



# **Lesser Slave Watershed 2020 Water Monitoring Report**



**Prepared for: Lesser Slave Watershed Council**

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

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**Cover Photo:** Upper Swan River site, view downstream, August 19, 2020 (M. Payne)

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## 1.0 INTRODUCTION

There is an ongoing concern in the Lesser Slave Lake watershed regarding water quality. Algal blooms have occasionally been observed in the lake. These blooms, if persistent, may degrade future water quality for aquatic life, and for recreation activity. The internal source of phosphorus in Lesser Slave Lake was estimated to be 65% of the total phosphorus load. Major tributaries to the lake were identified as the main source of external phosphorus load (contributing about 25% of the load) (Hutchinson *et al.* 2015). In addition to phosphorus, sediment loading to the lake is a concern. Sediment accumulation at the mouths of rivers creates sandbars or spits and shallow water. In particular, the community is concerned with the increasing size of the sand bar between the east and west basins of Lesser Slave Lake.

Historic water monitoring programs have not been implemented consistently through time, resulting in water quality data that varies by site, the frequency in number of samples collected annually, and different parameters collected. Inconsistent data collection limits the ability to establish and understand baseline conditions or long-term trends, and/or plan mitigation strategies to improve water quality. Past monitoring efforts have not been consistent, leading to questions regarding the findings and relevance to current conditions.

In 2017, the Lesser Slave Watershed Council initiated a comprehensive water monitoring program in the Lesser Slave watershed. The monitoring program was initiated in response to Recommendation 10.3.3 z in the Lesser Slave Integrated Watershed Management Plan (PESL 2018). The recommendation proposed a comprehensive, long-term water monitoring program be implemented for tributaries to Lesser Slave Lake, with the objectives to:

- Collect baseline data
- Evaluate water quality condition in comparison to relevant federal and provincial guidelines, and existing historic data
- Establish site-specific water quality objectives when sufficient data becomes available (at least five years)

This report summarizes the results of the fourth year (2020) of water monitoring data collected by the Lesser Slave Watershed Council.

## 2.0 BACKGROUND

### 2.1 Overview of Water Quality

The LSWC water quality program monitors routine parameters (water temperature, dissolved oxygen, pH, conductivity, phosphorus (total and dissolved), nitrogen (total, organic and inorganic), total suspended solids, and fecal coliform bacteria. A short description (sources, concerns) of some of the water quality parameters is provided below.

**Conductivity** Conductivity is the measure of minerals (e.g., sodium, chloride, magnesium, potassium) dissolved in the water (total dissolved solids), or the salinity. Sources can include soil and mineral weathering, surface runoff from saline soils, groundwater discharge, municipal and industrial effluents, agricultural runoff and aerosol fallout. Excessive salts added to soils may interfere with extraction of water by plants. High total dissolved solids may also affect taste and palatability of drinking water and at

high concentrations may have a laxative effect. High conductivity water is also undesirable in most industrial process waters. EC is measured as the resistance of a solution to electrical flow; therefore, the purer the water is (i.e., the lower its salinity) the greater its resistance to electrical flow will be. Conductivity is expressed as micro Siemens per centimetre ( $\mu\text{S}/\text{cm}$ ) (Cole 1994). The 'safe' irrigation guideline for electrical conductivity is  $\leq 1000 \mu\text{S}/\text{cm}$  (GoA 2018).

**Total Phosphorus and Dissolved Phosphorus** Phosphorus is an essential nutrient required for plant growth. Sources of phosphorus can include animal manures (e.g., cattle, waterfowl), commercial inorganic fertilizers, sewage treatment plants, food processing plants, urban runoff, atmospheric deposition, and natural concentrations found in soils and bottom sediments. Total phosphorus (TP) measures the nutrient in all forms whether particulate or dissolved, organic or inorganic. Dissolved phosphorus (DP) indicates the phosphorus not associated with sediment particles. Dissolved phosphorus is a closer measure of the nutrient more readily available for plant growth, though the phosphorus in particulate form is potentially available through time. The particulate phosphorus concentration gives an indication of the sediments suspended in the water column.

