

# **MILK RIVER WATERSHED WATER MONITORING REPORT 2021**



**Prepared for: Milk River Watershed Council Canada**

**Prepared by: Palliser Environmental Services Ltd.**

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## Acknowledgements

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### **Cover Photo of the Milk River at Writing-on-Stone Provincial Park (October 24, 2021):**

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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 1909 Boundary Waters Treaty.

The Milk River Watershed Council Canada (MRWCC) has monitored the Milk River and some of its tributaries since 2006. This report is a compilation of water monitoring data collected in 2021, with reference to the results from the previous three years (i.e., 2018-2020) (Palliser Environmental 2019 to 2021a). Comparisons are made to Water Quality Objectives that were developed as part of the Milk River Integrated Watershed Management Plan (IWMP) (PESL 2015), and relevant provincial guidelines (GoA 2018).

## 2.0 METHODS

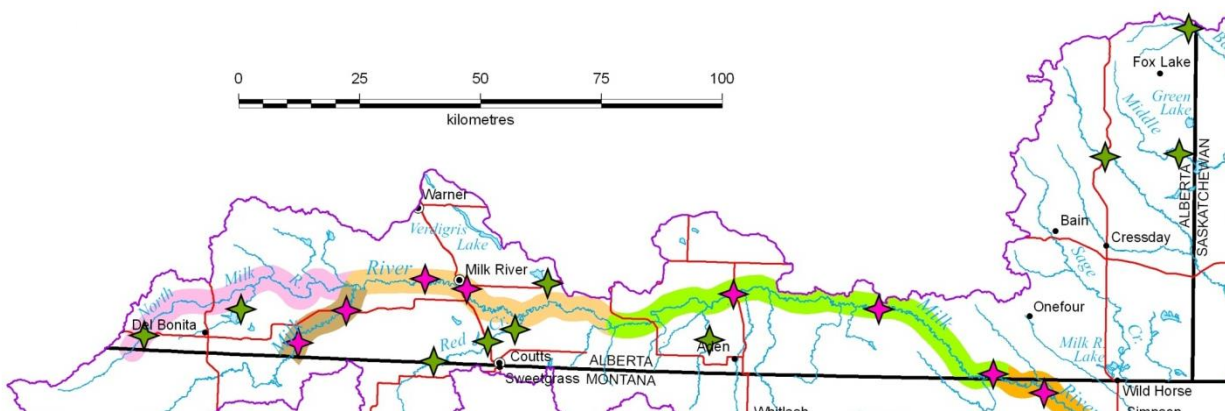
Grab samples were collected approximately every two weeks (April-June) and monthly (July-October) (N=10) from four sites: **North Fork at 501**, **Milk River at 501**, **Upstream of the Town of Milk River** (U/S Milk River) and **HWY 880 Bridge**. At the **Pinhorn** site, grab samples were collected approximately every two weeks (May-June) and monthly (July-October) (N=8).

A downstream site at Red Creek was monitored in 2021 by Alberta Environment and Parks (AEP). Monitoring in previous years at Red Creek included an upstream and middle site sampled by the MRWCC; however, these sites were not sampled in 2020 and 2021. The MRWCC Research and Monitoring Team determined sufficient data has been collected to understand the trends and conditions on Red Creek and a summary report was completed in 2020. Monitoring in previous years has included three tributaries known as the “Eastern Tributaries” (i.e., Battle Creek, Middle Creek and Lodge Creek). These three tributaries were not sampled in 2020 and 2021. Verdigris Coulee and Miners Coulee, two ephemeral tributaries to the Milk River which have been dry in past years were sampled in 2021.

The MRWCC water monitoring program was conducted in collaboration with staff from Cardston County and Alberta Environment and Parks. 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 is **CALA**<sup>1</sup> accredited for criteria and standards established by the Association under their Certificate of Laboratory Proficiency.

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<sup>1</sup> **CALA** – Canadian Association for Laboratory Accreditation Inc.



**Figure 1 - Map showing water monitoring locations sampled in the Milk River watershed, 2021.**

Samples were analysed using **APHA**<sup>2</sup> approved methods for general parameters (e.g., pH, specific conductivity), nutrients (total phosphorus (TP), total dissolved phosphorus (TDP), nitrate+nitrite nitrogen ( $\text{NO}_3+\text{NO}_2\text{-N}$ ), total kjeldahl nitrogen (TKN) and total nitrogen [TN; calculated]), total suspended solids (TSS) and fecal coliform bacteria (FCB).

Water monitoring results were compared to Milk River Water Quality Objectives (WQO) and to applicable provincial surface water quality guidelines (GoA 2018). The WQO were established using data from 2006 to 2011 at four main river reaches (i.e., North Fork Milk River, Mainstem Milk River, Milk River Gravel Bed and Milk River Sand Bed) (PESL 2015). 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 2021 data set is the ninth year of data collected since the WQOs were established.

## 3.0 RESULTS

### 3.1 Precipitation

Overall, total precipitation in the Milk River watershed in 2021 varied across the watershed, ranging from 139.9 mm at Onefour to 294.1 mm at Cardston (Tables 1 and 2). May was the wettest month (mean = 62.4 mm) while September was the driest month (mean = 7.2 mm) (Table 1). Comparing mean total precipitation for each year, 2021 was the third driest of the ten years (mean: 195.1 mm) (Table 2). The driest year was recorded in 2017 (mean: 178.8 mm) and the wettest year occurred in 2014 (mean: 344.0 mm) a difference of 165.2 mm of precipitation between the wettest and driest years.

Comparing the 2021 precipitation data to 2020, the weather stations Cardston and Del Bonita had similar precipitation; however, the weather stations Milk River, Masinasin and Onefour had less precipitation in 2021 compared to 2020 (Table 2). In 2021, the weather stations Milk River and Onefour had the lowest precipitation of ten years and Del Bonita and Masinasin had the third lowest of 10 years. Cardston in 2021 had average precipitation recording the fifth lowest in ten years.

<sup>2</sup> **APHA** – American Public Health Association



**Table 1 – Total precipitation (mm) at five weather stations, April to October, 2021.**

Month	Cardston	Del Bonita	Milk River	Masinasin	Onefour
April	28.1	22.8	18.1	10.9	11.0
May	77.1	48.9	47.6	63.0	75.5
June	28.4	16.7	5.2	3.8	5.6
July	53.2	39.7	21.8	13.2	11.9
August	59.0	66.9	44.2	43.5	25.8
September	12.9	6.3	6.6	5.5	4.6
October	35.4	23.0	16.7	17.2	6.8
<b>Total</b>	<b>294.1</b>	<b>224.3</b>	<b>160.2</b>	<b>157.1</b>	<b>139.9</b>

Data Source: Environment Canada - [http://climate.weather.gc.ca/index\\_e.html](http://climate.weather.gc.ca/index_e.html) (Note: April to June data for Cardston and April and June data for Onefour is from ACIS viewer: <https://acis.alberta.ca/>)

**Table 2 - Historical total precipitation (mm) at five weather stations for the water monitoring period April to October, 2012 to 2021.**

Year	Cardston	Del Bonita	Milk River	Masinasin	Onefour	Mean
2012	282.5	266.8	326.8	216.1	272.6	273.0
2013	323.1	245.1	347.5	256.8	408.6	316.2
2014	376.8	404.7	290.1	333.7	314.7	344.0
2015	256.3	192.6	199.6	123.5	198.6	194.1
2016	304.0	309.3	315.5	323.1	319.1	314.2
2017	184.4	175.9	261.6	132.2	140.0	178.8
2018	303.9	251.9	195.4	180.0	154.0	217.0
2019	369.2	334.3	299.4	278.5	250.2	306.3
2020	272.5	246.5	294.3	283.0	232.3	265.7
2021	294.1	224.3	160.2	157.1	139.9	195.1

Data Source: Environment and Climate Change Canada - <http://agriculture.alberta.ca/acis/weather-data-viewer.jsp>

## 3.2 Red Creek

### 3.2.1 General Water Chemistry

In 2021, four water samples (N=4) were collected at the downstream Red Creek site: one in each month from March to June. Starting in June, sampling was reduced to once every two months. Red Creek did not have any flow during August and October.

At Red Creek in 2021, the median (12.1°C) and maximum (20.8°C) water temperature at the downstream site was the lowest of the five years from 2017 to 2021 (Table 3). The maximum water temperatures at the downstream site occurred in June. The lower water temperatures may have been due to reduced sampling frequency at Red Creek which meant a July water temperature was not recorded.

