MILK RIVER WATERSHED

WATER MONITORING REPORT 2015

Prepared for: Milk River Watershed Council Canada

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Palliser Environmental Services Ltd.

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Cover Photo:

Middle Creek, by Lisa Monkman

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1.0 INTRODUCTION

The Milk River is the most southern major river system in Alberta and the only river in the province that flows to the Gulf of Mexico. The headwaters of the Milk River originate in Montana and the river flows eastward through Alberta for about 288 km. The mainstem of the Milk River is prairie fed and is often referred to as the South Fork of the Milk River. Flows in the North Fork of the Milk River are augmented by water from the St. Mary River (i.e., the St. Mary River Diversion) as part of the Boundary Waters Treaty (1909).

The Milk River Watershed Council Canada has monitored the Milk River and some of its tributaries since 2006. This report is a compilation of water monitoring data collected in 2015, with reference to the results from the previous two years (i.e., 2013 and 2014). Comparisons are made to Water Quality Objectives that were developed as part of the Milk River Integrated Watershed Management Plan (PESL 2015) as well as relevant provincial guidelines (ESRD 2014; Alberta Agriculture 1983).

2.0 METHODS

Grab samples were collected approximately every two weeks (April-June) and monthly (July-October) from five sites: N Fork Milk River at 501, South Fork Milk River at 501, Upstream of the Town of Milk River (U/S Milk River), at HWY 880 Bridge and at the Pinhorn Ranch. Alberta Environment and Sustainable Resource Development also collected monthly samples at HWY 880 Bridge in 2014 and 2015 (AEP) and Environment Canada collects monthly samples at the Western and Eastern crossings (Figure 1). Data from Alberta Environment and Parks and Environment Canada has not been included in this summary report). In 2015, the MRWCC sampled April 8, April 30, May 14, May 26, June 11, June 25, July 23, August 13, September 17 and October 20. The natural flow period is considered April 8, April 30, September 17 and October 20 as flows were ramped up to

Milk River tributaries were also monitored in 2015. The monitoring included three sites at Red Creek (i.e., Upstream, Middle and Downstream), Verdigris Coulee (that was dry the entire season) and, three tributaries known as the "Eastern Tributaries" (i.e., Battle Creek, Middle Creek and Lodge Creek). The Eastern tributaries flow east to Saskatchewan and contribute flows to the Frenchman River (a tributary of the Milk River in Montana).

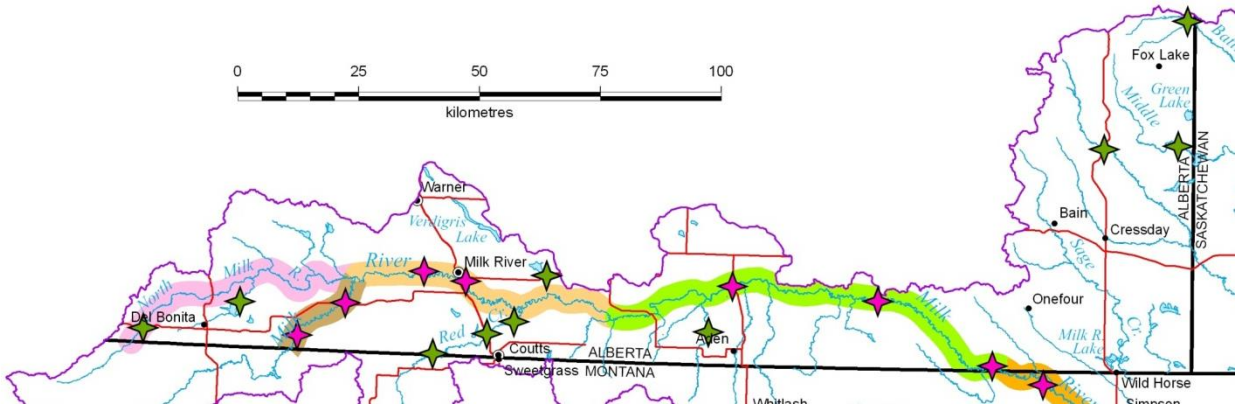

Figure 1. Map showing water monitoring locations sampled in the Milk River watershed, 2015.

The MRWCC water monitoring program was conducted in collaboration with Cardston County, County of Warner, County of Forty Mile and, Cypress County. Samples were only collected when flows could be

visually detected. Sample bottles were submersed to mid-depth by hand or using a sample pole (with sample bottle attached) when the water was deep or fast-flowing. Each sample container was prepared using standard protocols (e.g., triple rinsing and preservation, where required). Sterile sample containers were provided by the analytical laboratory. The water samples were kept on ice in coolers and transported to ALS Laboratories in Calgary. ALS Laboratories Analytics is **CALA**[1] accredited for criteria and standards established by the Association under their Certificate of Laboratory Proficiency.

Samples were analysed using **APHA**[2] approved methods for general parameters (e.g., pH, specific conductivity) nutrients (total phosphorus (TP), total dissolved phosphorus (TDP), nitrate+nitrite nitrogen (NO3+NO2-N), total kjeldahl nitrogen (TKN) and total nitrogen [TN; calculated]), total suspended solids (TSS) and fecal coliform bacteria (FCB).

Water monitoring results were compared to local Milk River Water Quality Objectives (WQO) that were established for the four main river reaches (i.e., North Fork Milk River, Mainstem Milk River, Milk River Gravel Bed and Milk River Sand Bed) within the Milk River Integrated Watershed Management Plan (IWMP) (PESL 2015) and to applicable provincial surface water quality guidelines (ESRD 2014). The Milk River IWMP Implementation Strategy suggests that water quality data should be compared to the WQOs annually with a trend analysis completed every five years. The current 2015 data set is the third year of data collected since the WQOs were established.

2.1 Missing Data

Table 1. Summary of missing data for the 2015 water monitoring year.

Site	Date	Measurement	Reason
Red Creek at Upstream	July 23, 2015	Water temperature, Dissolved oxygen	Not collected
Red Creek at Midstream	May 14, 2015	Water temperature	Not collected
	September 17, 2015	Water temperature	Not collected
Battle River	July 22, 2015	Fecal coliform bacteria	Sample water temperature was greater than 15^{o}C – laboratory did not analyse
Middle Creek	July 22, 2015	Fecal coliform bacteria	Sample water temperature was greater than 15^{o}C – laboratory did not analyse

[1] **CALA** – Canadian Association for Laboratory Accreditation Inc.
[2] **APHA** – American Public Health Association

3.0 RESULTS

3.1 Precipitation

Total precipitation in the Milk River watershed was generally highest in the west (Cardston, 250.6 mm) and lowest to the east (One Four, 189.4 mm). July and September were the wettest months for most parts of the watershed, while April and August were dry months.