Excessive nutrients in water can cause eutrophic conditions with increased algae and weed growth. In some circumstances, increased plant abundance can change the chemistry of the water, affect oxygen concentrations (through photosynthesis / respiration and decay of organic matter), affect aesthetics and affect the physical movement of water. Dense growths of filamentous algae and aquatic plants can physically block culverts and clog water intakes. Certain strains of algae can impart an off-taste to drinking water and in some instances blue-green algae produce a toxin that can cause toxicity and health issues for humans, livestock and waterfowl (Cole 1994). Until 2014, Alberta had a total phosphorus guideline of 0.050 mg/L for the protection of aquatic life but changed the guideline to the narrative "phosphorus concentrations should be maintained so as to prevent detrimental changes to algal and aquatic plant communities, aquatic biodiversity, oxygen levels, and recreational quality." Future monitoring effort is required to establish water quality objectives for tributaries in the Lesser Slave watershed.

**Nitrogen** Total Nitrogen (TN) is the sum of nitrate-nitrogen ( $\text{NO}_3\text{-N}$ ), nitrite-nitrogen ( $\text{NO}_2\text{-N}$ ), ammonia-nitrogen ( $\text{NH}_3\text{-N}$ ) and organically bonded nitrogen. Total nitrogen should not be confused with total kjeldahl nitrogen (TKN) which is the sum of ammonia-nitrogen plus organically bound nitrogen but does not include nitrate-nitrogen or nitrite-nitrogen. There is no PAL guideline for TKN and the guideline for total nitrogen is a narrative similar to total phosphorus.

Nitrate and nitrite nitrogen are mobile, dissolved forms of nitrogen. Nitrate is the principal and most stable form of inorganic nitrogen in aquatic environments. Nitrate is a plant nutrient; however, elevated concentrations can result in the excessive growth of algae and aquatic plants. High concentrations of nitrate can also pose a toxic risk for infants and livestock. The chronic PAL guideline for nitrate is 3.0 mg/L and the acute PAL guideline is 124 mg/L (GoA 2018). Nitrite is an intermediate form in the nitrification/denitrification pathway; it is usually found in low concentrations because of its instability in the presence of oxygen. Chronic and acute nitrite PAL guidelines vary with chloride.

**Total Suspended Solids** Total suspended solids (TSS) is a measure of the suspended particles such as silt, clay, organic matter, plankton and microscopic organisms which are held in suspension in water. Suspended solids can transport nutrients and contaminants (e.g., metals) downstream and may be aesthetically undesirable. Excessively high TSS in irrigation water can cause the formation of crusts on top of the soil which can inhibit water infiltration and plant emergence, and impede soil aeration. The

formation of films on plant leaves can reduce sunlight and impede photosynthesis. TSS residues can reduce the marketability of some leafy crops such as lettuce. High TSS can interfere with the treatment of drinking and industrial process water. As high concentrations of TSS settle out the capacity of lakes, reservoirs and rivers can be lowered, requiring dredging and higher maintenance costs. Total suspended solids concentrations are expressed as milligrams per litre (mg/L) of water.

The potential effects of elevated suspended sediment and sediment deposition on fish and fish habitat include:

- irritation and damage to fish gills, resulting in fish coughing and increased respiration;
- behavioural responses such as altered movement of fish (e.g., short-term to long-term habitat avoidance);
- decline in feeding success as turbidity increases and as sedimentation progresses, which negatively affects primary and secondary production;
- increased embeddedness from sediment deposition altering the porosity of coarse substrate types which can alter spawning habitats and impair egg development and fry emergence;
- increased stress and reduced disease resistance; and,
- alteration of benthic invertebrate habitat and production (Anderson *et al.* 1996, Robertson *et al.* 2006, Levesque and Dube 2007).