The median dissolved oxygen concentration at the downstream Red Creek site (13.03 mg/L) met the acute ( $\geq 5.0$  mg/L) and chronic ( $\geq 6.5$  mg/L) guideline in 2021. All samples at the downstream Red Creek site were in compliance in 2021. From 2017 through 2021, the median dissolved oxygen and all samples at the

**Table 3 - Median and range for water quality at Red Creek, 2017-2021. No samples were collected at the upstream and middle sites in 2020 or 2021.**

Parameter	Upstream			Middle			Downstream				
	2017	2018	2019	2017	2018	2019	2017	2018	2019	2020	2021
Water Temperature, °C	14.0 8.0-21.0	13.0 0.2-20.9	12.8 1.4-17.6	14.3 7.1-21.4	15.4 0.1-18.9	13.3 5.3-18.3	17.0 8.9-21.6	15.0 0.1-22.1	14.4 4.9-22.0	20.0 3.1-22.5	12.1 0.5-20.8
Dissolved Oxygen, mg/L	7.98 4.51-12.41	9.09 5.68-12.62	8.28 5.53-13.01	9.19 8.39-11.87	8.00 4.07-10.92	8.06 6.49-9.98	10.75 9.50-13.47	10.64 10.18-11.58	10.60 9.62-11.26	12.64 10.31-15.10	13.03 12.77-14.23
pH	8.24 7.98-8.34	8.44 7.99-8.55	8.19 7.99-8.33	8.42 8.18-8.61	8.49 8.12-8.64	8.33 7.94-8.40	8.35 7.97-8.50	8.17 8.06-8.56	8.24 7.71-8.48	8.29 8.19-8.39	8.28 7.94-8.43
Specific Conductivity, µS/cm	2,540 2,130-2,690	2,345 506 to 2,796	2,690 1,920-3,140	2,560 1,610-3,080	2,115 426-2,440	2,390 1,580-2,580	2,630 1,530-2,920	2,489 510-2,796	2,585 1,560-2,880	2,700 2,500-3,000	2,550 1,200-2,800
Total Phosphorus, mg/L	0.045 0.025-0.615	0.081 0.012-0.488	0.053 0.016-0.212	0.098 0.045-0.341	0.177 0.056-0.362	0.075 0.072-0.172	0.036 0.019-0.180	0.026 0.009-0.400	0.026 0.011-0.121	0.006 0.004-0.017	0.019 0.017-0.070
Total Dissolved Phosphorus, mg/L	0.021 0.008-0.447	0.067 0.003-0.413	0.017 0.008-0.111	0.047 0.024-0.310	0.081 0.036-0.174	0.045 0.039-0.094	0.019 0.007-0.160	0.020 0.003-0.320	0.011 0.007-0.068	0.003 0.002-0.009	0.009 0.006-0.051
Nitrate+Nitrite Nitrogen, mg/L	0.250 0.005-1.600	0.482 0.050-4.190	0.064 0.050-2.680	0.050 0.050-0.050	0.053 0.050-0.495	0.055 0.050-0.870	0.050 0.002-0.050	0.039 0.025-0.850	0.096 0.055-0.920	0.260 0.210-1.500	0.185 0.019-0.330
Total Kjeldahl Nitrogen, mg/L	1.00 0.84-2.12	1.33 0.73-1.68	1.17 0.67-3.01	1.28 1.08-1.89	1.18 0.60-1.58	0.92 0.65-1.64	1.02 0.51-1.30	0.82 0.25-1.40	0.71 0.44-1.55	0.63 0.49-0.97	0.78 0.57-1.30
Total Nitrogen, mg/L	1.81 0.85-2.54	1.96 0.85-5.74	2.05 0.73-4.10	1.33 1.13-1.94	1.28 0.65-1.82	1.08 0.71-2.51	1.07 0.51-1.30	1.05 0.64-2.04	0.81 0.53-2.47	1.06 0.71-1.99	0.89 0.80-1.60
Total Suspended Solids, mg/L	12 4-61	9.15 1.5-33.3	12 5-106	12 6-26	14.0 3.7-91.3	9 7-12	4 1-9	1.60 0.5-135	4.8 1.2-16	4.3 2.7-7.9	4.6 2.2-7.3
Fecal Coliform Bacteria, cfu/100 mL	19 1-400	61 1-204	4 1-300	87 1-600	57 1-83	2 1-300	118 1-700	100 6-3,600	121 1-2,000	20 6-1,091	5 1-1,364

**Table 4 - Summary of Red Creek water quality compliance with dissolved oxygen acute and chronic guidelines, 2015-2021 (GoA 2018).**

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
2015	100	100	100	87	100	100
2016	89	100	83	67	100	100
2017	75	50	100	100	100	100
2018	100	100	88	88	100	100
2019	100	88	100	80	100	100
2020	not sampled	not sampled	not sampled	not sampled	100	100
2021	not sampled	not sampled	not sampled	not sampled	100	100
Trend	no trend	no trend	no trend	no trend	stable	stable

downstream site have met the acute and chronic dissolved oxygen guidelines. The compliance rate for the acute and chronic guideline is high (100%) and stable at the downstream site (Table 4). The upstream and middle sites did not show a compliance trend from 2017 to 2019 with some exceedances of acute and chronic guidelines at both sites (Table 4).

In 2021, the median pH at the downstream Red Creek site (8.28) and all individual pH samples (range: 7.94 to 8.43) met the pH guideline of 6.5 to 9.0 for aquatic life (Table 3). From 2017 to 2021, the median pH and all individual pH samples at Red Creek met the pH guideline.

Median specific conductivity at the downstream Red Creek site in 2021 (2,550  $\mu\text{S}/\text{cm}$ ) exceeded the safe irrigation guideline ( $\leq 1,000 \mu\text{S}/\text{cm}$ ) and would be considered unsuitable for irrigation ( $\geq 2,000 \mu\text{S}/\text{cm}$ ) (GoA 2018). The specific conductivity results in 2021 at the downstream site were similar to previous years (2017-2020) (Table 3).

### 3.2.2 Nutrients

In 2021, the median total phosphorus (0.019 mg/L) and the maximum total phosphorus (0.070 mg/L) at the downstream site was the second lowest of the five years (Table 3). The maximum total phosphorus concentration at the downstream site occurred on March 16 and was likely due to increased precipitation and runoff containing phosphorus. In 2021, an average of 51% of the total phosphorus at the downstream site was present in the dissolved form.

The median total nitrogen concentration in 2021 at the downstream Red Creek site (0.89 mg/L) was similar to the previous four years. In 2021 at the downstream Red Creek site, 83% of the total nitrogen was present in the organic (TKN) form and 17% of the total nitrogen present was in the soluble form (nitrate+nitrite nitrogen) (Table 3).

### 3.2.3 Total Suspended Solids

In 2021 at Red Creek, the median total suspended solids (TSS) concentration at the downstream site was 4.6 mg/L and similar to previous years. The maximum TSS at the downstream site (7.3 mg/L) was the lowest of the five years and occurred in March (Table 3). The maximum total suspended solids concentrations at Red Creek have typically occurred during the spring and was likely the result of increased stream flows from snow melt runoff and/or higher precipitation.

### 3.2.4 Fecal Coliform Bacteria

The median fecal coliform bacteria count at downstream Red Creek site was 5 cfu/100 mL and the lowest of the five years (Table 3). The median fecal coliform bacteria count at downstream site met the provincial guideline for irrigation (100 cfu/100 mL) (GoA 2018). The maximum fecal coliform bacteria count at the downstream site (1,364 cfu/100 mL) was the third highest of the five years (Table 3). One (1) of four samples (25%) from downstream Red Creek site was greater than the irrigation guideline. Fecal coliform bacteria counts appear to be highly variable from year to year at Red Creek (Table 3) and may be the result of fluctuating wildlife populations and usage near the creek, varied cattle grazing intensity and environmental bacteria (i.e., self-sustaining naturalized populations of coliform bacteria).



### 3.2.5 Other Parameters

A review of historical water quality data for lower Red Creek up to 2020 (PESL 2021b) indicated some exceedances for livestock, irrigation and protection of aquatic life (PAL). The data from 2021 was reviewed and the following observations were made:

- Livestock Water Guidelines: From 2006 to 2020 (10-year dataset), sulphate sometimes exceeded the guideline (1,000 mg/L). In 2021, sulphate ranged from 400 to 1,100 mg/L (N=4) and one sample exceeded the livestock water guideline.
- Irrigation Guidelines: From 2016 to 2020 (5-year dataset), total boron occasionally exceeded the guideline (500 µg/L). In 2021, total boron ranged from 81.5 to 128 µg/L (N=4) and none of the samples exceeded the irrigation guideline.
- Protection of Aquatic Life Guidelines:
  - From 2016 to 2020 (5-year dataset), total arsenic occasionally exceeded the chronic guideline (5 µg/L). In 2021, total arsenic ranged from 1.33 to 2.92 µg/L (N=4) and none of the samples exceeded the PAL guideline.
  - From 2016 to 2020, total copper rarely exceeded the chronic guideline (7 µg/L). In 2021, total copper ranged from 0.29 to 1.31 µg/L (N=4) and none of the samples exceeded the PAL guideline.
  - From 2016 to 2020, total mercury rarely exceeded the chronic guideline (5 ng/L). In 2021, total mercury ranged from 0.86 to 2.27 ng/L (N=4) and none of the samples exceeded the PAL guideline.
  - From 2016 to 2020, total selenium almost always exceeded the chronic guideline (2 µg/L). In 2021, total selenium ranged from 2.7 to 10.4 µg/L (median: 4.7 µg/L) and all of the samples (N=4) exceeded the PAL guideline by a factor ranging from 1.4 to 5.2 times.