Table 2. Precipitation (mm) at five weather stations for the water monitoring April to October, 2015.

Month	Cardston	Del Bonita	Milk River	Masinasin	One Four
April	17.7	8.7	12.7	7.6	8
May	60.5	38	33.8	18.4	9.6
June	34.1	25.7	19.3	13	2.5
July	53.1	65	46	48.4	80.6
August	14.8	9.3	15.3	10.3	9.1
September	53.8	47.5	52.8	63.3	49.2
October	16.6	7.3	9.6	19.6	30.4
Total	**250.6**	**201.5**	**189.5**	**180.6**	**189.4**

3.2 Red Creek

3.2.1 General Water Chemistry

In general, the median water temperatures were cooler compared to previous years (2013 and 2014) but the maximum water temperatures at the upstream and downstream sites were substantially higher (Table 3). The median water temperature was 1.5^{o}C cooler at the upstream site (11.6^{o}C) compared to the downstream site (13.1^{o}C). Similarly, the maximum water temperature was substantially cooler at the upstream site (23.6^{o}C) compared to the downstream site (30^{o}C) (Table 3).

Dissolved oxygen concentrations met the acute (<5.0 mg/L) and chronic (<6.5 mg/L) guidelines at all sites at Red Creek in 2015 except at the Middle site where the concentration was 5.6 mg/L on October 20, 2015 (Table 3). In comparison to the previous two years, dissolved oxygen appears to be increasing at all sites, with the highest compliance rate observed in 2015 compared to the previous two years (Table 4).

All samples collected at Red Creek met the pH guideline of <9.0 for aquatic life. The pH tends to be increasing at the middle and downstream sites compared to 2013 and 2014 values.

Median specific conductivity was 2350 µS/cm at the upstream site, 2335 µS/cm at the middle site and 2665 µS/cm at the downstream site (Table 2). All samples collected exceeded the irrigation guideline of <1000 µS/cm for general crop irrigation (<700 µS/cm for sensitive crop irrigation) (Alberta Agriculture 1983; CCREM 1987). Conductivity values tended to decrease at the upstream and middle site and increase at the downstream site when compared to previous years (Table 3).

Table 3. Median and range for water quality parameters at Red Creek, 2013-2015.

Arrows and dashes identify trends in median values and concentrations (increasing ↑, decreasing ↓, no trend -). A green arrow means that the trend is positive (i.e., an improvement in water quality is observed); a yellow arrow means the trend represents a degradation in water quality; a dash means no trend was determined.

Parameter	Upstream				Middle				Downstream			
	2013	2014	2015	Trend	2013	2014	2015	Trend	2013	2014	2015	Trend
Water Temperature, °C	15.1 4.7-20.7	14.1 2.9-20.7	11.6 6.9-23.6	↓	16.3 6.6-22.2	16.2 4.9-23.6	13.6 8.5-23	↓	15.7 6.5-22.9	14.2 3.8-23.1	13.1 8.5-30.0	↓
Dissolved Oxygen, mg/L	8.97 4.61-10.37	5.95 2.61-10.7	9.50 6.61-12.24	↑	7.61 4.14-11.60	7.66 4.41-8.91	8.63 5.60-11.90	↑	9.33 7.84-10.91	9.38 5.48-12.84	11.46 6.84-18.3	↑
pH	8.24 7.94-8.32	8.22 8.11-8.42	8.28 7.95-8.37	-	8.29 8.01-8.79	8.33 8.26-8.64	8.39 7.89-8.67	↑	8.29 8.04-8.40	8.34 8.24-8.58	8.41 8.33-8.52	↑
Specific Conductivity, µS/cm	2550 2500-2700	2415 1880-2760	2350 2030-2700	↓	2665 2220-2860	2590 2110-2880	2335 2040-3020	↓	2500 2230-2960	2620 2250-2830	2665 2440-2890	↑
Total Phosphorus, mg/L	0.022 0.015-0.035	0.073 0.015-0.457	0.035 0.025-0.053	-	0.081 0.038-0.163	0.151 0.031-0.178	0.077 0.063-0.111	-	0.024 0.006-0.081	0.032 0.016-0.098	0.051 0.036-0.070	↑
Total Dissolved Phosphorus, mg/L	0.007 0.003-0.014	0.030 0.006-0.426	0.017 0.010-0.031	-	0.030 0.010-0.047	0.048 0.019-0.139	0.038 0.021-0.053	-	0.006 0.003-0.011	0.009 0.005-0.048	0.019 0.012-0.031	↑
Nitrate+Nitrite Nitrogen, mg/L	0.036 0.036-1.410	0.316 0.027-1.660	0.185 0.050-1.430	-	0.036 0.036-0.036	0.036 0.027-0.135	0.050 0.010-0.280	-	0.644 0.258-1.520	0.135 0.027-0.839	0.135 0.050-0.320	-
Total Kjeldahl Nitrogen, mg/L	0.760 0.690-1.080	0.985 0.570-1.710	0.850 0.100-1.100	-	1.215 0.880-1.420	1.310 0.460-1.560	0.880 0.310-1.530	-	0.655 0.380-2.480	0.79 0.530-1.590	0.815 0.520-2.760	↑
Total Nitrogen, mg/L	1.066 0.746-2.100	1.638 0.787-2.230	0.985 0.380-2.390	-	1.251 0.916-1.456	1.367 0.487-1.695	0.930 0.320-1.580	-	1.244 0.898-3.780	1.230 0.717-1.725	1.015 0.640-2.930	↓
Total Suspended Solids, mg/L	2 2-13	6 2-26	4 2-6	-	5 2-21	16 4-40	7 3-11	-	6 2-32	9 3-25	17 5-42	↑
Fecal Coliform Bacteria, cfu/100 mL	18 1-400	46 1-900	122 1-900	↑	14 1-74	400 1-49000	49 1-192	-	44 1-17800	300 1-4600	315 9-6000	↑

Table 4. Summary of Red Creek water quality compliance with dissolved oxygen acute and chronic guidelines (ESRD 2014).