**Fecal Coliform Bacteria** Fecal coliform bacteria (FCB) are specific to the intestinal tracts of warm-blooded animals (e.g., cattle, birds, pets etc.) and humans and are thus a more specific test for animal waste or sewage contamination. *Escherichia coli* are one species of fecal coliform bacteria. Bacterial contamination also indicates potential viral and parasitic contamination which can affect drinking water, irrigation and recreation. FCB can be a concern for fresh garden produce particularly leafy crops such as lettuce. Fecal coliform bacteria levels are expressed as the number of bacteria colonies per 100 mL of water (cfu/100 mL). The irrigation guideline for fecal coliform bacteria is 100 cfu/100 mL (GoA 2018). The recreation guideline for fecal coliform bacteria (*Escherichia coli*) is  $\leq 100$  cfu/100 mL (geometric mean, 30-d interval) and  $\leq 320$  cfu/100 mL (statistical threshold, no more than 10% of samples should exceed over a 30-d interval) (GoA 2018).

## 3.0 METHODS

### 3.1 Field Sampling

Grab samples were collected approximately every two weeks from May to July, and monthly (August-October) at fourteen sites. Three sites were monitored to represent the upper, middle and lower reaches of the Driftpile River, Swan River and South Heart River. Two sites were monitored to represent the upper and middle reaches of the East Prairie River and West Prairie River. The Grouard Channel upstream of Lesser Slave Lake was also monitored at the same frequency. In 2020, the LSWC sampled on May 5/6, May 19/20, June 2/3, June 16/17, June 29/30, July 14/15, July 28/30, August 18/19, September 15/16 and October 13/14. The lower Swan River was not sampled on June 17 and 29 as the site was inaccessible due to poor road conditions. Note that sampling in 2018 and 2020 was initiated in May compared to April in 2017 and 2019.

LSWC staff completed the field sampling. 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 Edmonton. ALS Laboratories is **CALA**<sup>1</sup> accredited for criteria and standards established by the Association under their Certificate of Laboratory Proficiency.

Samples were analysed using **APHA**<sup>2</sup> approved methods for routine parameters (e.g., 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).

Field measurements (*in situ*) were taken for the parameters temperature, pH and dissolved oxygen using a HACH® HQD Portable Meter, Rugged 101 probe series.

Additional samples were collected on May 5/6, June 2/3, June 29/30, July 28/30, August 18/19, September 15/16 and October 13/14 at the Swan River (upper, middle and lower sites), upper West Prairie River, middle East Prairie River and middle Driftpile River for metals analysis (total and dissolved). Sampling for metals analysis from 2017 to 2019 only included the Swan River sites. The West Prairie River, East Prairie River and Driftpile River were added as metal analysis sites in 2020 to provide reference sites to compare to the Swan River sites. Seven metals samples were collected at each site from 2018 to 2020, compared to 5 samples at each site in 2017. In 2020, the lower Swan River was not sampled on June 29 for metals as the site was inaccessible due to poor road conditions.

### 3.2 Streamflow Data

Daily mean streamflow data for 2017 to 2020 was retrieved from the Alberta Environment and Parks (AEP) Monitoring Section for sites listed in Table 1. Streamflow data is considered “Near Real Time Flows (NRT)” and are best estimates available at the time. This data may differ from Water Survey of Canada (WSC) data that will be posted in the future (G. Rojas, pers. comm.). All streamflow data should be considered interim, until the Water Survey of Canada validation is complete.

