Research & Science Note 9

Groundwater Quality Trends in the Milk River Basin

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Background

Availability of safe, secure drinking water supplies is a part of the quality of life for Albertans. Water for Life is the Government of Alberta's strategy for water. The strategy is intended to help manage both water quality and quantity issues, as well as environmental concerns. As a not–for-profit and charitable society mandated under the Water for Life Strategy, the MRWCC provides a forum to engage communities, share information, discuss concerns, and implement stewardship initiatives in the Milk River watershed.

The MRWCC has been working with partner organizations and stakeholders since 2007 to better understand groundwater quality in the Milk River watershed. The data collected helped to establish a baseline groundwater quality data set for the watershed.

Monitoring was conducted in 2007, 2011, and 2016.

Samples were collected at each site, for bacteriological, routine chemical, and trace metal analysis. 40 sites were selected, approximately 10 per each county. The idea was to revisit and sample the same locations over the long-term trend, however, circumstances beyond control proved difficult for the sampling site consistency as some of the initial wells had been decommissioned or changed ownership and the new owner didn't buy into the program. This caused a small variation in the number and sampling locations over the years.

Groundwater quality can vary considerably across the watershed, even though most of the wells are developed within the same aquifer. Local and areal variations in recharge, depth of completion, relation to groundwater flow path, and variations in the chemical compositions of glacial and bedrock deposits, can all contribute to the chemical composition of groundwater.

Study Area

The Milk River watershed contains a number of significant groundwater aquifer resources. Unlike surface water that defines a watershed boundary, groundwater may cross one or more watershed boundaries below ground.

The two main aquifers that provide for municipal and agricultural uses in the watershed are the Milk River Sandstone Aquifer (Milk River Aquifer) and the Whisky Valley Aquifer. The Whisky Valley Aquifer is a regional sand and gravel aquifer that extends approximately 30 km along the river in the vicinity of the Town of Milk River. The Whisky Valley aquifer is a "surficial deposit" that is generally less than 50 m below ground (Stantec Consulting Ltd. 2002; Hydrogeological Consultants Ltd. 2004). The Milk River Aquifer is an extensive formation that underlies much of the watershed. The formation outcrops at ground surface along the Milk River in Ranges 13 and 15, near Writing-On-Stone Park. The formation is much deeper elsewhere, in excess of 200 m over much of the County of Forty Mile and dips steeply to the west where it is found about 550 m below the Milk River Ridge.

Methods

Comparative Groundwater Quality Study 2007, 2011, and 2016

In 2007, the Milk River Watershed Council Canada commissioned a study to investigate groundwater quality in 40 private wells across the watershed in Alberta. Ten water wells were selected and sampled within each of the counties of Cardston, Warner, Forty Mile and Cypress. Samples were analyzed for nutrients, salts, metals and bacteria. Results of this study were presented in the Milk River State of the Watershed Report (2008). The information formed a valuable snapshot of groundwater quality in the basin and acts as a benchmark for future comparative studies.

In 2011 and 2016, 34 samples were obtained from many of the same groundwater wells as sampled in 2007. For comparison, results for the three years of study are reported as percent exceedance of applicable Canadian Drinking Water Quality Guidelines (CDWQG). In addition, the results for select parameters are presented as median (50th percentile) and range values (Table 1).

Generally the combination of these constituents determines the suitability of a groundwater supply for human and livestock consumption.

Table 1. Summary of select parameters measured in the comparative groundwater study in Milk River, 2007, 2011, and 2016. Median and (ra
Note that many, but not all, of the same wells sampled in 2007 were re-sampled in 2011 and 2016.