Year	Compliance: Dissolved Oxygen					
	Upstream		Middle		Downstream	
	Acute <5.0 mg/L	Chronic <6.5 mg/L	Acute <5.0 mg/L	Chronic <6.5 mg/L	Acute <5.0 mg/L	Chronic <6.5 mg/L
2013	89	67	90	70	100	100
2014	70	40	67	67	100	89
2015	100	100	100	87	100	100
Trend	-	-	-	-	-	-

3.2.2 Nutrients

Median total phosphorus concentration was lowest at the upstream site (0.035 mg/L) and highest at the Middle site (0.077 mg/L). No trends were observed at these Upstream and Middle sites, but median concentrations tend to be increasing at the Downstream site (0.053 mg/L) in 2015 compared to 2014 (0.032 mg/L) and 2013 (0.024 mg/L) (Table 3). Similarly, median total dissolved phosphorus was lowest at the upper site (0.017 mg/L) and highest at the Middle site (0.038 mg/L). Median total dissolved phosphorus concentrations tend to be increasing at the Downstream site (0.019 mg/L) compared to 0.009 mg/L (2014) and 0.006 mg/L (2013).

Median total nitrogen concentration was lowest at the Middle site (0.930 mg/L) and highest at the Downstream site (1.015 mg/L). Unlike phosphorus, total nitrogen concentration tends to be decreasing at the Downstream site compared to previous years (1.230 mg/L in 2014 and 1.244 mg/L in 2013). In 2015, most of the total nitrogen was present in the organic (TKN) form with a much smaller percentage of the nitrogen present in soluble form (Nitrate+Nitrite Nitrogen) (Table 3).

3.2.3 Total Suspended Solids

The Downstream site had the highest median total suspended solids concentration (17 mg/L) compared to the Upstream (4 mg/L) and Middle (7 mg/L) sites (Table 3). Median total suspended solids concentration appears to be increasing at the Downstream site in 2015 (17 mg/L), compared to 2014 (9 mg/L) and 2013 (6 mg/L).

3.2.4 Fecal Coliform Bacteria

The median fecal coliform bacteria count was highest at the Downstream site (315 mg/L), compared to the Upstream site (122 mg/L) and Middle site (49 mg/L) (Table 3). Fecal coliform bacteria counts appear to be increasing at the Upstream and Downstream sites compared to previous years (Table 2).

3.3 Eastern Tributaries

3.3.1 General Water Chemistry

Battle Creek – The median water temperature was 8.9°C in 2015, the same median temperature reported in 2014 and cooler compared to 2013 (10.6°C) (Table 4). Maximum water temperature reached 16.4°C on August 13. Dissolved oxygen concentrations met the chronic (<6.5 mg/L) and acute (<5.0 mg/L) guidelines throughout 2015 with all concentrations greater than 8.53 mg/L. Similarly, all pH values met the aquatic life guideline in 2015 (<9.0 mg/L). Median specific conductivity was 376 µS/cm and all samples were well below the irrigation guideline for sensitive crops (<700 µS/cm).

Middle Creek – The median water temperature was 15.3°C in 2015, warmer than 2014 (13.6°C) and similar to 2013 (15.0°C) (Table 4). Maximum water temperature reached 21.2°C on June 11. Dissolved oxygen concentrations met the chronic (<6.5 mg/L) and acute (<5.0 mg/L) guidelines throughout 2015 with all concentrations greater than 9.42 mg/L. Similarly, all pH values met the aquatic life guideline in 2015 (<9.0 mg/L). Median specific conductivity was 694 µS/cm; 4 of 10 samples (40%) did not meet the irrigation guideline for sensitive crops (<700 µS/cm), but all samples met the guideline for general crops (<1000 µS/cm). Maximum conductivity was recorded at 745 µS/cm. A minimal increasing trend was observed at Middle Creek.

Lodge Creek – The median water temperature was 14.8°C in 2015, warmer compared to 2014 (13.2°C) and cooler compared to 2013 (15.8°C) (Table 4). Dissolved oxygen concentrations met the chronic (<6.5 mg/L) and acute (<5.0 mg/L) guidelines throughout 2015 with all concentrations greater than 10.37 mg/L. Similarly, all pH values met the aquatic life guideline in 2015 (<9.0 mg/L). Median specific conductivity was 1270 µS/cm; 6 of 6 samples (100%) did not meet the irrigation guideline for sensitive crops (<700 µS/cm), and 5 of 6 samples (83%) did not meet the guideline for general crops (<1000 µS/cm). Maximum conductivity was 1540 µS/cm. An increasing trend in specific conductivity was observed at Lodge Creek.

3.3.2 Nutrients

Battle Creek – Median total phosphorus concentration was 0.018 mg/L in 2015, similar to 2014 (0.017 mg/L) and lower compared to 2013 (0.022 mg/L) (Table 4). Total dissolved phosphorus concentration was the highest in 2015 (0.010 mg/L) and an increasing trend is observed since 2013 (0.008 mg/L). About 50% of the total phosphorus was present in the dissolved form. Median total nitrogen was the lowest in 2015 (0.110 mg/L) compared to 2014 (0.127 mg/L) and 2013 (0.136 mg/L) and a decreasing trend is observed (Table 3). Over 90% of total nitrogen was comprised of organic nitrogen. Median nitrate-nitrogen concentrations have decreased from 0.036 mg/L (2013) to 0.010 mg/L (2015). Note that the detection limit of the analytical equipment has improved from <0.071 mg/L in 2013 to <0.020 mg/L in 2015. The decreasing trend is likely the result of this improvement.

Middle Creek - Median total phosphorus concentration was 0.104 mg/L in 2015, lower compared to 2014 (0.116 mg/L) and higher compared to 2013 (0.075 mg/L) (Table 4). Similar to conditions at Battle Creek, total dissolved phosphorus concentration was the highest in 2015 (0.103 mg/L) and an increasing trend is observed since 2013 (0.055 mg/L). In 2015, a substantial portion of total phosphorus was present in the dissolved form. Median total nitrogen was the lowest in 2015 (0.480 mg/L) compared to 2014 (0.722mg/L) and 2013 (0.591 mg/L) and no trend was observed (Table 4). Similar to Battle Creek, over 90% of total nitrogen was comprised of organic nitrogen. Median nitrate-nitrogen concentrations

decreased from 0.036 mg/L (2013) to 0.010 mg/L (2015). The decreasing trend is likely the result of improved detection limits of analytical equipment.

Lodge Creek - Median total phosphorus concentration was 0.049 mg/L in 2015, lower compared to 2014 (0.060 mg/L) and similar to 2013 (0.047 mg/L) (Table 4). Unlike Battle and Middle creeks, total dissolved phosphorus concentration was the lowest in 2015 (0.022 mg/L) and a decreasing trend was observed since 2013 (0.033 mg/L). In 2015, about 50% of total phosphorus was present in dissolved form. Median total nitrogen was the lowest in 2015 (0.465 mg/L) compared to 2014 (0.677 mg/L) and 2013 (0.536 mg/L) and no trend was observed (Table 4). Similar to the other two Eastern tributaries, over 90% of total nitrogen was comprised of organic nitrogen. Median nitrate-nitrogen concentrations tended to decrease from 0.036 mg/L (2013) to 0.010 mg/L (2015). The decreasing trend is likely the result of improved detection limits of analytical equipment.

