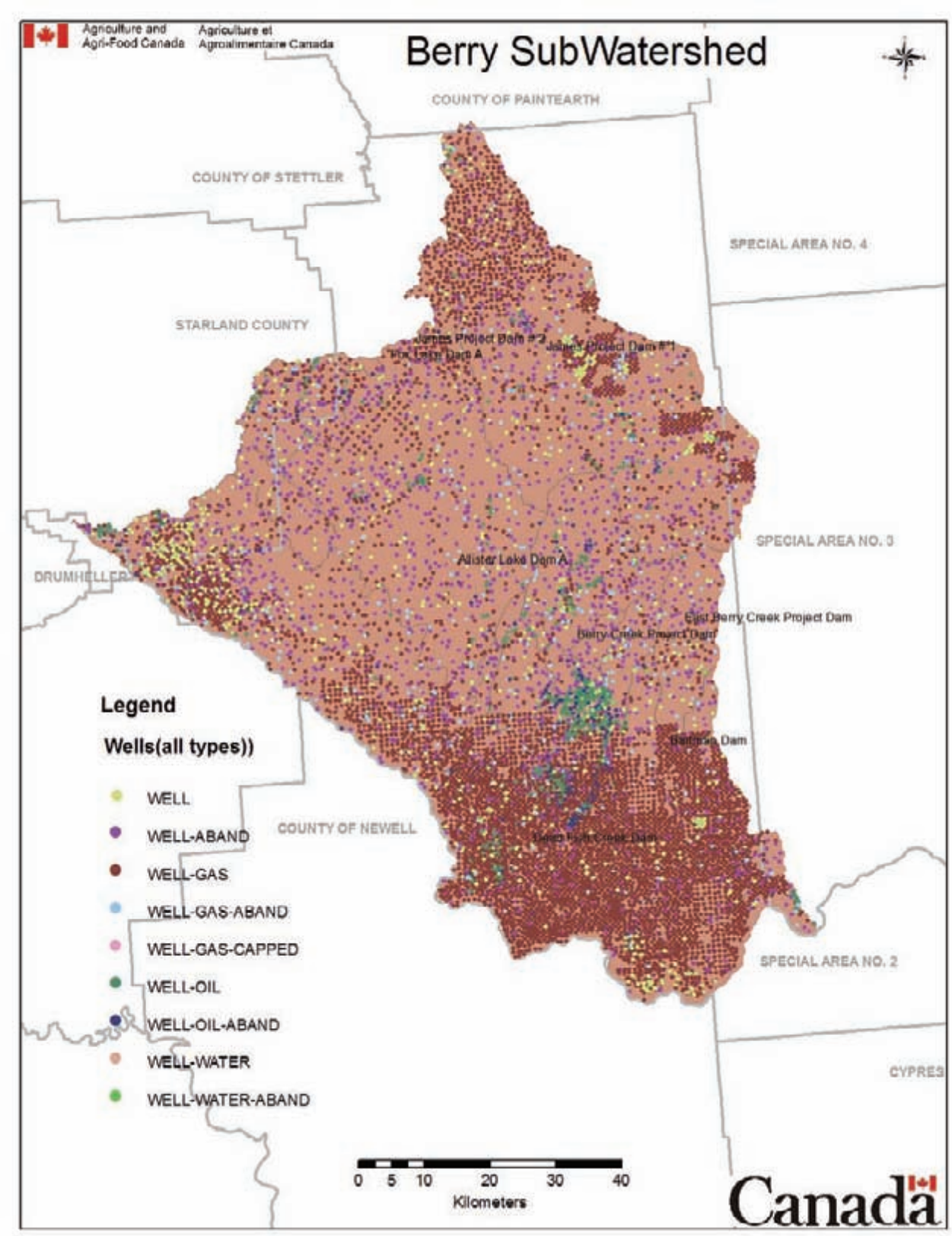


Figure 343. Known active and abandoned oil, gas, water and other wells in the Berry Creek subwatershed (AAFC-PFRA, 2008).

4.13.3 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.

4.13.3.1 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.

TP and TN concentrations in Berry Creek and Bullpound Creek exceeded CCME PAL guidelines (0.05 mg/L and 1.0 mg/L, respectively) (Table 142). 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 Berry Creek subwatershed and may contribute to the nutrient loading of both creeks.

4.13.3.2 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.

Bacterial concentrations have been assessed in the two largest creeks in the subwatershed: Berry Creek and Bullpound Creek (Table 142). Concentrations in neither creek exceeded CCME Agriculture/Irrigation guidelines.

Table 142. Water quality in the Berry Creek subwatershed. n = sample size. All concentrations in mg/L unless otherwise noted. Concentrations exceeding water quality guidelines are highlighted *.

Parameter	Berry Creek		Bullpound Creek	
	Mean	n	Mean	n
TP	0.219	14	0.091	2
TDP	0.032	4	0.047	2
TN	1.363	16	1.086	2
NO_3^--NO_2^-	0.014	14	0.006	2
NH_3	0.075	11	0.500	2
DO	8.87	12	7.39	2
Chl. *a* (µg/L)	---	---	---	--
pH	7.86	15	7.84	2
Specific Conductivity (µS/cm)	585	16	1,059	2
TDS	---	---	---	--
Total coliforms (CFU/100 mL)	77	10	---	--
Fecal coliforms (CFU/100 mL)	88	14	60	2

* TN from ASWQG PAL chronic exposure guideline; fecal and total coliforms from CCME-Agriculture/Irrigation guideline; all others from CCME PAL. In Berry Creek, water samples were collected October-March 1993, July 1996, and July-August 1998; in Bullpound Creek, water samples were collected July 1996 and July 1998 (data from Alberta Environment). Variable abbreviations as in Table 10.

4.13.3.3 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 Berry Creek subwatershed.

4.13.3.4 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 Berry Creek subwatershed.

4.13.3.5 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 50 upstream oil/gas facilities, 1 mining operation and 1 power generation facility have released pollutants continuously or sporadically into the air in the Berry Creek subwatershed since 2000. Pollutants from the upstream oil/gas facilities include carbon monoxide (CO), nitrous oxide (N_2O) and particulate matter < 10 µm in size. The pollutants from the mining operation (coal) are limited to particulate matter < 10 µm in size (NPRI, 2008), although records prior to 2006 do not exist, since pollutant releases did not have to be reported to the National Pollution Release Inventory from this sector. The power generation facility has released a myriad of pollutants into the air, landfilled them on-site or recycled them off-site. These pollutants include CO, N_2O, sulphur dioxide (SO_2), particulate matter < 10 µm in size, hydrochloric acid (HCl), sulphuric acid (H_2SO_4), hydrocarbons (e.g., dioxins, furans) and heavy metals (e.g., As, Cd, Co, Cr, Cu, Hg, Mn, Ni, Pb, Va and Zn). No pollutants were released directly into aquatic ecosystems according to the National Pollution Release Inventory.