Parameter	CDWQG	Cardston County			County of Warner			
		2007	2011	2016	2007	2011	2016	200
Total Dissolved Solids[a]	500	934 (505 - 1690)	1100 (360 - 1700)	938 (410 - 1711)	910 (442 - 2430)	770 (350 - 1800)	1069 (337 - 1789)	114 (813 -
Sodium[a]	200	206 (57 - 630)	160 (16 - 620)	222 (29 - 639)	237 (66 - 795)	290 (58 - 630)	391 (51 - 614)	42 (354 -
Chloride[a]	250	28.9 (2.7 - 96.4)	55 (13.0 - 110.0)	31.9 (6.8 - 84.9)	15.5 (2.8 - 61.7)	15 (3.7 - 230)	56.5 (3.2 - 313.9)	20 (4.3 -
Manganese[b]	0.05	0.006 (0.002 - 0.598)	0.0063 (0.002 - 0.14)	0.037 (0 - 0.146)	0.033 (0.0002 - 0.266)	0.002 (0.002 - 0.270)	0.0826 (0.004 - 0.317)	0.0 (0.002 -
Dissolved Nitrate[b]	45	1 (0.003 - 19.9)	14 (0.0065 - 78)	16 (0 - 63.8)	0.008 (0.002 - 0.892)	0.0065 (0.0015 - 39)	0.3544 (0 - 0.886)	0.00 (0.0015 -
Dissolved Lead[b]	0.01	0.0001 (0.0001 - 0.0003)	0.00022 (0.0001 - 0.0014)	0.00157 (0.002 - 0.009)	0.0001 (0.0001 - 0.0007)	0.0001 (0.0001 - 0.0005)	0.0002 (0 - 0.002)	0.00 (0.00 0.01
Cadmium (µg/ L)[b]	5	0.01 (0.005 - 0.13)	0.011 (0.0025 - 0.11)	0 (0 - 0)	0.008 (0.005 - 1.14)	0.0025 (-0.0025)	0 (0 - 0)	0.0 (0.005 -
[a] The CDWQG sets Aesthetic Objectives, which are not health related.								
[b] The CDWQG sets Maximum Acceptable Concentrations; exceedances over a life-time exposure can cause health concerns.								

Results

Summary of select parameters measured in the comparative groundwater study, 2007, 2011, and 2016. Median and (range) concentrations are presented. All concentrations are reported as mg/L unless otherwise noted (MRWCC unpublished). Note that many, but not all, of the same wells sampled in 2007 were re-sampled in 2011 and 2016.

Total Dissolved Solids (TDS)

Total dissolved solids (TDS) is a measure of calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulphate and nitrate in water. TDS above 500 mg/L results in excessive scaling in water pipes, water heaters, boilers and appliances. TDS can be naturally occurring, or it can be an indicator of point or non-point source pollution.

In the study, TDS ranged from 270 mg/L to 3,640 mg/L and was highest in the eastern part of the watershed. In 2007 and 2016, 88% of samples exceeded appropriate guidelines compared to 79% of samples collected in 2011. These results are comparable to the literature which has stated that the Milk River Aquifer is generally high in sodium, fluoride and bicarbonate. Untreated, the concentration of total dissolved solids (TDS) typically exceeds the CDWQG.

Sodium

Sodium is a naturally occurring ion that originates from the erosion and weathering of salt deposits and contact with igneous rock or seawater intrusion. Sources of sodium also include point and non-point sources such as sewage and industrial effluents, and sodium-based water softeners. Sodium can impact taste to water and can impact human health when ingested in excess.

About 60% of the samples collected in the groundwater study in 2007 and 2011 exceeded the CDWQG of 200 mg/L. In the 2016 study, 71% of the samples exceeded the CDWQG. Sodium concentrations ranged from 12 mg/L to 1,800 mg/L, with both the highest and lowest concentrations measured in eastern part of the watershed (Cypress County) (Table 1).

Chloride (Cl)

Chloride (Cl) is a naturally occurring element that may also be present due to dissolved salt deposits, highway salt, industrial effluents, oil well operations, sewage and irrigation drainage. Chloride imparts taste to drinking water and can corrode distribution systems.

About 5% of samples collected from water wells in 2007 and 2011, and 9% of those collected in 2016, exceeded the CDWQG of 250 mg/L. The lowest and highest concentration of chlorides was measured in eastern part of the watershed, 1.1mg/ L and 1772mg/ L respectively (Table 1).

Manganese (Mn)

Manganese (Mn) is a naturally occurring element that is made

ange) concentrations are presented. All concentrations are reported as mg/L unless otherwise noted.

County of Forty Mile			Cypress County			% Exceedance		
07	2011	2016	2007	2011	2016	2007	2011	2016
40 2440)	1000 (760 - 1200)	983 (754 - 1273)	762 (270 - 3640)	1100 (280 - 3400)	1445 (510 - 3417)	88 (35/ 40)	79 (27/ 34)	88 (30/ 34)
5 947)	380 (300 - 450)	388 (287 - 468)	65.3 (12.3 - 1160)	420 (12 - 1800)	442 (21 - 1326)	60 (24/ 40)	62 (21/ 34)	71 (24/ 34)
.9 187)	19 (4.3 - 72)	23.8 (2 - 70.7)	15.7 (1.1 - 1130)	12 (1.7 - 1200)	432.9 (1.4 - 1771.8)	5 (2/ 40)	6 (2/ 34)	9 (3/ 34)
04 - 1.05)	0.002 (0.002 - 0.4)	0.0328 (0 - 0.299)	0.051 (0.002 - 1.05)	0.0084 (0.002 - 0.67)	0.3729 (0.003 - 0.901)	35 (14/ 40)	21 (7/ 34)	29 (10/ 34)
015 - 0.015)	0.016 (0.0065 - 25)	0.1329 (0 - 1.329)	0.016 (0.003 - 1.05)	0.049 (0.0015 - 0.51)	1.329 (0 - 5.136)	0 (0/ 40)	9 (3/ 34)	3 (1/ 34)
001 01 - 55)	0.0001 (0.0001 - 0.0003)	0.0002 (0 - 0.001)	0.0001 (0.0001 - 0.0004)	0.0001 (0.0001 - 0.0005)	0.0007 (0 - 0.005)	3 (1/ 40)	0 (0/ 34)	0 (0/ 34)
05 - 0.21)	0.0025 (0.0025 - 0.0086)	0 (0 - 0)	0.005 (0.005 - 0.01)	0.0025 (0.0025 - 0.0052)	0 (0 - 0)	0 (0/ 40)	0 (0/ 34)	0 (0/ 0)