3.3.3 Total Suspended Solids

Battle Creek – Median total suspended solids was lowest in 2015 (1.5 mg/L) compared to 2014 (6.0 mg/L) and 2013 (5.0 mg/L) (Table 4). No trend in total suspended solids concentration was observed.

Middle Creek – Median total suspended solids was similar in 2015 (4.4 mg/L) compared to 2014 (4.0 mg/L) and 2013 (2.0 mg/L) (Table 4). No trend in total suspended solids concentration was observed.

Lodge Creek – Median total suspended solids was lower in 2015 (6.4 mg/L) compared to 2014 (8.0 mg/L) and higher compared to 2013 (3.0 mg/L) (Table 4). No trend in total suspended solids concentration was observed.

3.3.4 Fecal Coliform Bacteria

Battle Creek – The median fecal coliform count was highest in 2015 (26 cfu/100 mL) compared to 2014 (10 mg/L) and 2013 (22 mg/L) (Table 4). However, the maximum count of 390 cfu/100 mL in 2015 was lower compared to 2014 (500 cfu/100 mL). No trend in fecal coliform bacteria counts was observed.

Middle Creek – The median fecal coliform count was lower in 2015 (6 cfu/100 mL) compared to 2014 (36 cfu/100 mL) and 2013 (21 cfu/100 mL) (Table 4). Similarly, the maximum count was substantially lower in 2015 (51 cfu/100 mL) compared to 2014 (214 cfu/100 mL) and 2013 (264 cfu/100 mL). No trend in fecal coliform bacteria counts was observed.

Lodge Creek – The median fecal coliform count was higher in 2015 (43 cfu/100 mL) compared to 2014 (9.0 cfu/100 mL) and 2013 (21 cfu/100 mL) (Table 4). Similarly, the maximum count was substantially higher in 2015 (800 cfu/100 mL) compared to 2014 (300 cfu/100 mL) and 2013 (200 cfu/100 mL). No trend in fecal coliform bacteria counts was observed.

Table 4. Median and range for water quality parameters at the Eastern Tributaries, 2013-2015.

Arrows and dashes identify trends in median values and concentrations (increasing ↑, decreasing ↓, no trend -). A green arrow means that the trend is positive (i.e., an improvement in water quality is observed); a yellow arrow represents a degrading trend in water quality; a dash means no trend was determined.

Parameter	Battle				Middle				Lodge			
	2013	2014	2015	Trend	2013	2014	2015	Trend	2013	2014	2015	Trend
Water Temperature	10.6 0.7-17.4	8.85 0.8-16.9	8.9 1.3-16.4	-	15.0 5.2-21.0	13.55 -4.0-19.8	15.25 5.7-21.2	-	15.8 5.2-22.1	13.20 3.6-20.8	14.8 5.8-21.7	-
Dissolved Oxygen	7.67 6.34-9.93	8.26 6.48-9.30	10.23 8.53-12.08	↑	6.99 2.59-9.27	7.00 0.42-9.25	12.10 9.42-14.39	↑	8.52 4.88-9.56	8.38 6.67-9.59	11.77 10.37-15.90	-
pH	8.25 8.19-8.38	8.35 8.21-8.61	8.37 8.06-8.53	↑	8.20 7.97-8.29	8.28 8.22-8.57	8.41 7.94-8.69	↑	8.27 7.54-8.49	8.33 8.20-8.54	8.41 8.30-8.54	↑
Specific Conductivity	380 313-397	369 338-410	376 199-392	-	681 516-740	687 380-947	694 549-745	↑	1006 468-1480	1240 780-1630	1270 941-1540	↑
Total Phosphorus	0.022 0.009-0.045	0.017 0.012-0.041	0.018 0.014-0.023	-	0.075 0.030-0.163	0.116 0.055-0.293	0.104 0.013-0.327	-	0.047 0.020-0.601	0.060 0.013-0.106	0.049 0.040-0.084	-
Total Dissolved Phosphorus	0.008 0.003-0.015	0.009 0.006-0.012	0.010 0.006-0.016	↑	0.055 0.017-0.133	0.079 0.021-0.272	0.103 0.064-0.230	↑	0.033 0.003-0.080	0.025 0.003-0.068	0.022 0.006-0.048	↓
Nitrate+Nitrite Nitrogen	0.036 0.036-0.036	0.027 0.027-0.077	0.010 0.010-0.240	↓	0.036 0.036-0.036	0.027 0.027-0.175	0.010 0.010-0.010	↓	0.036 0.036-0.036	0.027 0.027-0.175	0.010 0.010-0.050	↓
Total Kjeldahl Nitrogen	0.100 0.100-0.100	0.100 0.100-0.230	0.100 0.100-0.100	-	0.555 0.440-0.750	0.695 0.310-0.990	0.470 0.100-1.460	-	0.500 0.440-1.840	0.650 0.370-1.020	0.455 0.250-0.740	-
Total Nitrogen	0.136 0.136-0.136	0.127 0.127-0.266	0.110 0.110-0.340	↓	0.591 0.476-0.789	0.722 0.337-1.165	0.480 0.110-1.470	-	0.536 0.476-1.876	0.677 0.397-1.047	0.465 0.260-0.790	-
Total Suspended Solids	5 2-13	6 2-19	1.5 1.5-16.7	-	2 2-2	4 2-17	4.4 1.5-14.0	-	3 2-30	8 2-16	6.4 3.3-22.7	-
Fecal Coliform Bacteria	22 1-191	10 1-500	26 1-390	-	21 1-264	36 1-214	6 1-51	-	21 1-200	9 1-300	43 6-800	-

3.4 Milk River

3.4.1 St. Mary/Milk River Diversion Operation

The St. Mary/Milk River Diversion was initiated on March 31, 2015 and increased to about 11.3 m^3/s (300 cfs) by May 4, 2015. The start date was earlier in 2015 compared to the previous year, but similar to the years 2006 to 2010, and 2013. The ramping down of flows began on September 8, 2015. Table 5 shows the start-up and shut-down dates of the St. Mary/Milk River Diversion since 2006.

Table 5. St. Mary/Milk River Diversion start-up and shut-down dates for the 2006 through 2015 monitoring period.

Year	Start Date	End Date
2006	March 05	September 24
2007	March 07	September 03
2008	March 17	September 12
2009	March 16	September 24
2010	March 21	September 03
2011	July 24	October 06
2012[a]	April 9	September 15
2013[b]	March 11	September 24
2014[c]	May 13	September 10
2015[d]	March 31 (May 4)	September 8 (August 28?)