4.13.4 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.

4.13.4.1 Volume

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

The total length of all water courses in the Berry Creek subwatershed is about 4,273 km (Figure 344) (AAFC-PFRA, 2008). The major streams in the subwatershed are Berry Creek, Bullpound Creek, Deadfish Creek, Dip Creek, East Berry Creek, Fish Creek, Galarneau Creek and Homestead Creek. The largest lakes and reservoirs in the subwatershed include Bartman, Berry Creek, Cessford, East Berry, Forster and McBride Reservoirs as well as Antelope, Coleman, Contracosta, Coyote, Handhills, Little Fish, Oakland, Plover, Traung and St. Louis lakes. There are numerous additional smaller creeks and slough in the subwatershed (Government of Canada, 2006).

Alberta Environment has been monitoring water discharge rates in the Berry Creek subwatershed at 19 locations: Bullpound Creek near Hutton (discontinued, 05CG001), Bullpound Creek near Hanna (discontinued, 05CG002), Bullpound Creek near the mouth (discontinued, 05CG003), Bullpound Creek near Watts (active, 05CG004), Fish Creek above Little Fish Lake (active, 05CG006), Berry Creek at Forster's Ranch (discontinued, 05CH001), Berry Creek near Wardlow (discontinued, 05CH002), East Berry Creek near Wardlow (discontinued, 05CH003), Berry Creek ranching company ditch near Wardlow (discontinued, 05CH004), Deadfish Creek near Hutton (discontinued, 05CH005), Bartman Reservoir on East Berry Creek near Wardlow (discontinued, 05CH006), Berry Creek near the mouth (active, 05CH007), Berry Creek near Rose Lynn (real-time active, 05CH008), Berry Creek near Pollockville (discontinued, 05CH010), Berry Creek Reservoir outlet (active, 05CH011), Deadfish Creek inflow canal near Cessford (discontinued, 05CH012), Forster Reservoir near Cessford (active, 05CH013), Berry Creek Reservoir near Sunnynook (active, 05CH014) and Berry Creek below confluence with Deadfish Creek (discontinued, 05CH016) (Government of Alberta, 2008c).

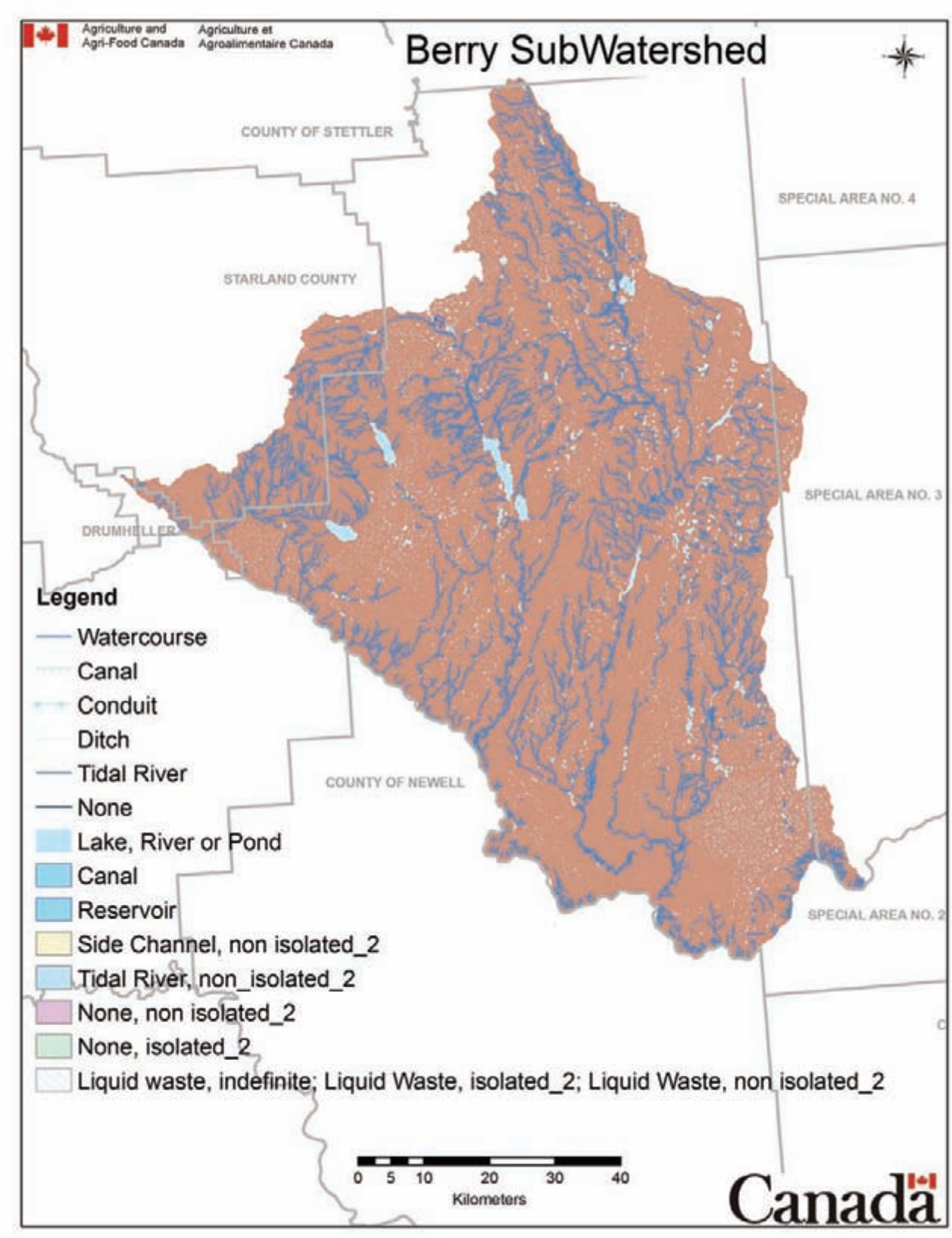


Figure 344. Waterbodies in the Berry Creek subwatershed (AAFC-PFRA, 2008).

In Berry Creek near Rose Lynn, water discharge rates are generally < 0.03 m^3/sec, although maxima of 0.3 m^3/sec have been reached in the past. Water discharges usually only in the spring (April) before decreasing and ultimately ceasing for the remainder of the year. In 2008, the only discharge of about 0.25 m^3/sec occurred in late October (Figure 345) (Government of Alberta, 2008c).