## 3.3 Ephemeral Tributaries

Miners Coulee contributed minor flow to the Milk River in 2021. During six site visits between March 16 and October 6, flowing water was observed on March 16, April 19, May 17 and June 21 with the June visit noting 'very low flow'. Verdigris Coulee contributed no flow to the Milk River in 2021. During six site visits between March 16 and October 6, no flowing water was observed at Verdigris Coulee.

### 3.3.1 General Water Chemistry

**Miners Coulee** – The median dissolved oxygen concentration was 10.40 mg/L (9.07 to 12.21 mg/L) at Miners Coulee in 2021. The dissolved oxygen at Miners Coulee met the acute (>5.0 mg/L) and chronic (>6.5 mg/L) guideline. The pH (range: 8.08 to 8.27) at Miners Coulee in 2021 met the aquatic life guideline (≥6.5 and ≤9.0) and was similar to previous years. Median specific conductivity at Miners Coulee in 2021 was 925 µS/cm (range: 780 to 1,100 µS/cm) and generally higher than previous years. The April 19 specific conductivity (1,100 µS/cm) was considered 'possibly safe' for irrigation (GoA 2018) (Table 6).

**Verdigris Coulee** – No samples were collected at Verdigris Coulee in 2021 (Table 6).

### 3.3.2 Nutrients

**Miners Coulee** – In 2021, the median total phosphorus concentration at Miners Coulee was 0.034 mg/L (range: 0.020 to 0.054 mg/L) and lower than previous years (Table 6). The median total dissolved

phosphorus concentration at Miners Coulee was 0.024 mg/L (range: 0.011 to 0.045 mg/L) and lower than previous years (Table 6). In 2021, median total nitrogen at Miners Coulee was 0.67 mg/L (range: 0.61 to 1.0 mg/L) and generally lower than previous years (Table 6). Almost all of the total nitrogen was present in the organic (TKN) form with a small percentage of the nitrogen present in soluble form (nitrate+nitrite nitrogen). The median nitrate+nitrite nitrogen concentration in 2021 was 0.008 mg/L (range: <0.0042 to 0.019 mg/L) (Table 6).

**Verdigris Coulee** – No samples were collected at Verdigris Coulee in 2021 due to a lack of flowing water (Table 6).

### 3.3.3 Total Suspended Solids

**Miners Coulee** – The total suspended solids median concentration in 2021 at Miners Coulee was 3.6 mg/L (range: 1.7 to 4.4 mg/L) and was within the range of previous years (Table 6).

**Verdigris Coulee** – No samples were collected at Verdigris Coulee in 2021 due to a lack of flowing water (Table 6).

### 3.3.4 Fecal Coliform Bacteria

**Miners Coulee** – The median fecal coliform bacteria count in 2021 at Miners Coulee was 75 cfu/100 mL (range: <2 to 220 cfu/100 mL) and was generally lower than previous years (Table 6). The fecal bacteria counts on May 17 and June 23 did not meet the irrigation guideline (100 cfu/100 mL).

**Verdigris Coulee** – No samples were collected at Verdigris Coulee in 2021 due to a lack of flowing water (Table 6).

**Table 6 - Median and range for water quality parameters at the ephemeral tributaries (Miners Coulee and Verdigris Coulee), 2018 to 2021.**

Parameter	Miners Coulee				Verdigris Coulee			
	2018 (N=2)	2019 (N=1)	2020 (N=2)	2021 (N=4)	2018 (N=4)	2019 (N=1)	2020 (N=0)	2021 (N=0)
Water Temperature, °C	7.1 - 15.7	15.78	18.8 - 19.6	10.1 1.6 - 17.4	16.4 1.47 - 17.9	3.02	No samples collected due to Covid-19 restrictions on sampling (April 27 and May 29) and lack of flow (June to October)	No samples collected due to lack of flow (Mar 16, Apr 19, May 17, Jun 21, Aug 16, Oct 6)
Dissolved Oxygen, mg/L	5.22 - 10.78	8.12	4.32 - 9.75	10.40 9.07 - 12.21	4.57 2.14 - 11.06	8.41		
pH	7.90 - 8.13	7.67	8.22 - 8.28	8.25 8.08 - 8.27	8.42 7.53 - 9.29	7.19		
Specific Conductivity, µS/cm	583 - 905	994	590 - 650	925 780 - 1,100	2,562 83 - 4,414	277		
Total Phosphorus, mg/L	0.096 - 0.160	0.043	0.061 - 0.072	0.034 0.020 - 0.054	0.109 0.044 - 0.350	0.190		
Total Dissolved Phosphorus, mg/L	0.082 - 0.150	0.027	0.047 - 0.067	0.024 0.011 - 0.045	0.054 0.031 - 0.280	0.140		
Nitrate+Nitrite Nitrogen, mg/L	<0.004 - 0.008	0.01	0.0021	0.008 <0.004 - 0.019	0.007 <0.004 - 0.024	0.45		
Total Kjeldahl Nitrogen, mg/L	0.90 - 0.91	0.87	0.80 - 0.81	0.66 0.60 - 1.0	1.93 0.340 - 3.8	0.71		
Total Nitrogen, mg/L	0.90 - 0.92	0.88	0.80 - 0.81	0.67 0.61 - 1.0	1.93 0.370 - 3.8	1.2		
Total Suspended Solids, mg/L	<1	2.2	2.2 - 4.8	3.6 1.7 - 4.4	9.65 1.3 - 45	6.5		
Fecal Coliform Bacteria (cfu/100 mL)	20 - 310	173	900 - 1,091	75 <2 - 220	360 1 - 900	220		
Sample Dates	Apr 23, May 22	May 14	Jun 23, Jul 21	Mar 16, Apr 19, May 17, Jun 21	Apr 23, May 22, Jun 19, Jul 16	Oct 8		

### 3.4 Milk River

#### 3.4.1 St. Mary/Milk River Diversion Operation

The St. Mary/Milk River Diversion was initiated on March 22 and was shut down on September 16, 2021. Diversion to the St. Mary Canal was initially 1.4 m<sup>3</sup>/s (50 ft<sup>3</sup>/s) which was ramped up to approximately 2.8 m<sup>3</sup>/s (100 ft<sup>3</sup>/s) on March 23 but the diversion was also shut down to 0.0 ft<sup>3</sup>/s on March 23 to allow for minor repairs at a turnout. Diversion was ramped up to 5.7 m<sup>3</sup>/s (200 ft<sup>3</sup>/s) on March 30 and further increased to 8.5 m<sup>3</sup>/s (300 ft<sup>3</sup>/s) on March 31 and 12.7 m<sup>3</sup>/s (450 ft<sup>3</sup>/s) on April 1. On April 2 diversion was increased to 17.0 m<sup>3</sup>/s (600 ft<sup>3</sup>/s) and maintained at that diversion rate until August 17. On August 18 diversion was ramped down to 15.6 m<sup>3</sup>/s (550 ft<sup>3</sup>/s) and further decreased to 14.2 m<sup>3</sup>/s (500 ft<sup>3</sup>/s) on August 19. Diversion to the St. Mary Canal was maintained at 14.2 m<sup>3</sup>/s (500 ft<sup>3</sup>/s) until September 7. Canal shutdown was initiated on September 8 with diversion reduced to 11.3 m<sup>3</sup>/s (400 ft<sup>3</sup>/s). Diversion was further reduced to 8.5 m<sup>3</sup>/s (300 ft<sup>3</sup>/s) on September 9 and held there until September 12. On September 13, diversion was further reduced to 5.7 m<sup>3</sup>/s (200 ft<sup>3</sup>/s) and reduced again to 2.8 m<sup>3</sup>/s (100 ft<sup>3</sup>/s) on September 14. Diversion was reduced to 1.4 m<sup>3</sup>/s (50 ft<sup>3</sup>/s) on September 15 and reduced to 0

m<sup>3</sup>/s (0 ft<sup>3</sup>/s) on September 16 (shut-down complete). Table 7 shows the start-up and shut-down dates of the St. Mary/Milk River Diversion since 2006.

**Table 7 - St. Mary/Milk River Diversion start-up and shut-down dates for the 2006 through 2021 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	April 9	September 15
2013	March 11	September 24
2014	May 13	September 10
2015	March 31	August 28
2016	March 22	September 10
2017	March 22	September 22
2018	May 9	September 28
2019	April 8	September 27
2020 <sup>a</sup>	March 31	October 31
2021	March 22	September 16

<sup>a</sup>Due to a drop structure failure, there was no diversion to the St. Mary Canal from May 17 to October 7, 2020.

### 3.4.2 Streamflow

Mean daily streamflow data for 2021 is shown in Figures 2A to 2D at four Milk River sites.