[a]Start-up was April 9th and flows were ramped up until April 14th; shut-down started on September 11th and was ramped down to zero on September 15th.
[b]Note that the start date was March 11 with 1.4 m^3/s (50 cfs) of water, but flows were not substantial until about March 25 when flows reached about 11.3 m^3/s (400 cfs).
[c]Note that flow ramping began on May 13 increasing to 11.3 m^3/s (400 cfs) by May 20. Flow reductions began on September 3 with daily reductions of about 2.1 m^3/s (75 cfs) and complete shut-down by September 10.
[d]Start-up was March 31st with 1.4 m^3/s (50 cfs) ramped over a week to 5.0 m^3/s (175 cfs), it was increased to 8.5 m^3/s (300 cfs) on May 4th. Dewatering started on September 8th. Must confirm with streamflow data – currently unavailable. Results for streamflow at the site Milk River at Milk River show declines in streamflow beginning in August.

3.4.2 Streamflow

Mean daily streamflow data from 2010 through 2015 is shown in Figure 2. Generally, mean daily flows were lower in 2015 compared to previous years (2010 to 2014), particularly in April when diversions were kept at a minimum until May, and in June and July when the area typically receives substantial rainfall but did not in 2015.

There was zero flow recorded at the Milk River at the Western Crossing site for 15 days in August and four days in September (Environment Canada 2016). The Milk River at 501 site does not receive any diversion water, therefore flows are always natural. No samples were collected at the Milk River at 501 site in August or in September due to total absence of flow.

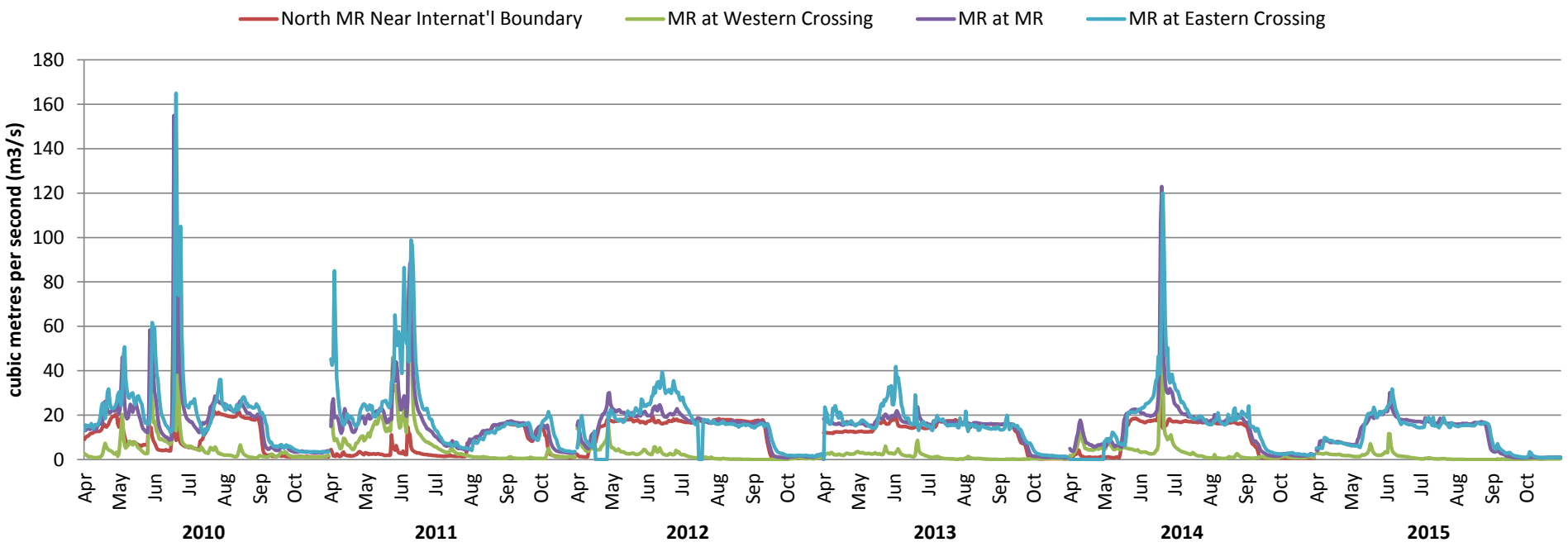

Figure 2. Mean daily streamflow data recorded at various stations at the Milk River, 2010 to 2015. Note that data for the North Milk River near the International Boundary was not available at time of reporting.

3.4.3 General Water Chemistry

Note that while 2013 and 2014 water chemistry results are presented in the data tables for comparison, they are generally not discussed in the result summaries.

General water chemistry parameters are presented in Table 6. In 2015, median water temperature ranged from 9.4°C at the U/S Milk River site to 14.1°C at the Pinhorn site. The lowest water temperature was recorded at the N. Milk River at 501 site (3.6°C) on April 8 and the highest water temperature was recorded at the Milk River at 501 site (21.4°C) on June 25.

Median dissolved oxygen concentration ranged from 9.91 mg/L at the U/S Milk River site to 10.60 mg/L at the HWY 880 site (Table 6). Dissolved oxygen concentration was lowest at the U/S Milk River site (8.19 mg/L) and highest at the N. Milk River at 501 site (11.61 mg/L). The acute daily minimum dissolved oxygen concentration for the protection of aquatic life is 5.0 mg/L and the chronic, 7-day average concentration is 6.5 mg/L (ESRD 2014). In 2015, all samples met the acute daily minimum guideline and the chronic guideline at all sites.

The pH guidelines for the protection of aquatic life is $\geq$6.5 and $\leq$9.0 (ESRD 2014). The pH was within guidelines for the protection of aquatic life at all sites in 2015.

Table 6. Summary (median and range) of general water quality parameters at the Milk River, 2013 to 2015.