available through erosion and weathering of rocks and minerals. It is a household nuisance as it degrades taste and can stain laundry and plumbing fixtures.

Water from 35% of wells sampled in 2007, 21% of wells in 2011, and 29% of wells in 2016, exceeded the CDWQG of 0.05 mg/L for manganese (Table 1).

Dissolved nitrate (NO3)

Dissolved nitrate (NO3) can be naturally occurring or be found in surface runoff from fertilized lawns or fields, manure and domestic sewage. Nitrate may be produced from excess ammonia or from microbial activity in distribution systems. In excess, dissolved nitrate can pose a serious health risk, particularly to infants less than three months of age, as it is the cause of methaemoglobinaemia (blue baby syndrome). It is also classified as a possible carcinogen. The Maximum Allowable Concentration (MAC) for dissolved nitrate in drinking water is 45 mg/L. Three percent of wells (1 site) sampled in the watershed exceeded the CDWQG in 2016, compared to nine percent of wells (3 sites) in 2011, and zero in 2007; all wells were located in Cardston County (Table 1) The source of the nitrate is unknown at this time.

Metals

Twenty-nine elements were analyzed as part of the standard metals' quality analysis, including lead and cadmium. Metals in domestic drinking water supplies can cause aesthetic issues and some metals have human health implications. Iron may impart a taste to the water and cause staining of plumbing fixtures and laundry.

One water sample exceeded the lead CDWQG of 0.01 mg/L in 2007 and no samples exceeded the guideline in 2011 and 2016. Sources of lead in drinking water include leaching from plumbing (e.g., pipes, solder, brass fittings and lead service lines). Lead can affect intellectual development and behaviour in infants and young children (under 6 years). It can also cause anaemia, affect the central nervous system and is classified as a probable human carcinogen. No water from wells sampled in 2007, 2011, and 2016 exceeded the CDWQG MAC (5µg/L) for cadmium.

Bacteria

The presence of Escherichia coli (E. coli) indicates recent fecal contamination and the potential presence of microorganisms capable of causing gastrointestinal illnesses. It is used as an indicator of the microbiological safety of drinking water; if detected, enteric pathogens may also be present. The CDWQG MAC is zero CFU/100 mL, where CFU is defined as Colony Forming Units. Bacteria was analysed in samples collected in the 2011 and 2016 monitoring year. One sample exceeded the guideline in Cardston County in 2011, having a value of 27 CFU/100 mL. Water in this same well also measured high in dissolved nitrate.

Recommendations

In Alberta, drinking water samples from private residences can be submitted free of charge for testing. Any samples collected for real estate, commercial, or agricultural purposes will not be eligible for free testing. Municipal water supplies (from cities and towns) are tested regularly for safety by the municipality, and the general public cannot submit samples from these sources.

There are three different types of water tests that can be done to make sure the water in your home is safe to drink. Bacteria water sampling tests water samples for indicator bacteria to ensure water is safe. These samples can be submitted annually, or more frequently if there has been a significant change to your water system (e.g.: flooding, new treatment system). Chemical water sampling tests can be submitted every two years, and look at both routine chemicals and trace metals found in the water. Routine chemical analysis tests for pH, sodium, hardness, nitrates, fluoride, and a variety of other things. Trace metal analysis tests for arsenic, lead, uranium, and other elements.

For more information on how to collect and submit a water sample, please visit this website: https://www.albertahealthservices.ca/eph/Page15233.aspx. You may also visit our web at www.mrwcc.ca for more information on groundwater.

Future Steps:

The Milk River Watershed Council Canada strives to provide accurate information to the public and its members regarding water and land resources in the watershed. The Council plans to continue the long-term groundwater monitoring at five-year interval and continue providing direction and support for necessary stewardship work to help maintain and improve the health of the watershed.

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Alberta Government

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