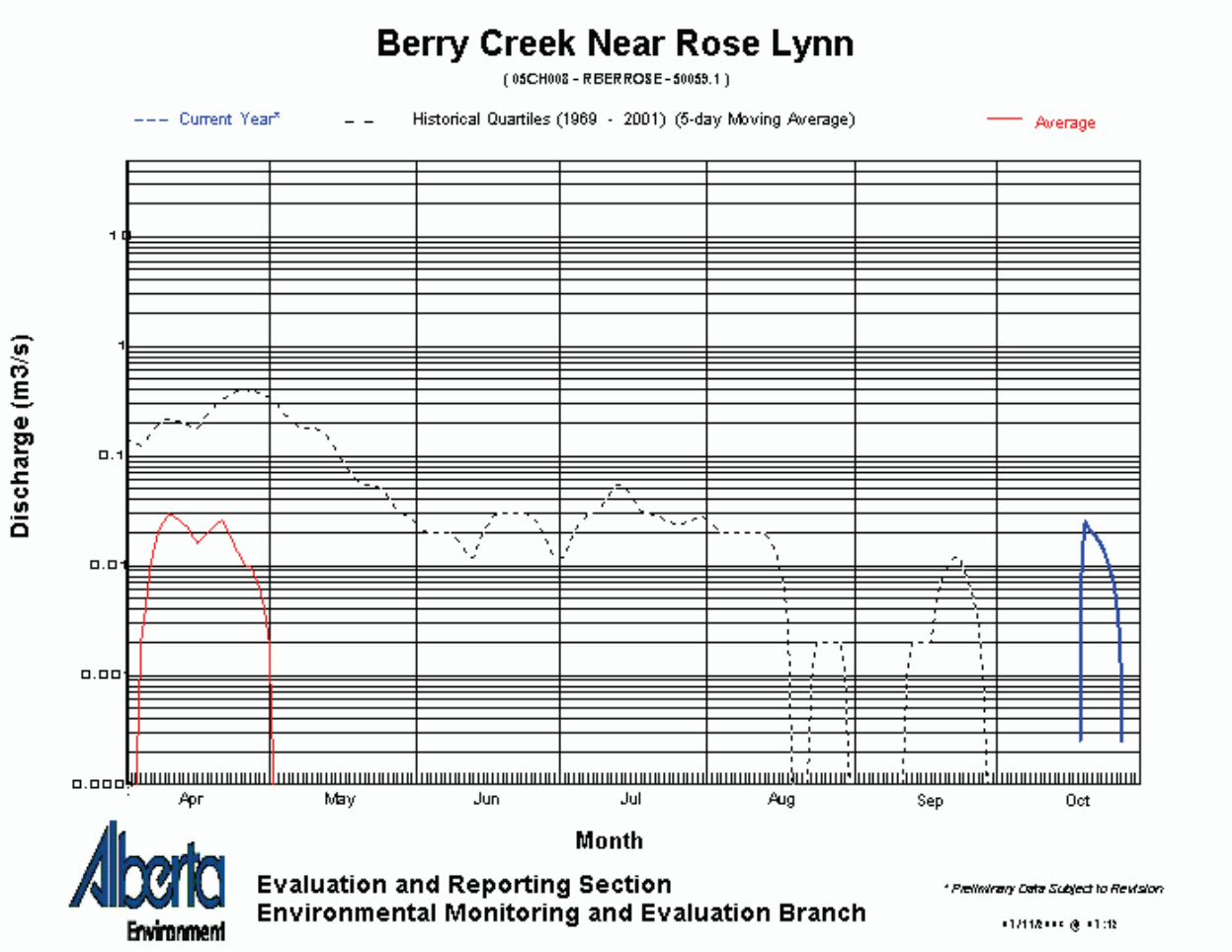


Figure 345. Discharge rates in Berry Creek near Rose Lynn (Government of Alberta, 2008c). "Current year" indicates water discharge rates in 2008.

There are nine major dams in the Berry Creek subwatershed (Figure 346). The southern-most dam in the subwatershed is Deadfish Creek Dam west of Cessford. On East Berry Creek, the Bartman Dam creates Bartman Reservoir east of Pollickville and the East Berry Creek Dam Project has created McBride Reservoir in the headwaters of the creek. Carolside Reservoir is created by the Berry Creek Project dam near Sunnynook. In the headwaters of Berry Creek, James Project Dams 1 and 2 are located on tributaries of Berry Creek. Fox Lake Dam A is located on a tributary of Bullpound Creek east of Hanna. In addition, Allister Lake Dam A is located on Allister Lake in the central area of the subwatershed. In addition, there are numerous smaller water infrastructures in the subwatershed, e.g., small dams, sluices, weirs and dykes, which control water flow.