Site	Water Temperature °C								
	2013			2014			2015		
	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	12.1	3.2-18.5	9	12.1	4.3-18.2	9	9.8	3.6-18.6
Milk River at 501	10	12.9	4.8-18.8	9	14.4	5.2-19.0	7	10.1	4.8-21.4
U/S Milk River	10	14.5	6.4-20.5	10	14.4	2.0-21.5	8	9.4	6.4-21.0
AT HWY 880	7	17.2	5.2-21.9	9	17.0	0.8-20.5	10	13.3	5.1-20.8
Pinhorn	10	15.4	4.3-21.2	9	15.6	0.1-20.7	10	14.1	5.5-20.5

Site	Dissolved Oxygen mg/L								
	2013			2014			2015		
	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	7.57	6.79-9.58	9	7.70	7.03-9.29	9	10.26	8.92-11.61
Milk River at 501	10	7.37	6.94-9.47	9	7.14	6.72-8.56	7	10.27	8.93-11.47
U/S Milk River	10	7.37	6.84-9.36	10	7.69	6.51-9.87	9	9.91	8.19-11.31
AT HWY 880	7	8.70	7.87-12.50	9	7.44	6.37-10.82	10	10.60	8.83-11.50
Pinhorn	10	7.18	6.36-9.76	9	7.49	6.23-10.84	10	10.34	8.66-11.50

Site	pH								
	2013			2014			2015		
	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	8.21	7.84-8.37	9	8.43	8.17-8.51	10	8.19	7.62-8.38
Milk River at 501	10	8.44	8.36-8.65	10	8.49	8.32-8.57	8	8.52	8.30-8.59
U/S Milk River	10	8.38	8.21-8.58	10	8.40	8.28-8.60	10	8.35	7.91-8.54
AT HWY 880	7	8.22	8.02-8.32	9	8.36	8.28-8.61	10	8.41	7.76-8.53
Pinhorn	10	8.34	8.19-8.49	9	8.36	8.30-8.63	10	8.41	7.95-8.57

Specific conductivity was lowest during the diversion period. During the diversion period, median conductivity was lowest at the N. Milk River at 501 site (154 µS/cm) and highest at the HWY 880 site (237 µS/cm). During the natural flow period, median specific conductivity ranged from a low of 300 µS/cm at the N. Milk River at 501 site to a high of 591 µS/cm at the Pinhorn site (Table 6). The irrigation guideline is ≤700 µS/cm for sensitive crops such as strawberries and ≤1000 µS/cm for non-sensitive crops like cereals and forages (Alberta Agriculture 1983, CCREM 1987). In 2015, all samples met the irrigation guidelines for non-sensitive crops and, one of 10 samples exceeded the guideline for sensitive crops at the Hwy 880 site and at the Pinhorn site (on October 20). The WQO-50 and the WQO-90 objectives for specific conductivity were met at all sites in 2015 (Table 7).

3.4.4 Nutrients

Total Phosphorus

In general, total phosphorus in the Milk River tends to increase in the downstream direction. During the diversion period, median total phosphorus concentration was 0.016 mg/L at the North Fork at 501 site, 0.079 mg/L at the U/S Milk River site and 0.156 mg/L at the Pinhorn site (Table 8). During the natural flow period, median total phosphorus was 0.010 mg/L at the North Fork at 501 site, 0.013 mg/L at the U/S Milk River site and 0.033 mg/L at the Pinhorn site. Total phosphorus concentration ranged from 0.010 to 0.021 mg/L at the Milk River at 501 site in 2015 (April-October) (Table 8).

During the diversion period, median total phosphorus concentration met the WQO-50 objective only at the North Fork at 501 site. The WQO-50 was exceeded by more than 20% at the U/S Milk River, HWY 880 and Pinhorn sites during the same period. During the natural flow period, the WQO-50 was met at the U/S Milk River site, but was exceeded at the downstream sites (HWY 880 and Pinhorn) (Table 8).

Unlike 2014, the WQO-90 was met at all sites during both the diversion and natural flow periods in 2015 except at the Pinhorn site which was in the cautionary range (Table 8).

Total Dissolved Phosphorus

During the diversion period, median total dissolved phosphorus concentration ranged from 0.003 mg/L at the North Fork at 501 site to 0.007 mg/L at the Pinhorn site (Table 9). During the natural flow period, median total dissolved phosphorus was 0.003 mg/L at all sites except HWY 880 (0.006 mg/L) (Table 9). Total dissolved phosphorus concentration ranged from 0.003 to 0.006 mg/L at the Milk River at 501 site in 2015 (April-October).

Median total dissolved phosphorus concentrations met the WQO-50 objective during the diversion period at all sites except HWY 880 and Pinhorn where the objective was exceeded by more than 20%. During the natural flow period, the WQO-50 was exceeded only at the HWY 880 site.

The total dissolved solids WQO-90 was met at all sites in 2015 during both the diversion and natural flow periods (Table 9).

Table 7. Summary of specific conductivity at the Milk River, 2013 to 2015.

Site	Flow Period	WQO		2013				2014				2015			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	165	246	9	152	163	132-164	4	149	165	139-172	6	154	159	145-161
	Natural	445	512	1	399	-	-	5	454	473	427-474	4	300	427	190-448
MR at 501	April-Oct	510	882	10	473	592	434-799	10	489	579	354-588	8	489	696	461-863
U/S MR	Diversion	210	398	9	218	247	161-265	5	208	317	170-383	6	198	224	152-225
	Natural	570	674	1	522	-	-	5	492	580	458-606	4	423	539	308-567
HWY 880	Diversion	250	540	6	***308***	321	206-322	5	245	382	210-460	6	237	265	181-273
	Natural	727	936	1	782	-	-	4	654	735	477-759	4	522	707	391-766
Pinhorn	Diversion	250	540	9	***311***	326	200-348	5	261	404	223-481	6	212	286	116-296
	Natural	727	936	1	691	-	-	4	696	759	482-785	4	591	739	440-791

If the measured 50th (median) or 90th percentile value is ≤10% above the WQO it is considered to meet the WQO (**Green**); if the value is >10% but ≤20% above the WQO, it is considered within normal range (**Yellow**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

Table 8. Summary of total phosphorus concentrations at the Milk River, 2013 to 2015.

Site	Flow Period	WQO		2013				2014				2015			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	0.014	0.037	9	0.010	0.029	0.003-0.059	5	0.013	0.029	0.008-0.033	6	0.016	0.022	0.010-0.023
	Natural	0.012	0.100	1	0.003	-	-	5	0.013	0.022	0.003-0.027	4	0.010	0.015	0.007-0.016
MR at 501	April-Oct	0.019	0.186	10	0.021	0.044	0.012-0.047	10	0.021	0.089	0.008-0.098	8	0.014	0.020	0.010-0.021
U/S MR	Diversion	0.044	0.148	9	0.035	0.061	0.012-0.083	5	***0.050***	***0.232***	0.039-0.255	6	***0.079***	0.148	0.036-0.183
	Natural	0.013	0.504	1	0.007	-	-	5	***0.029***	0.134	0.009-0.202	4	0.013	0.024	0.008-0.028
AT HWY 880	Diversion	0.088	0.220	6	***0.099***	***0.260***	0.033-0.410	5	0.089	***0.311***	0.076-0.325	6	***0.141***	0.197	0.066-0.204
	Natural	0.013	0.086	1	0.005	-	-	4	***0.029***	***0.202***	0.007-0.270	4	***0.021***	0.040	0.007-0.045
Pinhorn	Diversion	0.088	0.220	9	***0.120***	***0.246***	0.061-0.352	5	***0.190***	***0.436***	0.133-0.446	6	***0.156***	***0.245***	0.107-0.284
	Natural	0.013	0.086	1	0.006	-	-	4	***0.048***	***0.210***	0.009-0.271	4	***0.033***	0.066	0.009-0.072

If the measured 50th (median) or 90th percentile value is ≤10% above the WQO it is considered to meet the WQO (**Green**); if the value is >10% but ≤20% above the WQO, it is considered within normal range (**Yellow**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

Table 9. Summary of total dissolved phosphorus concentrations at the Milk River, 2013 to 2015.