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

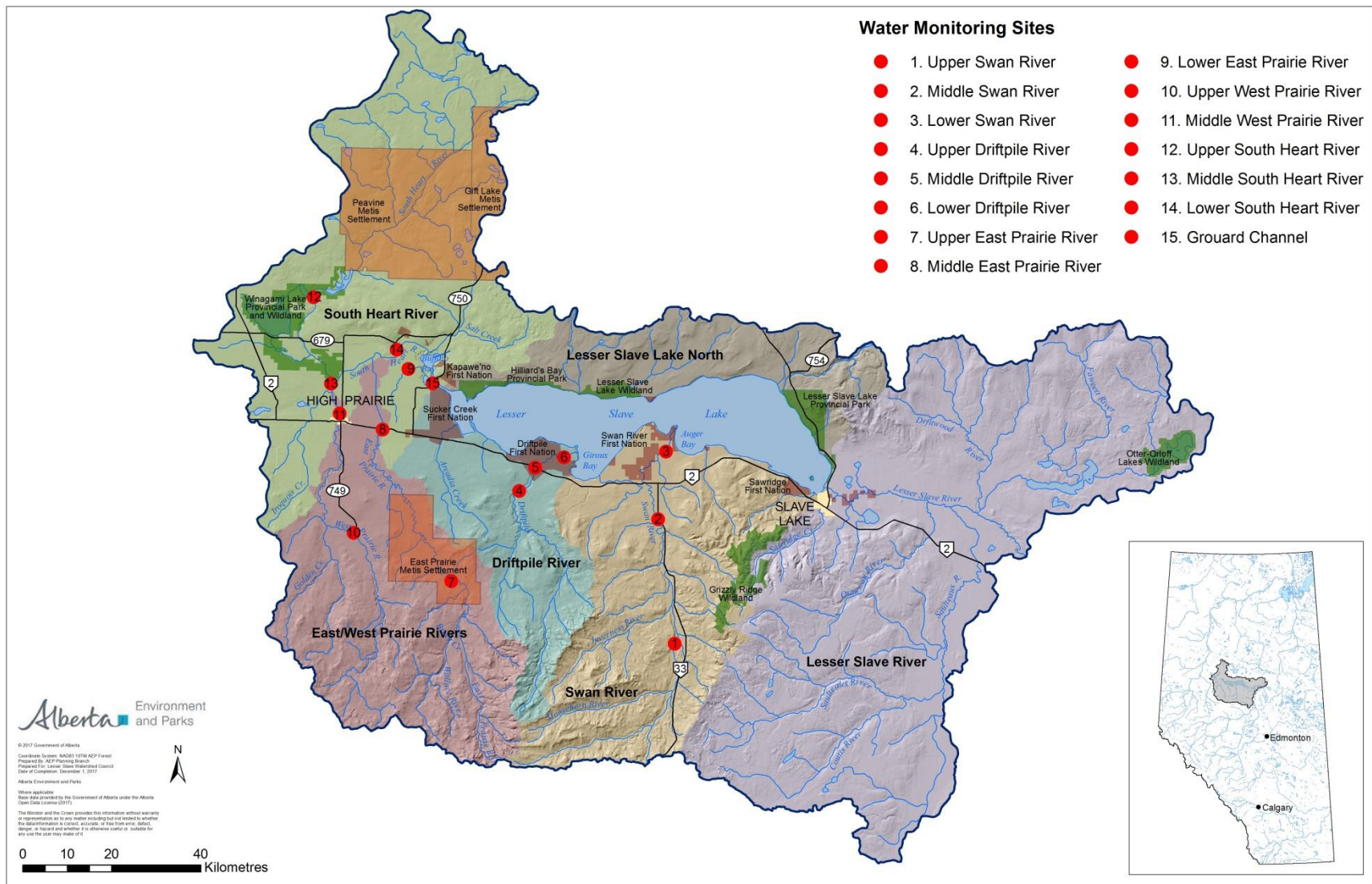
<sup>2</sup> **APHA** – American Public Health Association



**Table 1.** Streamflow gauging stations, Lesser Slave Lake watershed, and missing data (dates and days) for the period April 1 to October 31, 2017 to 2020.