At 'Milk River at Western Crossing of International Boundary', the majority of streamflow occurred from March 31 to July 15 when the median flow was 0.08 m<sup>3</sup>/s (range: 0.00 to 12.07 m<sup>3</sup>/s). Six peak flow events occurred during this period: April 7 (3.91 m<sup>3</sup>/s, snowmelt), May 4 (4.61 m<sup>3</sup>/s, rainfall), May 11 (3.57 m<sup>3</sup>/s, rainfall), May 26 (12.07 m<sup>3</sup>/s, rainfall), June 12 (1.77 m<sup>3</sup>/s, rainfall) and June 23 (1.47 m<sup>3</sup>/s, rainfall) (Figure 2A). There may have been peak flows prior to March 31; however, the gauging station did not begin operation until March 31. Due to reduced snowmelt and precipitation, the peak flow in 2021 (~12 m<sup>3</sup>/s) at the 'Western Crossing of the International Boundary' was less than the peak flows from 2017 to 2020 (~19 to 65 m<sup>3</sup>/s). Low flow occurred from July 16 to September 6, when the median flow was 0.008 m<sup>3</sup>/s (range: 0.00 to 0.26 m<sup>3</sup>/s). No flow (0.0 m<sup>3</sup>/s) was recorded from September 7 to October 31. There was no flow after October 31; however, the streamflow gauging station stopped operation on October 31. Streamflow at the Milk River at Western Boundary site is not augmented by the St. Mary diversion; therefore, flows are always natural.

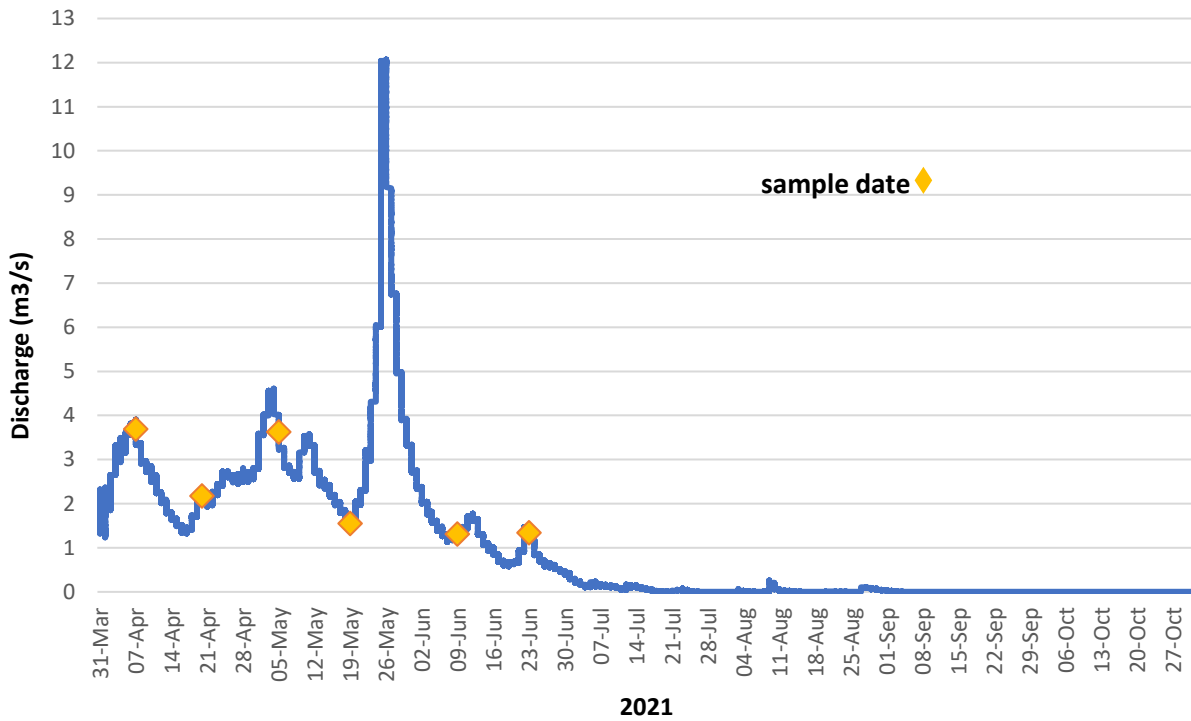
At 'North Milk River near International Boundary', flows during the peak diversion period (April 7 to August 19) typically ranged between 16 to 19 m<sup>3</sup>/s. Four small peak flow events occurred during this period: May 25 (20.61 m<sup>3</sup>/s, rainfall), June 20 (18.03 m<sup>3</sup>/s, rainfall), July 5 (18.42 m<sup>3</sup>/s, rainfall) and August 9 (18.42 m<sup>3</sup>/s, rainfall) (Figure 2B). The peak flow in 2021 (~21 m<sup>3</sup>/s) at the North Milk River was higher than the peak flows from 2017 to 2020 (~7 to 17 m<sup>3</sup>/s). The discharge decreased from approximately 16

m<sup>3</sup>/s on August 19 to 13 m<sup>3</sup>/s on August 21. Flows from August 21 to September 8 were relatively stable at approximately 13 m<sup>3</sup>/s. The flow decreased from approximately 13 m<sup>3</sup>/s on September 9 to 0.40 m<sup>3</sup>/s on September 20. Discharge at the North Milk River was low and less than 0.4 m<sup>3</sup>/s from September 21 to October 28. The diversion to the St. Mary canal ended on September 16.

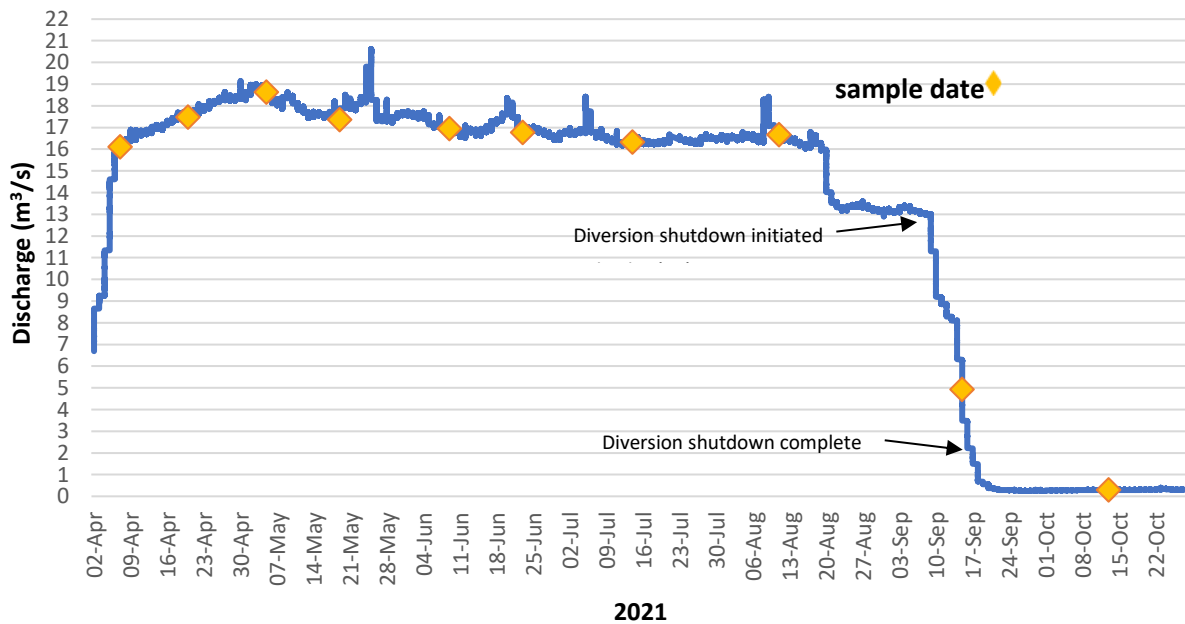
At 'Milk River at Milk River', flows during the peak diversion period (April 2 to September 9) typically ranged between 13 to 20 m<sup>3</sup>/s. Three peak flow events occurred during this period: April 7 (29.96 m<sup>3</sup>/s, snowmelt), May 26 (32.87 m<sup>3</sup>/s, rainfall) and July 1 (38.48 m<sup>3</sup>/s, rainfall) (Figure 2C). Due to reduced snowmelt and precipitation, the peak flow in 2021 (~38 m<sup>3</sup>/s) at the Milk River at Milk River was at the low end of the range of peak flows from 2017 to 2020 (~36 to 82 m<sup>3</sup>/s). The discharge decreased from approximately 16m<sup>3</sup>/s on August 21 to 13 m<sup>3</sup>/s on August 25. Flows from August 25 to September 9 were relatively stable at approximately 13 m<sup>3</sup>/s. The flow decreased from approximately 13 m<sup>3</sup>/s on September 10 to 0.60 m<sup>3</sup>/s on September 26. Discharge at the Milk River at Milk River was low and generally less than 0.6 m<sup>3</sup>/s from September 26 to October 28; although, flows increased marginally to >0.6 to 1.26 m<sup>3</sup>/s from October 29 to 31. The diversion to the St. Mary canal ended on September 16.