Site	Flow Period	WQO		2013				2014				2015			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	0.003	0.007	9	0.003	0.008	0.003-0.010	4	0.003	0.003	0.003-0.003	6	0.003	0.003	0.003-0.003
	Natural	0.005	0.066	1	0.003	-	-	5	0.006	0.007	0.003-0.007	4	0.003	0.005	0.003-0.006
MR at 501	Apr-Oct	0.006	0.015	10	0.003	0.009	0.003-0.010	10	0.004	0.008	0.003-0.022	8	0.006	0.008	0.003-0.008
U/S MR	Diversion	0.003	0.010	9	0.003	0.008	0.003-0.010	5	0.003	0.024	0.003-0.039	6	0.003	0.006	0.003-0.006
	Natural	0.005	0.173	1	0.003	-	-	5	0.007	0.021	0.003-0.030	4	0.003	0.005	0.003-0.006
HWY 880	Diversion	0.004	0.011	6	0.003	0.008	0.002-0.010	5	0.006	0.028	0.003-0.043	6	0.007	0.015	0.003-0.020
	Natural	0.004	0.021	1	***0.013***	-	-	4	0.005	0.007	0.003-0.008	4	0.006	0.006	0.003-0.007
Pinhorn	Diversion	0.004	0.011	9	0.003	0.009	0.003-0.010	5	0.006	0.022	0.003-0.033	6	0.006	0.011	0.003-0.014
	Natural	0.004	0.021	1	0.003	-	-	4	0.004	0.007	0.003-0.007	4	0.003	0.006	0.003-0.007

If the measured 50th (median) or 90th percentile value is ≤10% above the WQO it is considered to meet the WQO (**Green**); if the value is >10% but ≤20% above the WQO, it is considered within normal range (**Yellow**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

Total Nitrogen

During the diversion period, median total nitrogen concentration ranged from a low of 0.146 mg/L at the North Fork at 501 site to 0.319 mg/L at the Pinhorn site (Table 10). During the natural flow period, total nitrogen ranged from 0.214 mg/L at the U/S Milk River site to 0.301 mg/L at the Pinhorn site. Total nitrogen ranged from 0.110 to 0.290 mg/L at the Milk River at 501 site (April-October) (Table 10).

Total nitrogen concentration met the WQO-50 and WQO-90 objectives during the diversion and natural flow periods at all sites in 2015 (Table 10).

3.4.5 Total Suspended Solids

During the diversion period, median total suspended solids concentrations ranged from 11.4 mg/L at the North Fork at 501 site to 185 mg/L at the Pinhorn site (Table 11). During the natural flow period, total suspended solids ranged from 4.1 mg/L at the U/S Milk River site to 20.0 mg/L at the Pinhorn site (Table 11). Total suspended solids concentration ranged from 1.5 to 7.3 mg/L at the Milk River at 501 site in 2015 (April-October).

During the diversion period, total suspended solids concentration exceeded the WQO-50 objective by more than 10% (but less than 20%) at the HWY 880 site and, by more than 20% at the U/S Milk River and the Pinhorn sites. All samples collected at all sites met the WQO-90 objectives in 2015 (Table 11).

3.4.6 Fecal Coliform Bacteria

Fecal coliform bacteria counts were generally high in 2015. During the diversion period, median fecal coliform bacteria counts ranged from 80 cfu/100 mL at the North Fork at 501 site, to 176 cfu/100 mL at the U/S Milk River site (Table 12). During the natural flow period, median fecal coliform bacteria counts ranged from 8 cfu/100 mL at the U/S Milk River site, to 78 cfu/100 mL at the N. Milk River at 501 site. Fecal coliform bacteria counts ranged from 4 to 900 cfu/100 mL at the Milk River at 501 site in 2015 (April-October).

Similar to 2014, median fecal coliform bacteria counts exceeded the WQO-50 objective by more than 20% at all the sites during the diversion period (Table 12). During the natural flow period, the WQO-50 was exceeded by more than 20% only at the N. Milk River at 501 and Pinhorn sites (Table 12). The WQO-90 objective was only exceeded by more than 20% at the HWY 880 site during the diversion period (Table 12). The WQO-50 and WQO-90 objectives were met at the Milk River at 501 site in 2015.

Table 10. Summary of total nitrogen concentrations at Milk River, 2013 to 2015.

Site	Flow Period	WQO		2013				2014				2015			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	0.240	0.468	9	0.136	0.290	0.136-0.334	5	0.176	0.274	0.100-0.320	6	0.146	0.155	0.110-0.157
	Natural	0.900	1.578	1	0.488	-	-	5	0.289	0.516	0.202-0.576	4	0.225	0.316	0.121-0.338
MR at 501	April-October	0.600	1.360	10	0.411	0.578	0.316-0.871	10	0.347	0.552	0.277-0.596	8	0.110	0.283	0.110-0.290
U/S MR	Diversion	0.325	0.667	9	0.296	0.434	0.136-0.506	5	0.307	0.624	0.127-0.717	6	0.264	0.315	0.110-0.317
	Natural	0.680	1.637	1	0.326	-	-	5	0.486	1.036	0.297-1.070	4	0.214	0.327	0.110-0.352
HWY 880	Diversion	0.365	0.668	6	0.330	0.435	0.160-0.470	5	0.367	***0.859***	0.277-0.880	6	0.315	0.463	0.122-0.466
	Natural	0.320	1.400	1	0.210	-	-	5	***0.486***	0.966	0.036-1.106	4	0.225	0.354	0.110-0.403
Pinhorn	Diversion	0.365	0.668	9	***0.446***	0.682	0.136-0.806	5	***0.487***	***1.043***	0.297-1.101	6	0.319	0.522	0.129-0.525
	Natural	0.320	1.400	1	0.136	-	-	5	0.227	0.931	0.036-1.222	4	0.301	0.609	0.110-0.660

If the measured 50th (median) or 90th percentile value is ≤10% above the WQO it is considered to meet the WQO (**Green**); if the value is >10% but ≤20% above the WQO, it is considered within normal range (**Yellow**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

Table 11. Summary of total suspended solids concentrations at Milk River, 2013 to 2015.