Site (Station Name)	2017	2018	2019	2020
Driftpile River near Driftpile (07BH003)	None	Apr 1-29; May 1-7; Jun 12-20 (45 d)	Apr 1-30 (30 d)	Apr 1-28, Oct 17-31 (43 d)
Swan River near Kinuso (07BJ001)	Apr 8-11; Jul 1; Aug 25; Oct 15, 19, 28-29 (10 d)	Apr 1-9; May 15-31; Jun 1-4 (50 d)	Apr 1-30; Aug 12; Sep 10, 11; Oct 23-28 (39 d)	Apr 1-30, Oct 26-31 (36 d)
Swan River near Swan Hills (07BJ003)	None	Apr 1-30; May 1-8; Jun 12-14, 16-30; Jul 1-2, 5-31; Aug 1-2 (60 d)	Apr 1-28; May 24-Jun 13; Jun 29-Jul 8; Jul 25, 26; Aug 13-Sep 10 (90 d)	Apr 1-27, Oct 26-31 (33 d)
East Prairie River near Enilda (07BF001)	Aug 16, 17; Oct 16 (3 d)	Apr 1-30; May 1-8; Jun 6 (39 d)	Apr 1-30 (30 d)	Apr 1-27, Sep 4, Oct 26-31 (34 d)
West Prairie River near High Prairie (07BF002)	May 17 (1 d)	Apr 1-30; May 1-8; Jun 13; Jul 18; Aug 14-31 (68 d)	Apr 1-May 8; Oct 9-11; Oct 28, 29 (43 d)	Apr 1-28, Oct 26-31 (34 d)
South Heart River near Big Prairie Settlement (07BF905)	None	Apr 1-30; May 1-8 (38 d)	Apr 1-May 8; Oct 29 (39 d)	Apr 1-28, Sep 4, Oct 26-31 (35 d)
South Heart River near Peavine (07BF010)	May 3-13, 18, 20-31; Jun 1, 5-8; Jul 6, 15; Aug 12, 13, 15 (34 d)	Apr 1-30; May 1-15, 18, 24; Jun 20, 22; Aug 3-16, 21-31; Sep 1-30; Oct 1-31 (135 d)	Apr 1-May 8; Aug 5-16; Sep 12-Oct 31 (100 d)	Apr 1-28, Oct 17-31 (43 d)
Average missing days per station (range)	7 (0 - 34)	62 (38 - 135)	53 (30 - 100)	37 (33 - 43)

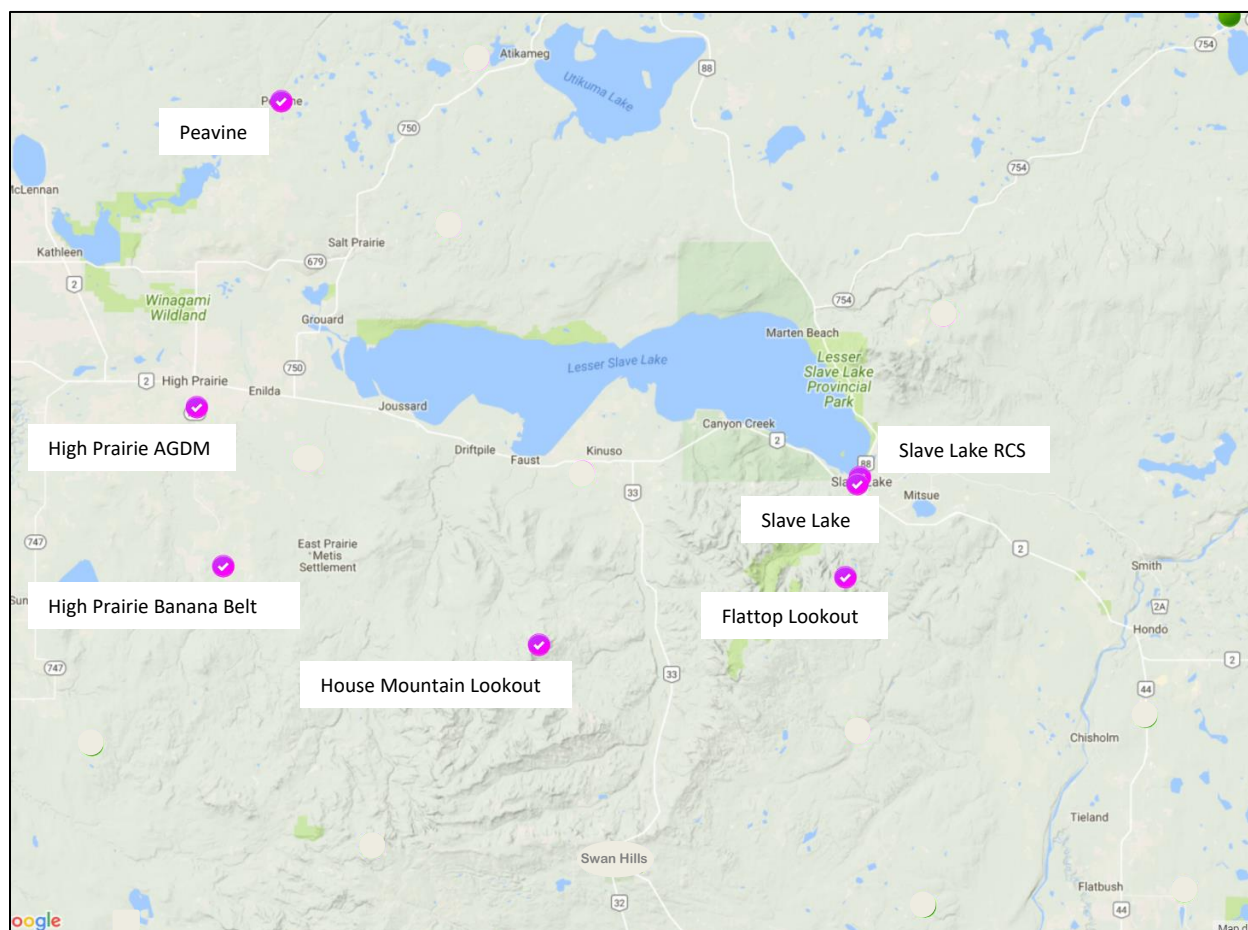
Streamflow data for the April 1 to October 31 monitoring period was isolated from the AEP data set. Streamflow data collection for the April 1 to October 31 period contains missing data; therefore, the datasets are incomplete (Table 1). In 2017, there was only an average of 7 missing days per station (range: 0 to 34 days). Missing streamflow data was substantial in 2018 when there was an average of 62 missing days per station (range: 38 to 135 days) and 2019 when there was an average of 53 missing days per station (range: 30 to 100 days). In 2020, there was an average of 37 missing days per station (range: 33 to 43 days). A substantial period of missing data each year limits the comparison of streamflow between years.