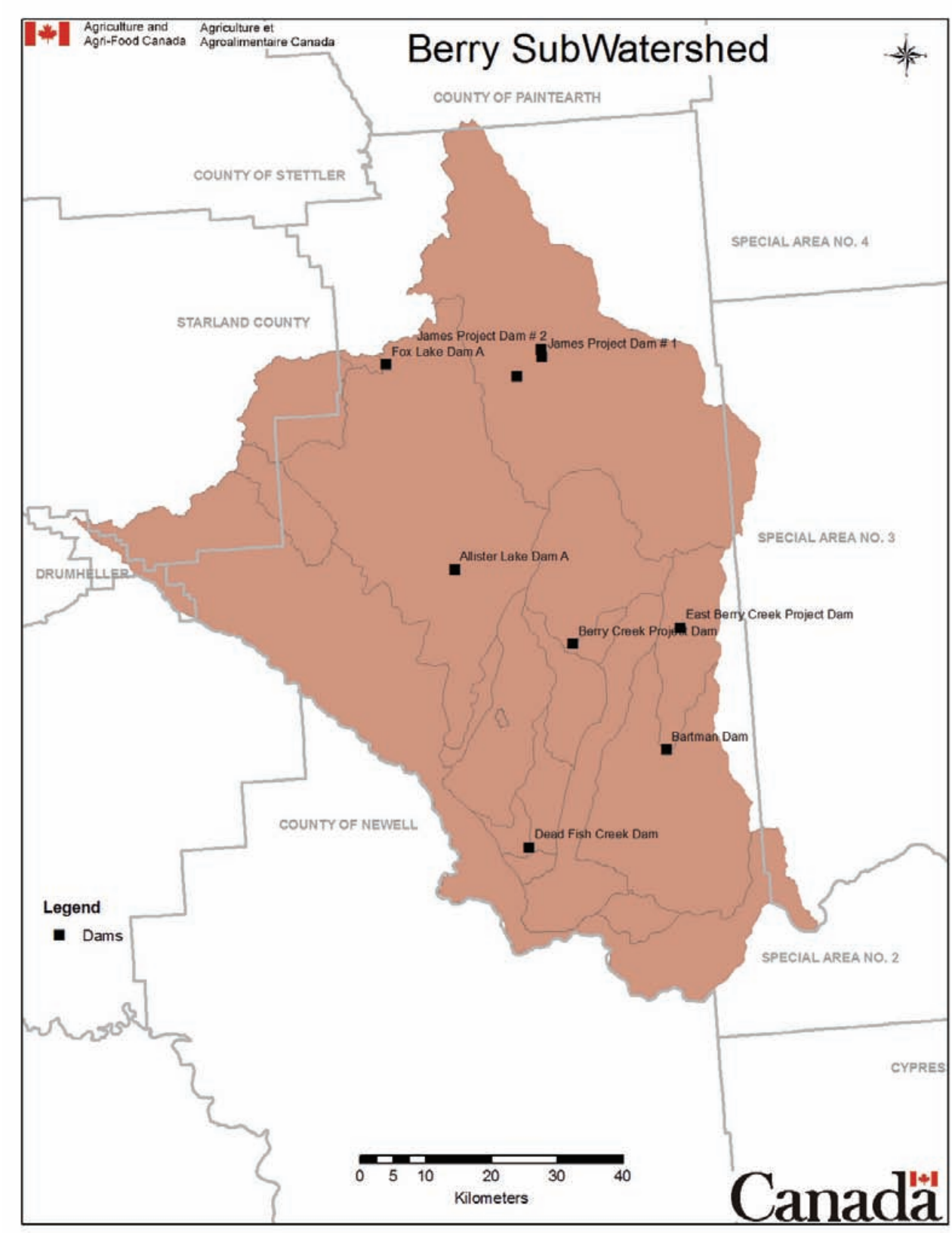


Figure 346. Major dams in the Berry Creek subwatershed (AAFC-PFRA, 2008).

4.13.4.2 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 Berry Creek subwatershed.

4.13.4.3 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 Berry Creek subwatershed, 344,450 ha (or 50.4% of the total area of the subwatershed) of land do not contribute to the drainage of the subwatershed (Figure 347). These areas are located throughout the entire subwatershed and include primarily areas not in the vicinity of creeks and streams and with a relatively flat topography (Figure 348) (AAFC-PFRA, 2008).

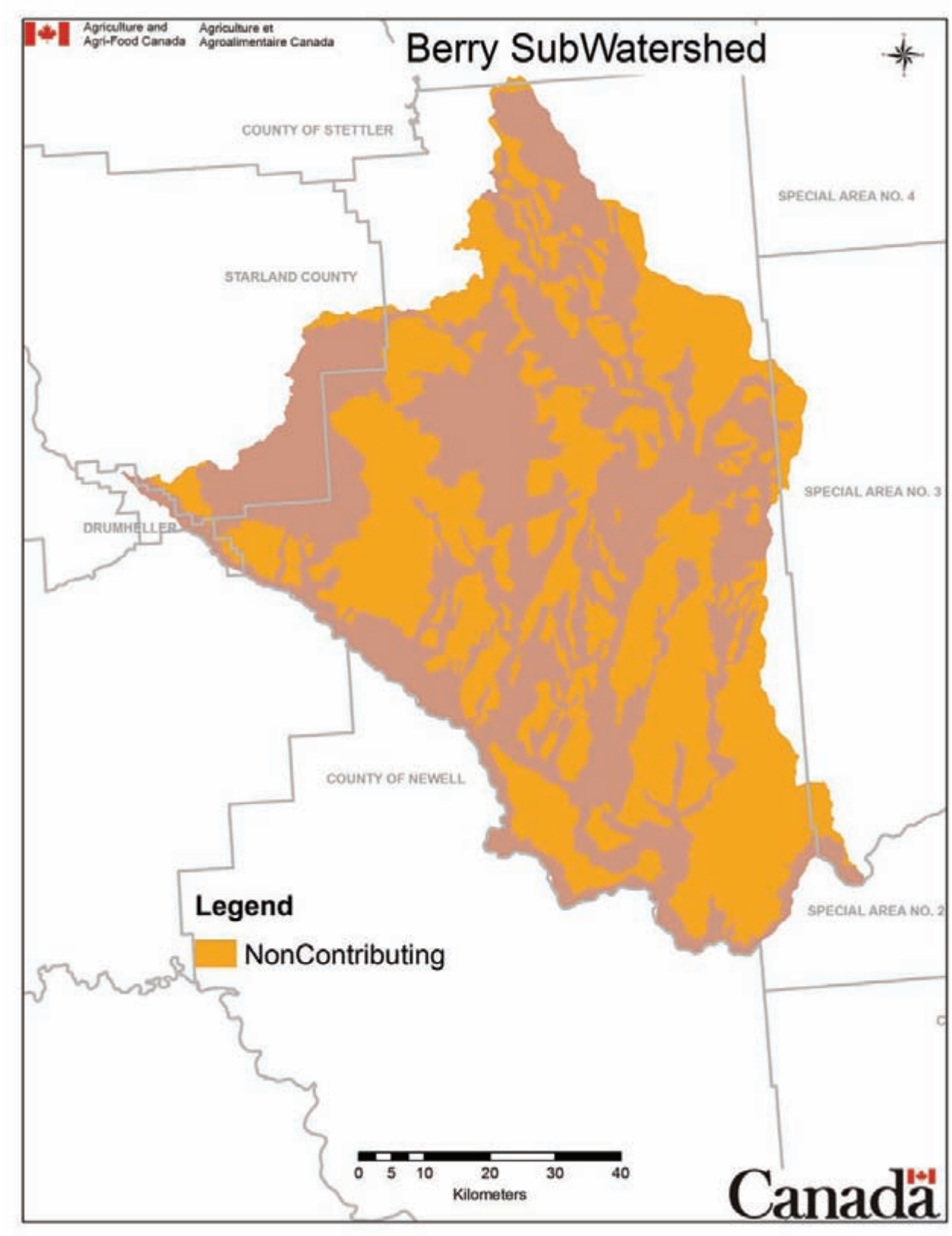


Figure 347. Non-contributing drainage areas in the Berry Creek subwatershed (AAFC-PFRA, 2008).

Figure 348. Topography (10-m contour intervals) of the Berry Creek subwatershed (AAFC-PFRA, 2008).

4.13.4.4 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 Berry Creek subwatershed, 2,900 surface water licenses and 532 groundwater licenses have been issued for water diversion projects (Figures 349, 350, respectively). They are distributed throughout the entire subwatershed, although there is an increasing density of surface water and groundwater licenses issued from the south-eastern to the north-western areas of the subwatershed (AAFC-PFRA, 2008).

About 30.71 million m^3 of surface and groundwater are diverted annually in the Berry Creek subwatershed (Government of Alberta, 2008d). The most prominent uses of surface water are for habitat enhancement (40% of total surface water diversions) and irrigation (28% of total surface water diversions), while the most prominent users of groundwater are agricultural operations (77% of total groundwater diversions) and municipalities (14% of total groundwater diversions) (Table 143). The majority of water diverted in the entire subwatershed comes from surface water sources, e.g., lakes, streams and rivers (98%) (Government of Alberta, 2008d). Additional groundwater diversion information is provided in HCL (1999a, b, 2000b).