At 'Milk River at Eastern Crossing of International Boundary', flows during the peak diversion period (April 13 to September 13) typically ranged between 13 to 20 m<sup>3</sup>/s. Five peak flow events occurred during this period: March 30 (15.19 m<sup>3</sup>/s, snowmelt), April 10 (28.63 m<sup>3</sup>/s, snowmelt), May 22 (29.91 m<sup>3</sup>/s, rainfall), May 28 (31.99 m<sup>3</sup>/s) and July 9 (18.30 m<sup>3</sup>/s, rainfall) (Figure 2D). Due to reduced snowmelt and precipitation, the peak flow in 2021 (~32 m<sup>3</sup>/s) at the 'Eastern Crossing of the International Boundary' was at the low end of the range of peak flows from 2017 to 2020 (~30 to 105 m<sup>3</sup>/s). The discharge decreased from approximately 16m<sup>3</sup>/s on August 24 to 11 m<sup>3</sup>/s on August 27. Flows from August 27 to September 14 ranged from 11 to 14 m<sup>3</sup>/s. The flow decreased sharply from approximately 11 m<sup>3</sup>/s on September 14 to 2 m<sup>3</sup>/s on September 25. Discharge at the Milk River at Eastern Crossing was low from September 26 to October 31, ranging from 0.7 to <2.0 m<sup>3</sup>/s. The diversion to the St. Mary canal ended on September 16.

**Figure 2A: Milk River at Western Crossing of International Boundary - natural flow only**



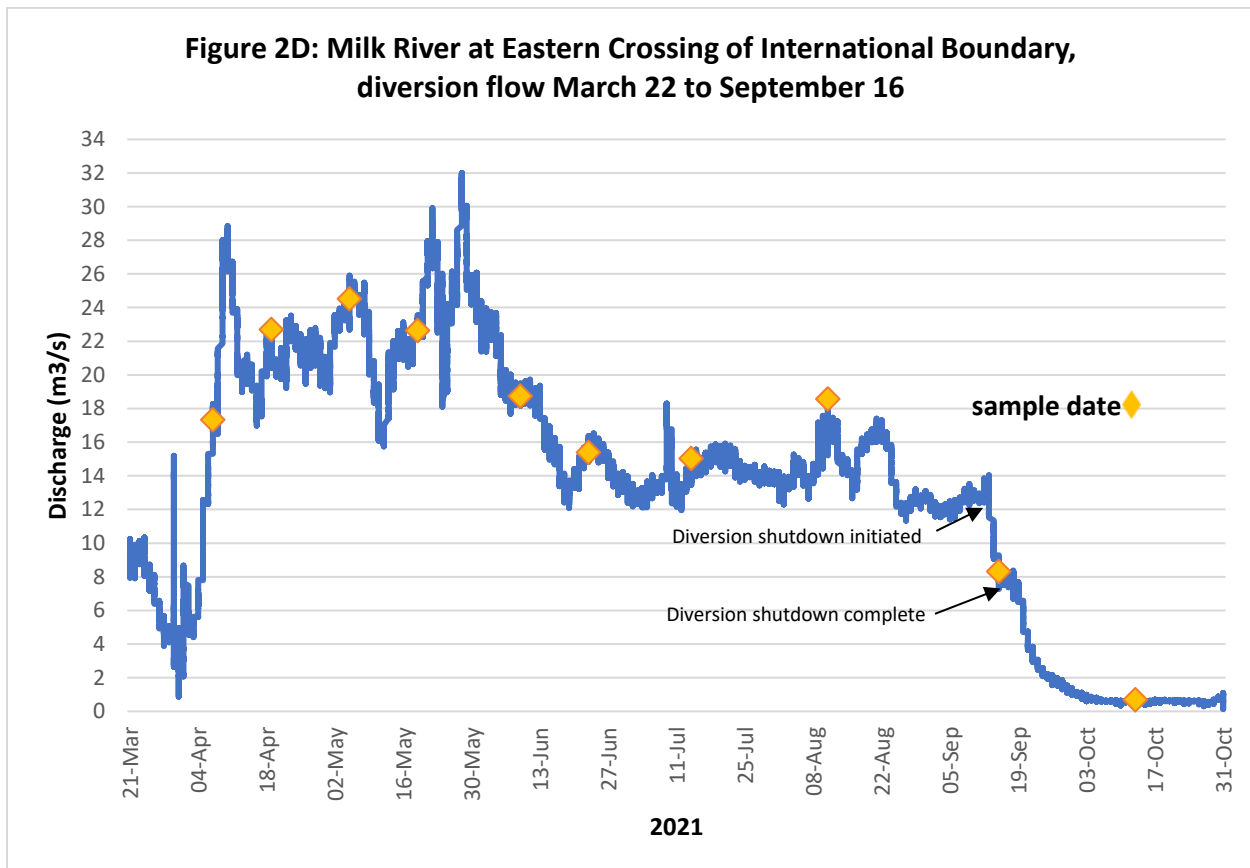
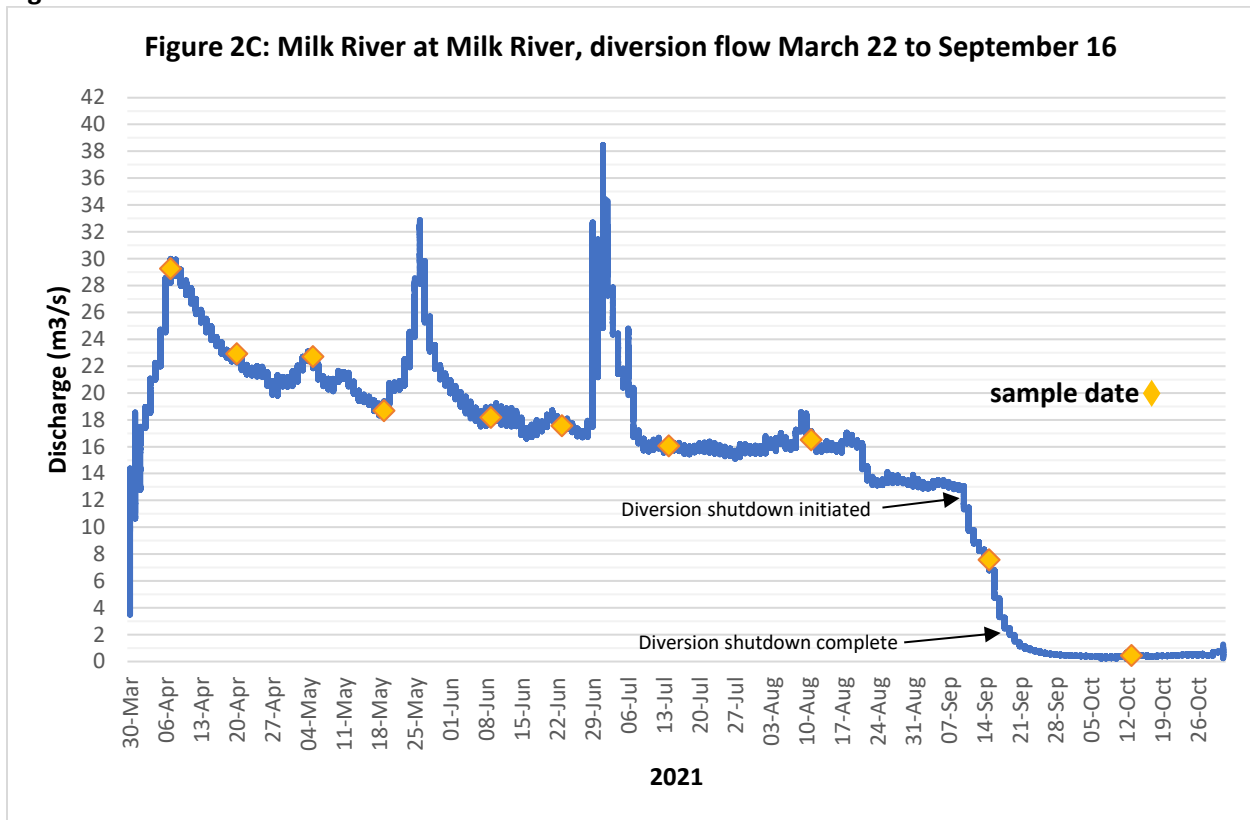
**Figure 2B: North Milk River near International Boundary - diversion flow March 22 to September 16**



**Figures 2A to 2D – Discharge data (m<sup>3</sup>/s) at four Milk River sites during the open water season, 2021.**  
Raw data from Environment and Climate Change Canada (2020).



Figures 2C to 2D – cont'd



### 3.4.3 General Water Chemistry

Water chemistry parameters are presented in Table 8. Note that while water chemistry results from 2018 to 2020 are presented in the tables, they are generally not discussed in detail in the result summaries. In 2021, median water temperature ranged from 10.4°C at the Milk River at 501 site to 14.5°C at the Pinhorn site. Median water temperatures at North Fork at 501, U/S Milk River and HWY 880 were quite similar from 2018 to 2021 within each site (Table 8). The warmest water temperature in 2021 (22.3°C on June 23) was recorded at the Milk River at 501 site.