Site	Flow Period	WQO		2013				2014				2015			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	16	59	9	9	39	2-45	4	15	30	7.9-34.6	4	11.4	21.0	1.5-22
	Natural	5	55	1	2	-	-	5	2	6.4	1.5-9.3	6	4.8	10.8	1.5-12
MR at 501	April-October	14	247	10	10	-	2-39	10	14.7	98.6	1.5-112	8	6	6.9	1.5-7.3
U/S MR	Diversion	56	282	9	40	66	22-90	5	***78***	239	47.7-267	6	***88.2***	160.0	15.3-175
	Natural	7	267	1	2	-	-	5	***17.6***	88.0	1.5-132	4	4.1	21.6	1.5-28
HWY 880	Diversion	131	384	6	130	290	42-410	5	151	386.8	87.6-388	6	154	212	36.7-250
	Natural	13	228	1	2	-	-	4	***20.8***	226.2	1.5-306	4	10.8	39.1	1.5-47.3
Pinhorn	Diversion	131	384	9	***163***	298	30-463	5	***213***	***488***	137-540	6	***185***	292	113-293
	Natural	13	228	1	2	-	-	4	***36.8***	195.4	3.8-251	4	***20.0***	57.5	1.5-67

If the measured 50th (median) or 90th percentile value is ≤10% above the WQO it is considered to meet the WQO (**Green**); if the value is >10% but ≤20% above the WQO, it is considered within normal range (**Yellow**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

Table 12. Summary of fecal coliform bacteria counts at Milk River, 2013 to 2015.

Site	Flow Period	WQO		2013				2014				2015			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	27	140	9	***64***	***320***	8-400	5	***138***	***201.2***	56-226	6	***90***	133	44-138
	Natural	55	668	1	28	-	-	5	11	46	5-53	4	***78***	160	3-164
MR at 501	April-October	77	619	10	53	410	1-500	10	***104***	***2030***	4-3200	8	86	462	4-900
U/S MR	Diversion	68	272	9	32	71	1-102	5	***158***	289	89-360	6	***176***	193	104-194
	Natural	49	522	1	2	-	-	5	5	91.2	2-142	4	8	46	1-62
HWY 880	Diversion	78	280	6	40	***1118***	1-2100	5	***142***	206	70-210	6	***156***	***741***	84-1100
	Natural	29	163	1	18	-	-	4	5.5	42	1-57	4	20	57	1-65
Pinhorn	Diversion	78	280	9	48	206	17-300	5	***128***	189	48-229	6	***157***	277	115-366
	Natural	29	163	1	7	-	-	4	13	33	2-38	4	***39***	46	8-45

If the measured 50th (median) or 90th percentile value is $\leq$10% above the WQO it is considered to meet the WQO (**Green**); if the value is >10% but $\leq$20% above the WQO, it is considered within normal range (**Yellow**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

4.0 SUMMARY

Weather and Streamflow

- Mean daily flows were lower in April 2015 compared to April flows in previous years (2010 to 2014) when diversions were kept at a minimum, and in June and July when the area typically receives substantial rainfall but did not.

Eastern Tributaries

- A few trends have emerged since 2013 at the Eastern Tributaries
- Dissolved oxygen was generally higher in 2015 compared to the previous two years
- A minor increasing trend in pH was observed at Battle, Middle and Lodge creeks
- A minor decreasing trend in nitrate+nitrite nitrogen at Battle, Middle and Lodge creeks
- A decreasing trend in total nitrogen at Battle Creek

Red Creek

- No real trends were observed since 2013 at the Red Creek sites "Middle" and "Upstream"
- At the "Downstream" site, an increasing trend (degrading water quality) was observed for many parameters, including pH, conductivity, phosphorus, organic nitrogen, total suspended solids and fecal coliform bacteria

Milk River Mainstem

- Milk River Water Quality Objectives (WQOs) were used to determine water quality at sites in 2015 (i.e., median WQO-50 and WQO-90 [90^{th} percentile])
- Conductivity (salts) met the median WQO-50 and WQO-90
- Total phosphorus exceeded the median WQO-50 at HWY 880 and Pinhorn during the natural and diversion flow period, as well as U/S Milk River during the diversion flow period; but all sites met the WQO-90 (90^{th} percentile objective) for both flow periods
- Total nitrogen met the WQO-50 and WQO-90 during the natural and diversion flow periods
- Total suspended solids exceeded the median objective at the Pinhorn for both natural and diversion flow period, and also at U/S Milk River during the diversion period
- Fecal coliform bacteria exceeded the WQO-50 during the diversion flow period, at N. Milk River at 501, U/S Milk River, HWY 880 and Pinhorn; fecal coliform bacteria also exceeded the WQO-50 during the natural flow period at N. Milk River and the Pinhorn; the WQO-90 objective was only exceeded at HWY 880 during the diversion flow period

5.0 RECOMMENDATIONS

Red Creek

- Historically, there have been landowner concerns regarding water quality at Red Creek. The main concerns are related to potential pesticide use and their impact on amphibians, as well as heavy metals (e.g., Mercury, Cadmium, and Lead) and their potential impact on livestock health. Landowners have noted that they have not observed the same abundance of leopard frogs, in particular, at the creek.

  To support the Red Creek Watershed Group, a scoping study could be undertaken to better understand pesticides and heavy metals at Red Creek. Further, a better understanding of land use, occurrence of streambank erosion and riparian health could help to better interpret water

quality results. There may be potential for fecal coliform source tracking to better understand the source of fecal coliform bacteria at Red Creek. Further discussions could be held with landowners who may observe changes in activity or land management in the area (e.g., livestock, wildlife).

Eastern Tributaries

- Continuation of the water monitoring program at the Easter Tributaries should continue to maintain an environmental condition of Battle, Middle and Lodge creeks for state of the watershed reporting. This work would also support future work in this area of the watershed, if desired.

Milk River

- The existing Milk River (mainstem) sites should be maintained.
- The site downstream of the Milk River treatment lagoons should be re-initiated.
- The MRWCC should continue to collect water quality data at HWY 880 for consistency with the overall Milk River water quality data base. AEP could consider increasing their monitoring frequency at HWY 880 to coincide with MRWCC sampling dates.

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