Table 143. Surface and groundwater diversions in the Berry 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	4,987,933	494,832
Commercial	193,520	19,840
Dewatering	1,230	---
Habitat enhancement	11,906,788	---
Irrigation	8,559,711	---
Management of fish	---	1,230
Municipal	820,260	91,870
Recreation	---	1,230
Water management	3,596,840	---
Total	**30,066,282**	**641,072**
Grand total		**30,707,354**

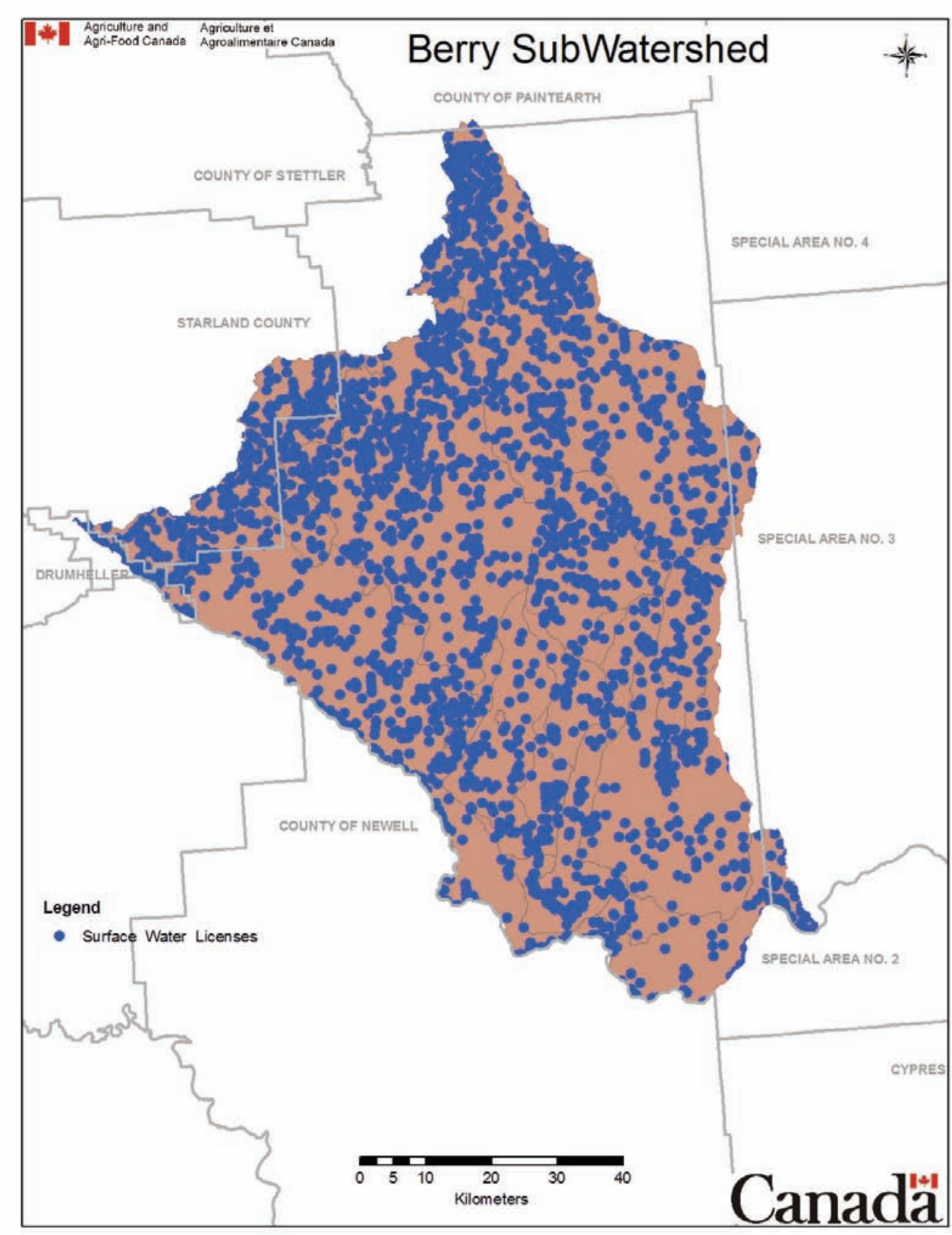


Figure 349. Surface water licenses in the Berry Creek subwatershed (AAFC-PFRA, 2008).