**Figure 1.** Water quality monitoring site locations in the Lesser Slave watershed, April-October, 2017 to 2020.

### 3.3 Precipitation Data

Daily precipitation data for the period January 1 to December 31 was retrieved from Alberta Agriculture and Forestry's website (<http://agriculture.alberta.ca/acis/alberta-weather-data-viewer.jsp>). Fourteen weather stations are located in the Lesser Slave watershed; two stations are situated in the Town of Slave Lake (Figure 2). Precipitation data for the monitoring period April through October was available for seven sites: Peavine, High Prairie AGDM, High Prairie Banana Belt, Slave Lake, Slave Lake RCS, House Mountain Lookout and Flattop Lookout. Incomplete precipitation data was available for Gift Lake Auto, Salt Prairie Auto, Kinuso Auto, Salteaux Auto, Swan Dive Auto and Enilda Auto; therefore, these sites were excluded from further consideration in this report. Marten Hills Auto was also excluded as its location was not as relevant as other sites in the watershed.



**Figure 2.** Weather stations in the Lesser Slave watershed.

### 3.4 Data Handling and Analysis

Median and range statistics were calculated for the water quality data using Microsoft Excel (2010). Water quality data was compared to applicable provincial surface water quality guidelines where possible (GoA 2018). Where provincial guidelines were not available, federal Canadian Council of Ministers of the Environment (CCME) guidelines were used. Comparisons were also made to historic data as presented in the Lesser Slave Integrated Watershed Management Plan (IWMP) (PESL 2018) (Table 3).

The Mann-Kendall Test was used to determine whether time series data had consistently increasing or decreasing monotonic trends. The Mann-Kendall test is a non-parametric test that does not require the data be normally distributed or linear. The test does require that there is no autocorrelation. The test can be used to find trends for as few as four samples; however, with only a few data points, the test has a high probability of not detecting a trend when one is present. To detect a true trend the minimum number of recommended data points is 8 to 10. The Mann-Kendall test was used to detect if trends existed for water quality parameters from 1991-92, 2012-13 and 2017 to 2020 (N = 4 to 6) (Table 16). The Mann-Kendall tests were completed using the Microsoft® Excel based GSI Mann-Kendall Toolkit (Connor *et al.* 2012). The metrics used to describe the trend are summarized below.