Median dissolved oxygen concentration ranged from 8.93 mg/L at the Pinhorn site to 10.41 mg/L at the North Fork at 501 site (Table 8). The lowest individual dissolved oxygen concentration occurred at the Pinhorn site (7.98 mg/L). The acute daily minimum dissolved oxygen concentration for the protection of aquatic life is  $\geq 5.0$  mg/L and the chronic, 7-day average concentration is  $\geq 6.5$  mg/L (GoA 2018). In 2021, all samples met the acute daily minimum guideline and the chronic guideline at all Milk River sites.

The pH guideline for the protection of aquatic life is  $\geq 6.5$  and  $\leq 9.0$  (GoA 2018). The median pH values (8.09 to 8.34) were within guideline for the protection of aquatic life at all Milk River sites in 2021. No individual sample exceeded the guideline (Table 8).

Specific conductivity was lowest during the diversion period. During the diversion period, median conductivity was lowest at the North Fork at 501 site (161  $\mu\text{S}/\text{cm}$ ) and highest at the Pinhorn site (236  $\mu\text{S}/\text{cm}$ ). During the natural flow period, median specific conductivity ranged from 267  $\mu\text{S}/\text{cm}$  at the U/S Milk River site to 895  $\mu\text{S}/\text{cm}$  at the HWY 880 site (Table 9).

The WQO-50 and WQO-90 objectives for specific conductivity were met at the North Fork at 501, Milk River at 501 and U/S Milk River sites in 2021 during both natural and diversion flow periods. The WQO-50 and WQO-90 objectives for the diversion flow period was met at the HWY 880 and Pinhorn sites; however, the WQO-50 objective for the natural flow period was not met at these sites (Table 9).

In 2021, all of the samples from the Milk River sites met the provincial guideline for safe irrigation ( $\leq 1000$   $\mu\text{S}/\text{cm}$ ).

**Table 8 - Summary (median and range) of general water quality parameters at the Milk River, 2018 to 2021.**

Site	Water Temperature (°C)											
	2018			2019			2020			2021		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	12.0	-0.4-17.9	10	12.1	0.4-16.4	10	11.3	3.0-18.9	10	11.7	0.4-18.1
Milk R. at 501	8	13.0	0.03-18.8	10	12.4	0.0-17.8	9	12.2	0.5-19.8	6	10.4	4.5-22.3
U/S Milk River	10	13.7	0.4-20.7	10	14.8	4.1-21.4	10	14.1	1.4-25.0	9	13.7	3.8-20.4
HWY 880	10	14.6	3.8-19.4	10	14.2	5.3-21.3	10	14.3	0.5-21.1	10	13.9	0.8-20.5
Pinhorn	9	17.6	4.4-21.3	10	12.8	0.3-18.4	-	--	--	8	14.5	0.6-20.3

Site	Dissolved Oxygen (mg/L)											
	2018			2019			2020			2021		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	10.10	8.7-12.9	10	9.69	8.84-12.38	10	9.54	8.35-11.57	10	10.41	9.47-14.07
Milk River at 501	8	9.76	8.3-12.4	10	9.36	8.46-12.50	9	9.59	8.69-12.47	6	10.00	9.33-13.10
U/S Milk River	10	9.15	8.6-12.8	10	9.06	8.00-11.24	10	9.71	7.52-13.63	9	9.59	8.21-12.90
HWY 880	10	9.28	8.5-12.3	10	11.25	8.06-12.06	10	9.71	8.41-13.38	10	9.65	8.14-12.97
Pinhorn	9	9.70	8.3-11.9	10	9.89	8.65-13.37	-	--	--	8	8.93	7.98-13.30

Site	pH											
	2018			2019			2020			2021		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	8.39	7.99-8.50	10	8.23	8.02-8.53	10	8.50	8.04-8.56	10	8.09	7.31-8.41
Milk R. at 501	8	8.47	8.24-8.63	10	8.42	8.29-8.79	9	8.48	8.14-8.58	6	8.34	8.12-8.64
U/S Milk River	10	8.33	8.02-8.48	10	8.25	8.10-8.41	10	8.54	8.21-8.59	10	8.25	7.42-8.38
HWY 880	11	8.27	8.09-8.51	10	8.35	8.10-8.41	10	8.53	8.24-8.50	10	8.10	7.51-8.49
Pinhorn	10	8.36	7.99-8.57	10	8.32	8.11-8.44	-	--	--	8	8.23	7.55-8.48

Table 9 - Summary of specific conductivity ( $\mu\text{S}/\text{cm}$ ) at the Milk River, 2018 to 2021.

Site	Flow Period	WQO		2018				2019				2020				2021			
		WQO-50	WQO-90	N	50 <sup>th</sup>	90 <sup>th</sup>	Range	N	50 <sup>th</sup>	90 <sup>th</sup>	Range	N	50 <sup>th</sup>	90 <sup>th</sup>	Range	N	50 <sup>th</sup>	90 <sup>th</sup>	Range
N. Fork at 501	Diversion	165	246	7	147	269	129-427	8	158	182	137-185	3	173	237	139-254	9	161	176	136-180
	Natural	445	512	3	329	426	234-449	2	324	-	237-411	7	390	452	102-466	1	435	--	435
Milk R. at 501	Natural	510	882	8	419	546	309-603	10	436	595	252-600	9	435	880	277-1400	6	476	508	418-522
U/S Milk River	Diversion	210	398	7	214	322	147-387	8	227	278	157-296	3	289	365	171-384	9	223	262	152-350
	Natural	570	674	3	341	510	306-552	2	394	-	350-437	7	499	617	339-657	1	267	--	267
HWY 880	Diversion	250	540	7	259	418	175-498	8	258	318	184-354	3	416	433	235-437	9	214	254	176-270
	Natural	727	936	4	473	660	447-729	2	527	-	504-549	7	900	1128	336-1170	1	895	--	895
Pinhorn	Diversion	250	540	7	266	457	196-523	8	277	333	200-392	-	-	-	--	7	236	287	192-299
	Natural	727	936	3	500	677	479-721	2	513	-	480-546	-	-	-	--	1	873	--	873

If the measured 50<sup>th</sup> (median) or 90<sup>th</sup> 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 the normal but cautionary range (**Orange**); if the measured value is  $>20\%$  above the WQO, it exceeds the WQO (**Red**).

### 3.4.4 Nutrients

#### **Total Phosphorus**

In 2021, compliance with the WQO-50 and WQO-90 objectives for total phosphorus (TP) was the highest of the four monitoring years from 2018 to 2021. Total phosphorus in the Milk River tends to increase in the downstream direction during both natural and diversion flow.

During the diversion in 2021, median total phosphorus concentration ranged from a low of 0.003 mg/L at the North Fork at 501 site to 0.099 mg/L at the Pinhorn site (Table 10). During diversion, the median total phosphorus was in the cautionary range of the WQO-50 at the Pinhorn site. The WQO-90 was met during diversion at all the Milk River sites.

During natural flow, median TP ranged from 0.003 mg/L at the North Fork at 501 site to 0.016 mg/L at the Milk River at 501 site. During natural flow, the WQO-50 was met at the Milk River sites (Table 10). During natural flow, a 90<sup>th</sup> percentile for total phosphorus could only be calculated at the Milk River at 501 site (N=6) as the other sites only had one sample collected during natural flow. During natural flow, the WQO-90 for TP was met at the Milk River at 501 site.

#### **Total Dissolved Phosphorus**

In 2021, compliance with the WQO-50 and WQO-90 objectives for total dissolved phosphorus (TDP) was the highest of the four monitoring years from 2018 to 2021.

During diversion, median TDP concentration ranged from 0.003 mg/L at the North Fork at 501, U/S Milk River and HWY 880 sites to 0.005 mg/L at the Pinhorn site (Table 11). In 2020, the median TDP concentration did not meet the WQO-50 at the Pinhorn site. The WQO-90 was met at all Milk River sites during the diversion period.

During natural flow, median TDP ranged from 0.003 to 0.006 mg/L at the Milk River sites (Table 11). The total dissolved phosphorus WQO-50 was met at all sites in 2021 during natural flow. The WQO-90 was met for TDP at the Milk River at 501 site during natural flow (Table 11).

#### **Total Nitrogen**

In 2021, compliance with the WQO-50 and WQO-90 for total nitrogen was the highest from 2018 to 2021.

During the diversion period in 2021, median total nitrogen concentration ranged from 0.122 mg/L at the North Fork at 501 site to 0.421 mg/L at the Pinhorn site (Table 12). During diversion in 2021, total nitrogen was in the cautionary range of the WQO-50 at the Pinhorn site. During the diversion period, the U/S Milk River and HWY 880 sites were in the cautionary range of the WQO-90 for total nitrogen (Table 12).

During natural flow, median total nitrogen ranged from 0.111 mg/L at the U/S Milk River site to 0.490 mg/L at the HWY 880 site (Table 12). During the natural flow period, the WQO-50 for total nitrogen was not met at the HWY 880 site. During natural flow, a 90<sup>th</sup> percentile for total nitrogen could only be calculated at the Milk River at 501 site (N=6) as the other sites only had one sample collected during natural flow. During natural flow, the WQO-90 for total nitrogen was met at the Milk River at 501 site.