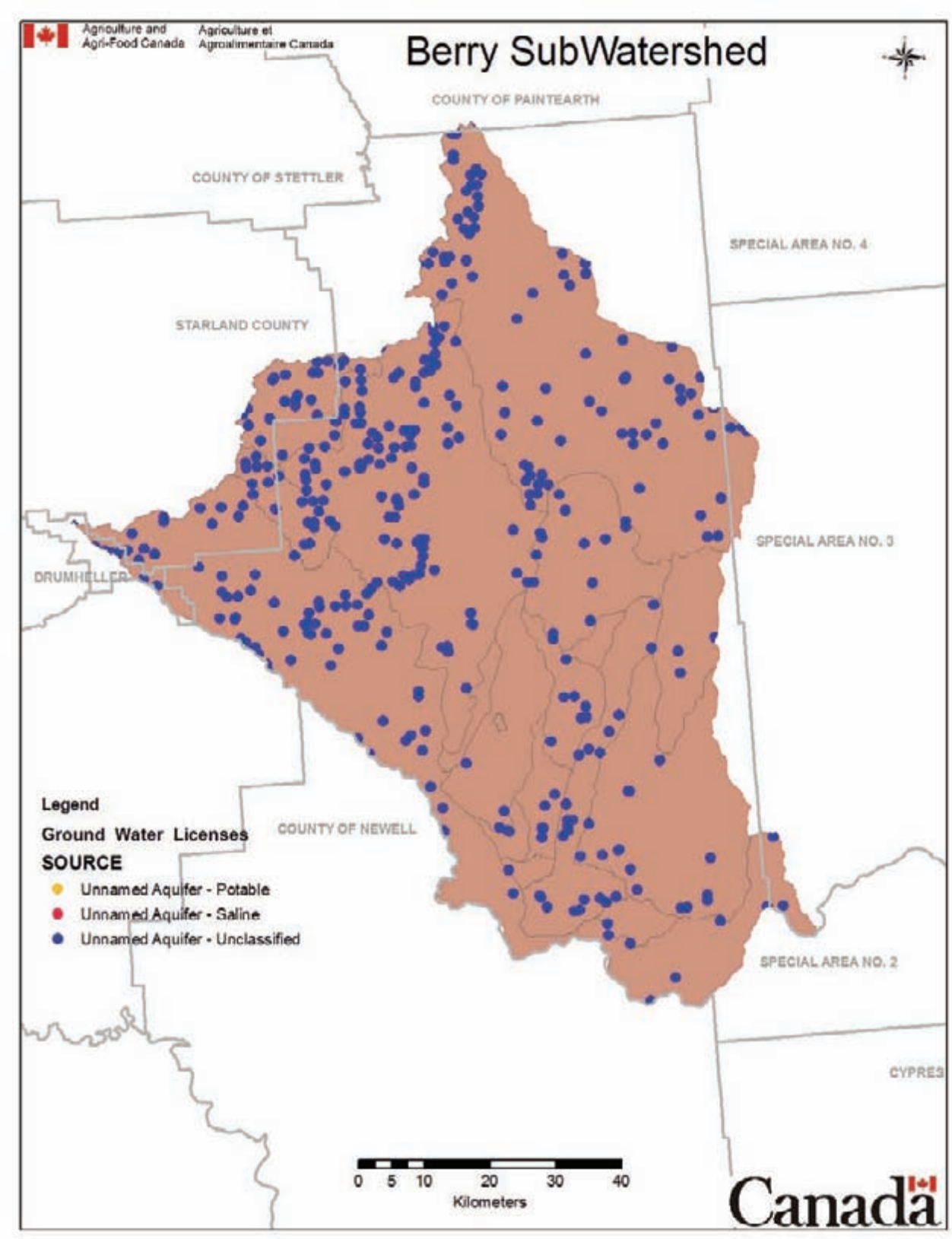


Figure 350. Groundwater licenses in the Berry Creek subwatershed (AAFC-PFRA, 2008).

4.13.4.5 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 Berry Creek subwatershed has about 40 freshwater springs, of which most are located in the western area of the subwatershed along the Red Deer River and Bullpound Creek and south of the Town of Hanna.

The Berry Creek subwatershed lies in Paintearth and Starland Counties and Special Areas 2 and 3. Groundwater assessments for these counties have been conducted by HCL (1999a, b, 2000b). These assessments indicated that virtually the entire subwatershed is a groundwater recharge area (i.e., water moves from the surface into groundwater reservoirs). There are only very isolated groundwater discharge areas (i.e., water moves from groundwater reservoirs 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 (1999a, b, 2000b).

4.13.5 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.

4.13.5.1 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 Berry Creek subwatershed.

4.13.5.2 Fish

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

The predominant species in this Berry Creek are brook stickleback and lake chub. There have been no significant changes in the populations of these species over the sampling period ($p > 0.2$ and 0.5, respectively). The species that is the most consistently found during the sampling period is the spottail shiner (Figure 351).

The brook stickleback prefers cool, clear, heavily weeded, spring-fed creeks, small rivers, lakes and ponds. They are occasionally found in brackish water. Its diet is quite varied and consists of nearly any organism small enough to be captured and swallowed. It is an opportunistic species, eating various aquatic invertebrates, fish, eggs and larvae of both, and plants (Nelson and Paetz, 1992; Scott and Crossman, 1998).

The lake chub is a freshwater cyprinid fish most commonly found in lakes, although it can also live in rivers and in streams. In mid-summer it may move to the deeper parts of a lake to avoid the warmer waters of the lake shore. Its diet is varied and includes zooplankton, insects, aquatic insect larvae and algae. The largest individuals can capture small fishes. It can itself be eaten by predatory fishes and is therefore used as bait for fishing (Nelson and Paetz, 1992; Scott and Crossman, 1998).

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

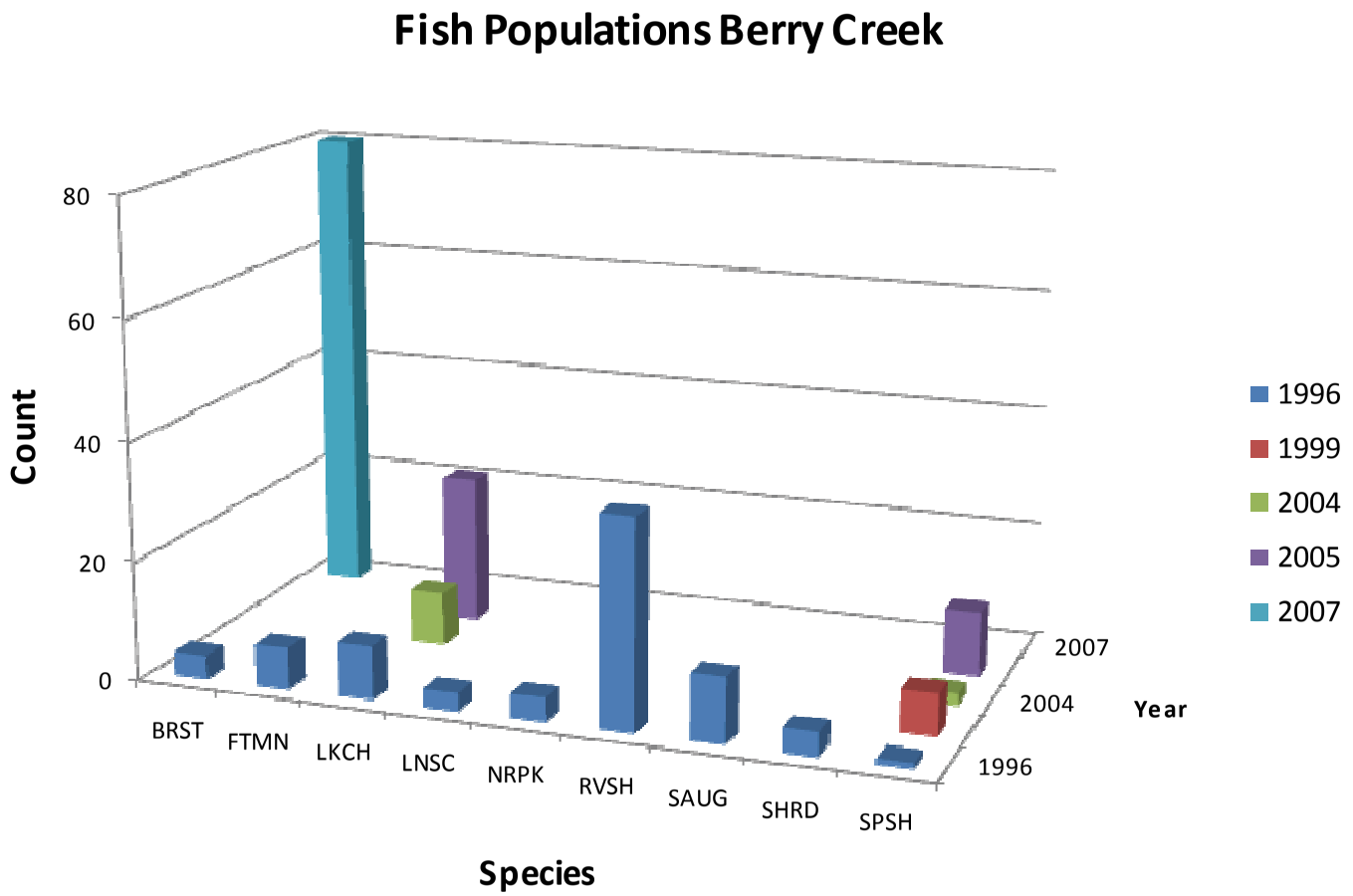


Figure 351. Fish populations in the Berry Creek from 1996-2007 (data from Alberta Sustainable Resource Development, 2008). For full species names, please refer to Table 23.