Statistical Metrics Used in GSI Mann-Kendall Toolkit (Connor *et al.* 2012)

S Statistic	Confidence In Trend	Trend	Trend Symbol
$S > 0$	$CF > 95\%$	Increasing	↑
$S > 0$	$95\% \geq CF \geq 90\%$	Probably Increasing	↗
$S > 0$	$CF < 90\%$	No Trend	NT
$S \leq 0$	$CF < 90\%$ and $COV \geq 1$	No Trend	NT
$S \leq 0$	$CF < 90\%$ and $COV < 1$	Stable	—
$S < 0$	$95\% \geq CF \geq 90\%$	Probably Decreasing	↘
$S < 0$	$CF > 95\%$	Decreasing	↓
<b>S Statistic</b> – Indicates whether concentration trend vs time is generally decreasing or increasing (negative or positive S value) <b>COV</b> – coefficient of variation (standard deviation / mean), COV is used to establish ‘no trend’ (highly variable concentration vs time) and ‘stable’ (relatively constant concentration) <b>CF</b> – confidence factor ( $1 - p$ value), CF is inversely proportional to $p$ (i.e., $CF > 95\% = p < 0.05$ ) and is a measure of confidence for rejecting null hypothesis of no trend vs time			

### 3.5 Missing Data

From 2017 to 2020, occasionally water quality data was missed at some sites due to poor road conditions, laboratory error, missed or late courier deliveries and locked gates (Table 2).

**Table 2.** Missing water quality data, 2017 to 2020.

Site	Date	Measurement	Reason
Middle Driftpile River	April 25, 2017	TDP	Laboratory reporting error; value removed from analysis.
Upper & Middle Swan River	May 24, 2017	EC, Nutrients, TSS, FCB	Courier did not deliver one of the coolers to the laboratory
Lower East Prairie River	May 24, 2017	EC, Nutrients, TSS, FCB	Road washed out, site inaccessible
Lower East Prairie River	June 18, 2018	All	Site inaccessible due to flooding
Lower Swan River	July 4, 2018	EC, Nutrients, TSS, FCB, Metals	Site inaccessible due to flooding
Lower Swan River	April 17, 2019	EC, Nutrients, TSS, FCB, Metals	Site inaccessible.
Lower Swan River	June 17, 2020 June 29, 2020	EC, Nutrients, TSS, FCB, Metals (June 29)	Site inaccessible due to poor road conditions
Grouard Channel Upper, Middle & Lower South Heart River Upper & Middle West Prairie River Upper & Middle East Prairie River	June 30, 2020	FCB	Courier delivery late, hold time exceedance
Upper Driftpile River	July 30, 2020	EC, Nutrients, TSS, FCB	Site not accessed due to locked gate
Upper & Lower Driftpile River	Sept. 16, 2020	EC	--

From 2018 to 2020, missing data at the Lower Swan River site probably resulted in an under-estimation of the median and maximum total phosphorus and total suspended solids concentrations at the Lower site when compared to the Upper and Middle sites.



**Table 3.** Historic water quality data for the main tributaries to Lesser Slave Lake, open-water season (May-October), and applicable provincial water quality guidelines (PESL 2018).