**Table 10 - Summary of total phosphorus concentrations (mg/L) at the Milk River, 2018 to 2021.**

Site	Flow Period	WQO		2018				2019				2020				2021			
		WQO-50 <sup>th</sup>	WQO-90 <sup>th</sup>	N	50 <sup>th</sup>	90 <sup>th</sup>	Range	N	50 <sup>th</sup>	90 <sup>th</sup>	Range	N	50 <sup>th</sup>	90 <sup>th</sup>	Range	N	50 <sup>th</sup>	90 <sup>th</sup>	Range
N. Fork at 501	Diversion	0.014	0.037	7	0.010	0.051	0.006-0.077	8	0.013	0.023	0.005-0.033	3	0.066	0.416	0.025-0.504	9	0.003	0.030	0.003-0.053
	Natural	0.012	0.100	3	0.081	0.367	0.004-0.438	2	0.036	-	0.032-0.041	7	0.006	0.016	0.003-0.007	1	0.003	--	0.003
Milk R. at 501	Natural	0.019	0.186	8	0.066	0.371	0.006-0.442	10	0.026	0.070	0.008-0.076	9	0.024	0.169	0.003-0.671	6	0.016	0.031	0.007-0.040
U/S Milk River	Diversion	0.044	0.148	7	0.059	0.107	0.012-0.120	8	0.045	0.149	0.014-0.170	3	0.163	0.212	0.038-0.224	9	0.023	0.112	0.011-0.214
	Natural	0.013	0.504	3	0.464	0.653	0.006-0.700	2	0.063	-	0.028-0.098	7	0.013	0.024	0.003-0.027	1	0.006	--	0.006
HWY 880	Diversion	0.088	0.220	7	0.090	0.194	0.350-0.260	8	0.075	0.285	0.034-0.570	3	0.071	0.255	0.053-0.301	9	0.063	0.176	0.005-0.322
	Natural	0.013	0.086	3	0.640	0.688	0.004-0.700	2	0.194	-	0.016-0.372	7	0.014	0.039	0.010-0.051	1	0.003	--	0.003
Pinhorn	Diversion	0.088	0.220	7	0.133	0.161	0.058-0.185	8	0.124	0.259	0.058-0.387	-	-	-	--	7	0.099	0.196	0.023-0.202
	Natural	0.013	0.086	3	0.437	0.911	0.009-1.030	2	0.137	-	0.025-0.249	-	-	-	--	1	0.003	--	0.003

If the measured 50<sup>th</sup> (median) or 90<sup>th</sup> 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 but cautionary range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

**Table 11 - Summary of total dissolved phosphorus concentrations (mg/L) at the Milk River, 2018 to 2021.**

Site	Flow Period	WQO		2018				2019				2020				2021			
		WQO-50 <sup>th</sup>	WQO-90 <sup>th</sup>	N	50 <sup>th</sup>	90 <sup>th</sup>	Range	N	50 <sup>th</sup>	90 <sup>th</sup>	Range	N	50 <sup>th</sup>	90 <sup>th</sup>	Range	N	50 <sup>th</sup>	90 <sup>th</sup>	Range
N. Fork at 501	Diversion	0.003	0.007	7	0.007	0.014	0.002-0.020	8	0.002	0.004	0.002-0.006	3	0.005	0.043	0.003-0.053	9	0.003	0.003	0.002-0.003
	Natural	0.005	0.066	3	0.056	0.155	0.002-0.180	2	0.016	-	0.010-0.022	7	0.003	0.006	0.003-0.006	1	0.003	--	0.003
Milk R. at 501	Natural	0.006	0.015	8	0.010	0.069	0.002-0.072	10	0.006	0.010	0.002-0.027	9	0.005	0.017	0.003-0.041	6	0.006	0.007	0.002-0.007
U/S Milk River	Diversion	0.003	0.010	7	0.002	0.010	0.002-0.010	8	0.003	0.005	0.002-0.005	3	0.007	0.027	0.006-0.031	9	0.003	0.004	0.002-0.008
	Natural	0.005	0.173	3	0.043	0.084	0.004-0.094	2	0.015	-	0.003-0.027	7	0.003	0.007	0.003-0.009	1	0.003	--	0.003
HWY 880	Diversion	0.004	0.011	7	0.004	0.014	0.002-0.020	8	0.004	0.007	0.002-0.007	3	0.013	0.031	0.010-0.036	9	0.003	0.006	0.002-0.009
	Natural	0.004	0.021	3	0.032	0.077	0.003-0.088	2	0.121	-	0.004-0.239	7	0.003	0.009	0.003-0.011	1	0.003	--	0.003
Pinhorn	Diversion	0.004	0.011	7	0.010	0.040	0.003-0.071	8	0.007	0.009	0.003-0.011	-	-	-	--	7	0.005	0.007	0.003-0.003
	Natural	0.004	0.021	3	0.028	0.042	0.003-0.045	2	0.023	-	0.003-0.044	-	-	-	--	1	0.003	--	0.003

If the measured 50<sup>th</sup> (median) or 90<sup>th</sup> 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 but cautionary range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).



**Table 12 - Summary of total nitrogen concentrations (mg/L) at Milk River, 2018 to 2021.**

Site	Flow Period	WQO		2018				2019				2020				2021			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	0.240	0.468	7	0.143	0.456	0.097-0.643	8	0.160	0.224	0.110-0.232	3	0.305	2.379	0.111-2.897	9	0.122	0.303	0.024-0.353
	Natural	0.900	1.578	3	0.646	2.127	0.320-2.497	2	0.665	-	0.439-0.890	7	0.324	0.343	0.160-0.346	1	0.339	--	0.399
Milk R. at 501	Natural	0.600	1.360	8	0.516	1.355	0.110-1.826	10	0.441	0.629	0.320-0.976	9	0.361	1.132	0.321-2.742	6	0.201	0.428	0.111-0.491
U/S Milk River	Diversion	0.325	0.667	7	0.207	0.514	0.110-0.610	8	0.261	0.394	0.150-0.570	3	0.640	2.658	0.271-3.163	9	0.271	0.797	0.111-1.101
	Natural	0.680	1.637	3	1.500	1.709	0.240-1.761	2	0.610	-	0.320-0.899	7	0.331	0.507	0.221-0.561	1	0.111	--	0.111
HWY 880	Diversion	0.365	0.668	7	0.284	0.610	0.064-0.640	8	0.305	0.800	0.240-1.300	3	0.303	2.765	0.045-3.380	9	0.371	0.754	0.111-1.249
	Natural	0.320	1.400	3	1.700	2.430	0.112-2.612	2	1.003	-	0.230-1.776	7	0.350	0.476	0.231-0.570	1	0.490	--	0.490
Pinhorn	Diversion	0.365	0.668	7	0.380	0.954	0.220-1.750	8	0.448	0.770	0.152-1.172	-	-	-	--	7	0.421	0.579	0.111-0.685
	Natural	0.320	1.400	3	1.26	2.34	0.370-2.620	2	0.968	-	0.151-1.785	-	-	-	--	1	0.271	--	0.271

If the measured 50<sup>th</sup> (median) or 90<sup>th</sup> 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 the normal but cautionary range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

**Table 13 - Summary of total suspended solids concentrations (mg/L) at Milk River, 2018 to 2021.**

Site	Flow Period	WQO		2018				2019				2020				2021			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	16	59	7	8.3	68	3-120	8	17	34	5-51	3	38	492	28-605	9	13	58	3-162
	Natural	5	55	3	7.7	161	2-199	2	15	-	9-20	7	4	18	2-32	1	2	--	2
Milk R. at 501	Natural	14	247	8	69	469	1-560	10	28	69	4-160	9	16	310	2-1,040	6	17	50	6-61
U/S Milk River	Diversion	56	282	7	91.3	144	22-150	8	82	239	14-260	3	265	957	41-1,130	9	46	184	18-359
	Natural	7	267	3	486	737	1-800	2	90	-	54-125	7	8	23	2-25	1	2	--	2
HWY 880	Diversion	131	384	7	141	288	41-360	8	140	403	55-810	3	83	1,385	20-1,710	9	95	257	7-483
	Natural	13	228	3	630	696	3-712	2	191	-	14-368	7	10	63	2-111	1	2	--	2
Pinhorn	Diversion	131	384	7	190	528	76-994	8	197	386	101-	-	-	-	--	7	136	297	45-335
	Natural	13	228	3	502	1908	4-2,260	2	136	-	31-240	-	-	-	--	1	2	--	2

If the measured 50<sup>th</sup> (median) or 90<sup>th</sup> 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 the normal but cautionary range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

### 3.4.5 Total Suspended Solids

In 2021, total suspended solids (TSS) compliance with the WQO-50 and WQO-90 objectives was the highest from 2018 to 2021. TSS at the Milk River sites in 2021 ranged between 2 and 483 mg/L.

During the diversion period, median TSS concentrations ranged from 13 mg/L at the North Fork at 501 site to 136 mg/L at the Pinhorn site (Table 13). During the diversion period, the WQO-50 and WQO-90 for TSS was met at all sites.