4.13.5.3 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 Berry Creek subwatershed is covered by grassland (58%) and annual and perennial croplands/pastures (18% and 15%, respectively). The remaining land cover types cover < 5% individually (Figure 352, Table 144) (AAFC-PFRA, 2008).

Table 144. Land cover in the Berry Creek subwatershed (AAFC-PFRA, 2008). The most prominent land cover types are highlighted.

Land cover type	Area (ha)	Proportion of subwatershed area (%)
Waterbodies	8,633	1.24
Exposed land	6,085	0.88
Developed land	3,454	0.50
Shrubland	6,633	0.96
Wetland	22,659	3.26
Grassland	404,184	58.23
Annual cropland	125,988	18.15
Perennial cropland/pastures	104,593	15.07
Coniferous forests	690	0.10
Deciduous forests	1,251	0.18
No data	9,944	1.43
Total	**694,114**	

There are seven Ecologically Significant Areas in the Berry Creek subwatershed: Dinosaur, Hand Hills, Hand Hills Fescue, Hand Hills Lake, Jenner Moraine, Little Fish Lake and Willow Creek (Table 145). There are no nationally designated Ecologically Significant Areas in the subwatershed (Alberta Environmental Protection, 1997).

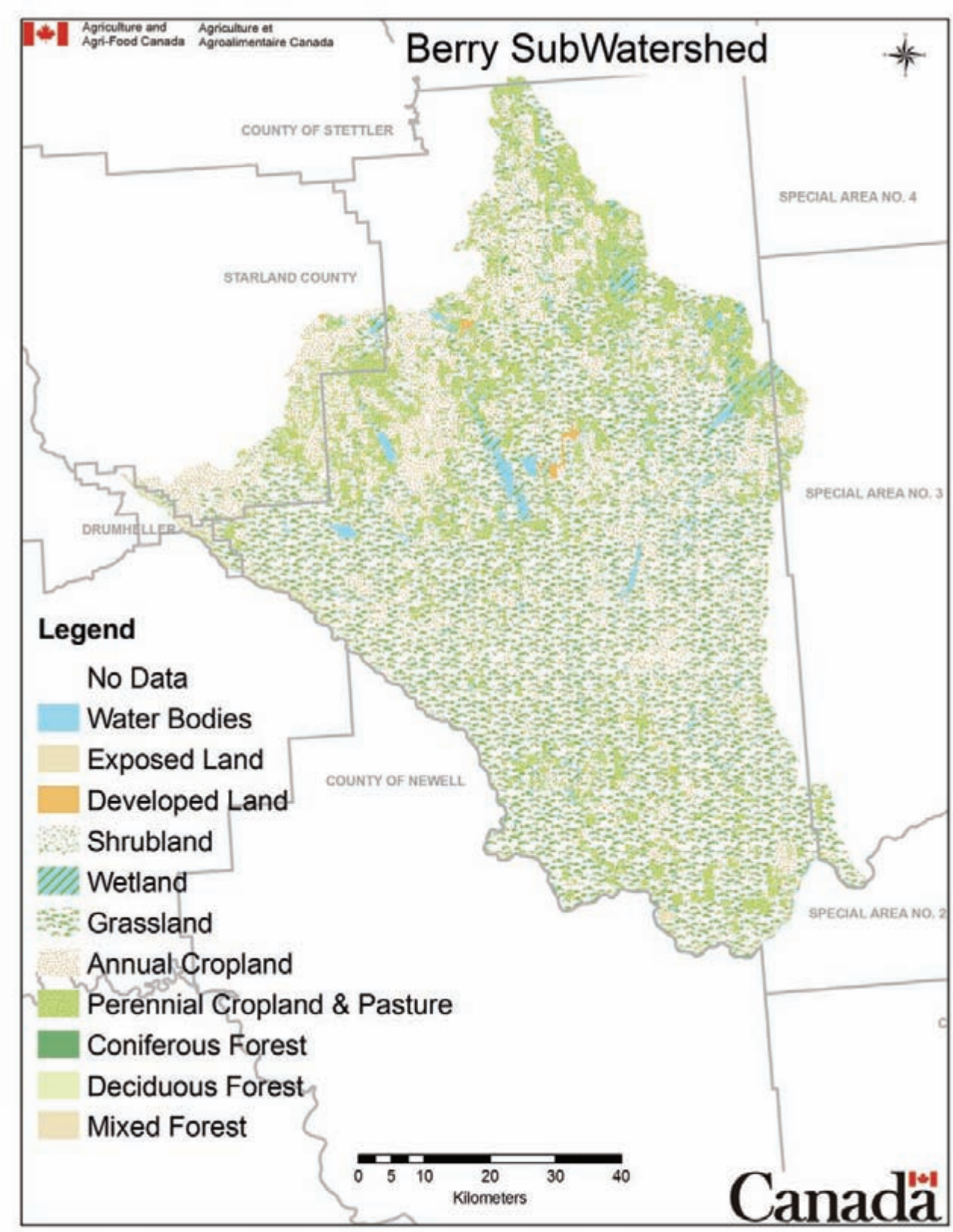


Figure 352. Land cover of the Berry Creek subwatershed (AAFC-PFRA, 2008).

Table 145. Ecologically Significant Areas in the Berry Creek subwatershed (Alberta Environmental Protection, 1997).

Ecologically Significant Area	Location	Area (ha)	Significance	Description
Dinosaur	Twp. 20-21, Rge. 11-13, W 4, County of Newell No. 4	22,886	Internationally	Much of the area is a World Heritage Site, noted for its paleontological, riparian and badland features, one of the most diverse river valley/badland complexes in the grasslands of Canada; extensive cottonwood, tall shrub and low shrub riparian habitats, some of which are ungrazed; diverse breeding bird habitat; key mule and white-tailed deer habitat; active great blue heron colony; uncommon birds including saw-whet owl; nesting area for COSEWIC endangered loggerhead shrikes and several rare birds of prey, including COSEWIC vulnerable ferruginous hawk as well as golden eagle and prairie falcon; rare plants, including annual lupine (*Lupinus pusillus*), nodding umbrella plant (*Eriogonum cernuum*), Powell's salt sage (*Atriplex powellii*) and runcinate-leaved rush-pink (*Stephanomeria runcinata*), the last three species are rare in Canada; locally important for breeding geese; hibernacula for bull snake and prairie rattlesnake; habitat for leopard frog, a potentially threatened species in Alberta
Hand Hills	Twp. 29-30, Rge. 17-18, W 4, Starland County	7,984	Provincially	Tertiary conglomerate and gravel cap, a rare geological feature, an ancient plateau that rises 225 m above the surrounding prairie; capped by significant Tertiary deposits; one of the more prominent hill systems in the Plains of Alberta; high plant community diversity; aspen woodlands, tall and low shrubbery, and grasslands on west and north slopes of the Hand Hills; includes some remnants of natural

				vegetation on the plateau; disjunct populations of Cordilleran plant species, including heart-leaved arnica (*Arnica cordifolia*) and yampa (*Perideridia gairdneri*); north-facing slopes along top edge of the escarpment have small stands of paper birch, a rare species in the region; springs and marl deposits; a high diversity of terrestrial birds of both grassland and parkland origin; key white-tailed deer and mule deer habitat; remnant fescue grasslands
Hand Hills Fescue	Twp. 27-29, Rge. 16-17, W 4, Starland County and Special Area 2	77,091	Internationally	Part of largest remaining area of northern fescue grassland in the world; significant populations of uncommon or threatened birds, including upland sandpiper and Baird's sparrow; rare or uncommon plants, including crowfoot violet (*Viola pedatifida*), yellow paintbrush (*Castilleja lutescens*), western wood lily (*Lilium philadelphicum*) and a rush (*Juncus confusus*); diverse flower blooms in wetter years; sharp-tailed grouse dancing grounds; aspen clones provide nesting habitat for merlins, an uncommon species in the region; includes a portion of the Hand Hills Ecological Reserve
Hand Hills Lake	Twp. 29, Rge. 16, W 4, Special Area 2	2 891	Internationally	Large, extensive mudflats; the most productive piping plover (COSEWIC endangered species) lake in Alberta; significant staging lake for waterfowl, particularly when lake levels are higher; provincially significant goose staging habitat
Jenner Moraine	Twp. 21-23, Rge. 6-10, W 4, Special Area 2	164,297	Provincially	Extensive mixed grassland and ephemeral wetlands on rolling hummocky moraine; provincially significant goose staging habitat; key pronghorn

				habitat in eastern section; nesting and feeding areas for prairie falcons (yellow A-listed species in Alberta), golden eagles, ferruginous hawks (a COSEWIC vulnerable species in Canada and a blue-listed species in Alberta) and burrowing owls (a COSEWIC endangered species in Canada and a red-listed species in Alberta)
Little Fish Lake	Twp. 28, Rge. 16, W 4, Special Area 2	1,849	Internationally	On the edge of the southeastern edge of the Hand Hills, lake is shallow, slightly saline and very productive; significant breeding lake for piping plover (a COSEWIC endangered species in Canada and a red-listed species in Alberta); algal blooms flourish in summer; significant habitat for other shorebirds, including a large ring-billed colony, waterfowl and shorebirds; yellow perch and white suckers reported for lake; includes Little Fish Lake Provincial Park; recreational use declining because of poor water quality and decreasing water levels
Willow Creek	Twp. 27-29, Rge. 17-18, W 4, Starland County	8,887	Provincially	Steep-walled coulees and upland northern mixed grassland, some of which is in excellent condition, transitional to Northern Fescue Grassland; diverse coulee vegetation including badlands, alkali springs, aspen woodland and tall and low shrubbery; diverse breeding bird habitats; nesting habitat for rare birds of prey, including prairie falcon and ferruginous hawk (a COSEWIC vulnerable species in Canada); key mule deer and white-tailed deer habitat

4.13.5.4 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 Berry Creek subwatershed is home to two endangered species (burrowing owl, *A. cunicularia*; piping plover, *C. melodus circumcinctus*), two threatened species (loggerhead shrike, *L. ludovicianus excubitorides*; 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.

4.13.6 Subwatershed Assessment

The Berry Creek subwatershed lies in the Northern Fescue, Dry Mixedgrass and Mixedgrass Subregions and is characterized by low livestock and agricultural intensities relative to the Alberta average. Urban centres are uncommon and include the Town of Hanna, the Village of Youngstown and several hamlets. Resource exploration and extraction activities have contributed to a complex network of linear developments (primarily roads) and the establishment of 9,841 wells (primarily natural gas wells). Despite these land uses, no riparian health assessment data were located for the subwatershed. In addition, the water quality in its two largest creeks (Berry and Bullpound) is generally poor and characterized by TP and TN concentrations exceeding CCME PAL guidelines. Concentrations of bacteria are below water quality guidelines. No parasite or pesticide data were located for any waterbody in the subwatershed. Water discharge rates in Berry Creek are virtually absent, even following the spring freshet, likely as a result of the majority of the subwatershed not contributing to drainage and being a groundwater recharge area. Nonetheless, there have been 3,432 water diversion licenses issued in the subwatershed, which permit the diversion of 30.71 million m^3 of water annually. No biodiversity assessment data were located for the subwatershed, but fathead minnows, northern pike and spottail shiners are the dominant fish species in Berry Creek. In addition, the grassland-dominated subwatershed is home to two endangered species, two threatened species and three species of special concern and contains seven ecologically significant areas, including the world-renowned Dinosaur Provincial Park.

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 Berry Creek subwatershed receives a rating of "fair" for the condition indicators and a rating of "medium" for the risk indicators (Tables 146, 147). Overall, this subwatershed receives a ranking of "B". There are substantial data gaps, and several of the condition rankings are based on limited data. Consequently, it is recommended to implement a detailed water quality sampling program, conduct a wetland inventory and regularly monitor riparian health conditions along the major waterbodies in the subwatershed. Of particular concern are (1) nutrient concentrations that occasionally exceed water quality guidelines, likely due to widespread impaired riparian area health conditions and excessive agricultural runoff, municipal effluent and urban runoff that reach waterbodies throughout the subwatershed, (2) the loss of wetlands, which likely occurred as a result of agricultural land conversions, drainage, infilling and the disruption of their hydrology following linear developments and (3) the high oil/gas well density, which represents a substantial risk to aquatic resources and habitats.

Table 146. Condition and risk indicator summary for the Berry Creek subwatershed. Gray logos indicate data gaps.

Condition Indicators

Risk Indicators


Table 147. Condition and risk assessments of the Berry Creek subwatershed. Indicators with a "poor" or "high" ranking are highlighted.

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