During natural flow, median TSS ranged from 2 mg/L at four sites to 17 mg/L at the Milk River at 501 site (Table 13). During natural flow, the WQO-50 for TSS was not met at the Milk River at 501 site (Table 13). During natural flow, a 90<sup>th</sup> percentile for TSS could only be calculated at the Milk R. at 501 site (N=6) as the other sites only had one sample collected during natural flow. During natural flow, the WQO-90 for TSS was met at the Milk River at 501 site.

### 3.4.6 Fecal Coliform Bacteria

In 2021, fecal coliform bacteria (FCB) compliance with the WQO-50 and WQO-90 objectives was the highest from 2018 to 2021. The 2020 year had the lowest compliance with FCB objectives. FCB at the Milk River sites in 2021 ranged between 1 and 204 cfu/100 mL.

During the diversion period, median FCB counts ranged from 15 cfu/100 mL at the North Fork at 501 site to 48 cfu/100 mL at the HWY 880 site (Table 14). The median FCB counts met the WQO-50 objective at all sites during the diversion period (Table 14). During the diversion period, the 90<sup>th</sup> percentile FCB counts ranged from 66 cfu/100 mL at the North Fork at 501 site to 136 cfu/100 mL at the HWY 880 site. The WQO-90 was met at all sites during the diversion period (Table 14).

During natural flow, median FCB counts ranged from 3 cfu/100 mL at the North Fork at 501 site to 49 cfu/100 mL at the U/S Milk River site. During natural flow, the FCB WQO-50 was not met at the HWY 880 site (Table 14). During natural flow, a 90<sup>th</sup> percentile FCB count could only be calculated at the Milk R. at 501 site (N=6) as the other sites only had one sample collected during natural flow. During natural flow, the WQO-90 was met at the Milk River at 501 site.

The Milk River at 501, U/S Milk River and Pinhorn sites each had a single exceedance of the provincial irrigation guideline for FCB (100 cfu/100 mL) in 2021 and the HWY 880 site had two exceedances. The FCB exceedances occurred primarily in July and August.

**Table 14 - Summary of fecal coliform bacteria counts (cfu/100 mL) at Milk River, 2018 to 2021.**

Site	Flow Period	WQO		2018				2019				2020				2021			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	27	140	7	46	109	9-180	8	28	46	1-69	3	60	556	35-680	9	15	66	3-81
	Natural	55	668	3	4	353	4-440	2	27	-	2-52	7	92	149	6-208	1	3	--	3
Milk R. at 501	Natural	77	619	8	86	841	7-1730	10	73	720	1-4,500	9	246	804	21-818	6	21	106	1-153
U/S Milk River	Diversion	68	272	7	56	121	13-164	8	71	469	2-490	3	85	497	10-600	9	24	119	5-204
	Natural	49	522	3	284	325	2-335	2	14	-	4-24	7	48	155	5-224	1	49	--	1
HWY 880	Diversion	78	280	7	36	134	26-171	8	51	161	4-240	3	20	324	3-400	9	48	136	9-187
	Natural	29	163	3	51	406	36-495	2	28	-	2-54	7	198	714	72-1,400	1	47	--	47
Pinhorn	Diversion	78	280	7	95	222	36-254	8	50	330	9-400	-	-	-	--	7	45	99	13-107
	Natural	29	163	3	70	90	1-95	2	1	-	1	-	-	-	--	1	12	--	12

If the measured 50<sup>th</sup> (median) or 90<sup>th</sup> 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 the normal but cautionary range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

## 4.0 SUMMARY

### Weather and Streamflow

- Overall, total precipitation in 2021 ranged from 139.9 mm at Onefour to 294.1 mm at Cardston. May was the wettest month (mean = 62.4 mm) while September was the driest month (mean = 7.2 mm). Based on mean precipitation, 2021 was the third driest year of 10 years (2012 to 2021).
- The streamflow regime at the three Milk River sites in 2021 augmented by the St. Mary diversion were within the range of typical flows and duration that occurred from 2017 to 2019. The flow regime in 2020 was substantially different compared to previous years due to a structural failure in Montana that resulted in no diversion to the Milk River for most of the 2020 irrigation season.
- Due to reduced snowmelt and precipitation in 2021, peak flows in 2021 were generally lower than the previous years of 2017 to 2020.

### Red Creek (downstream site only)

- Only the downstream Red Creek site was sampled in 2021.
- The median dissolved oxygen concentration and all samples complied with acute and chronic guidelines.
- All pH samples and the median value (8.28) met the aquatic life guideline.
- The median conductivity (2,550  $\mu\text{S}/\text{cm}$ ) did not meet safe irrigation guideline and would be considered unsuitable for irrigation.
- The median total phosphorus concentration (0.019 mg/L) was the second lowest of the five monitoring years (2017 to 2021).
- The median TSS concentration (4.6 mg/L) was low and similar to previous years. No TSS trends are apparent from 2017 to 2021.
- The median fecal coliform bacteria count (5 cfu/100mL) met the irrigation guideline and was the lowest of the five years.
- All total selenium samples in 2021 (N=4) exceeded the chronic guideline for the protection of aquatic life.

### Miners Coulee

- Four samples were collected at Miners Coulee in 2021 (March 16, April 19, May 17 and June 21).
- The dissolved oxygen concentrations ranged from 9.07 and 12.21 mg/L at Miners Coulee in 2021. All oxygen samples met the acute and chronic guideline for protection of aquatic life.
- The four pH samples met the aquatic life guideline at Miners Coulee in 2021.
- At Miners Coulee, three of four specific conductivity samples met the objective for safe irrigation.
- Total phosphorus concentrations at Miners Coulee in 2021 ranged from 0.020 and 0.054 mg/L and was lower than previous years.
- The median TSS concentration in 2021 at Miners Coulee was 3.6 mg/L (range: 1.7 to 4.4 mg/L) and similar to previous years.
- The four samples at Miners Coulee had a median fecal coliform bacteria count of 75 cfu/100 mL (range: <2 to 220 cfu/100 mL) and was lower than previous years. Two of four samples did not meet the irrigation guideline ( $\leq 100$  cfu/100 mL).

### Milk River Mainstem

- Milk River Water Quality Objectives (WQOs) were used to determine water quality at sites in 2021 (i.e., WQO-50 [50<sup>th</sup> percentile or median] and WQO-90 [90<sup>th</sup> percentile]).

- pH and dissolved oxygen (median and each sample) met aquatic life guidelines at all Milk River sites.
- Overall, compliance with specific conductivity objectives in 2021 was the second lowest of four years. Specific conductivity was lowest during the diversion period. All WQOs were met during the diversion period. The WQO-50 was not met at the HWY 880 or Pinhorn sites during natural flow. The WQO-90 was met at all sites during diversion and at Milk River at 501 during natural flow.
- Compliance with the WQO-50 and WQO-90 for total phosphorus was the highest of the four monitoring years from 2018 to 2021. The Pinhorn site was in the cautionary range of the WQO-50 for total phosphorus during diversion. All other sites met the WQO-50 and WQO-90 during diversion and natural flow.
- Compliance with total nitrogen objectives was the highest from 2018 to 2021. The Pinhorn site was in the cautionary range of the WQO-50 during the diversion period and the HWY 880 site did not meet the WQO-50 during the natural flow period and the. During diversion, the WQO-90 was in the cautionary range for U/S Milk River and the Pinhorn site.
- Compliance with TSS objectives was the highest at the Milk River sites from 2018 to 2021. During diversion, the WQO-50 and WQO-90 was met at all Milk River sites. The WQO-50 was not met during natural flow at the Milk River at 501 site. The highest TSS concentrations occurred during the diversion flow.
- Compliance with fecal coliform objectives was the highest at the Milk River sites from 2018 to 2021. During diversion, the fecal coliform WQO-50 and WQO-90 was met at all Milk River sites. During natural flow, the fecal coliform WQO-50 was not met at the HWY 880 site.

## 5.0 RECOMMENDATIONS

### Red Creek

- Total selenium at the lower Red Creek site is chronically elevated and almost always exceeds the chronic guideline for the protection of aquatic life. The MRWCC may want to consider an expanded study of total selenium in Red Creek to determine spatial and temporal trends for selenium and to identify potential sources.

### Eastern Tributaries

- Monitoring at the Eastern Tributaries was not completed in 2020 or 2021
- Water Quality Objectives could be determined using the data collected by the Milk River Watershed Council Canada. Future water quality data could be compared to the established five-year objectives and other relevant provincial guidelines.

### Milk River

- Water quality sampling at the existing Milk River (mainstem) sites should continue.
- The MRWCC should continue to collect water quality data at HWY 880 for consistency with the overall Milk River water quality database. AEP could consider increasing their monitoring frequency at HWY 880 to coincide with MRWCC sampling dates.
- The Milk River experienced events that impacted streamflows and water quality in 2020 (e.g., the St. Mary River Diversion failure and a substantial rain event in late June). MRWCC staff noted sediment transport and deposition patterns not previously observed, particularly sediment deposition at the Hoyt Bridge. The MRWCC should consider the occurrence of potential future events (e.g., streamflow conditions, spill, fire) and develop a plan to monitor them to help interpret annual water quality results.

## 6.0 LITERATURE CITED

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