Indicator	Statistic	South Heart		West Prairie	East Prairie	Driftpile		Swan		Alberta Surface Water Quality Guidelines (GoA 2018; CCME 2012)
		1991-92	2012-13	2012-13	2012-13	1991-92	2012-13	1991-92	2012-13	
		N=9	N=12	N=12	N=12	N=11	N=12	N=11	N=11	
pH	Median <sup>a</sup>	7.73	8.31	8.03	8.30	7.40	8.00	7.30	7.87	6.5 to 9.0
Conductivity, µS/cm	Median <sup>a</sup>	309	243	187	177	149	127	168	136	<1,000 for safe irrigation
Temperature, °C	Median	16.5	12.7	12.8	13.4	16.2	13.9	15.6	14.5	<22 <sup>c</sup>
	Minimum	12.0	0.9	3.3	1.3	0.7	1.6	0.8	2.5	
	Maximum	21.5	21.3	21.7	22.6	21.7	23.1	20.0	22.6	
Dissolved Oxygen, mg/L	Median	-	8.36	9.95	9.62	9.00	9.72	8.60	9.60	≥5.0 (acute daily minimum) ≥6.5 (chronic 7-day average) ≥9.5 (spawning)
	Minimum	-	6.05	8.23	7.94	8.00	7.54	8.16	7.80	
	Maximum	-	15.87	13.85	16.04	13.18	15.32	12.89	12.18	
Total Phosphorus, mg/L	Median	0.094	0.143	0.053	0.076	0.040	0.051	0.048	0.060	<b>Where site-specific nutrient objectives do not exist:</b> Nitrogen (total) and phosphorus concentrations should be maintained to prevent detrimental changes to algal and aquatic plant communities, aquatic biodiversity, oxygen concentration, and recreational quality.
	Minimum	0.050	0.079	0.028	0.028	0.022	0.020	0.026	0.031	
	Maximum	0.190	0.838	1.150	1.120	0.129	0.873	0.173	0.084	
Total Dissolved Phosphorus, mg/L	Median	0.027	0.024	0.018	0.013	0.016	0.012	0.015	0.012	
	Minimum	0.015	0.012	0.006	0.004	0.007	0.005	0.010	0.009	
	Maximum	0.058	0.064	0.033	0.032	0.021	0.025	0.016	0.023	
Total Nitrogen, mg/L	Median	1.197	1.187	0.859	0.565	0.482	0.546	0.431	0.518	
	Minimum	1.052	0.724	0.411	0.249	0.281	0.262	0.275	0.201	
	Maximum	1.955	2.762	3.786	2.972	0.976	7.878	0.832	2.110	
Nitrate+Nitrite Nitrogen, mg/L	Median	0.039	0.032	0.009	0.009	0.003	0.006	0.002	0.012	Nitrite-Nitrogen: Varies with Chloride Nitrate-Nitrogen: 3 (chronic 30-d average); 124 (acute instantaneous maximum)
	Minimum	0.002	0.003	0.003	0.003	0.001	0.003	0.001	0.003	
	Maximum	0.083	0.072	0.086	0.152	0.026	0.148	0.032	0.093	
Total Suspended Solids, mg/L	Median	10	-	-	-	14	-	21	-	<b>Clear Flow Period:</b> Max. increase of 25 mg/L from background for short-term exposure (e.g., 24-h period). Max. average increase of 5 mg/L from background for longer term exposures (e.g., inputs lasting between 24 h and 30 d). <sup>c</sup> <b>High Flow Period:</b> Max. increase of 25 mg/L from background at any time when background is between 25 and 250 mg/L. Should not increase more than 10% of background when background is ≥ 250 mg/L. <sup>b</sup>
	Minimum	5	-	6	12	2	-	4	-	
	Maximum	132	-	1170	1150	128	-	187	-	
Fecal coliform Bacteria, cfu/100 mL	Median	20	-	-	-	15	-	60	-	≤100 cfu per 100 mL (irrigation)
	Minimum	4	-	-	-	2	-	20	-	
	Maximum	264	-	-	-	200	-	200	-	

<sup>a</sup> N ranges from 9 to 12; <sup>b</sup> TSS guideline is relevant to instream construction; <sup>c</sup> Temperature is an objective based on historical data from 1991-92 and 2012-13

## 4.0 RESULTS

### 4.1 Precipitation

Table 4 summarizes the precipitation data for the seven weather stations in the Lesser Slave watershed. Total precipitation during the monitoring period (April to October) varied from west to east, and north to south in the Lesser Slave watershed (Table 4). In 2020, generally, less precipitation was recorded at weather stations in the north (318.0 to 401.1 mm at Peavine, High Prairie AGDM, Slave Lake RCS and Slave Lake) compared to weather stations in the south (375.0 to 555.7 mm at High Prairie Banana Belt, Flat Top Lookout, and House Mountain Lookout). This trend was also observed in 2019. Substantial precipitation events (>20 mm) occurred throughout the Slave Lake watershed on May 21, June 7 and July 1.

Precipitation was not evenly distributed across the watershed in 2020 (Table 4). In 2020, House Mountain Lookout had the most precipitation (555.7 mm) and Slave Lake RCS had the least precipitation (318.0 mm). While the total precipitation at those two sites was the lowest reported in four years, the High Prairie AGDM weather stations reported the second highest precipitation in four years. Overall, precipitation in 2020 was 17.4% less than 2019, 13.33% less than 2018 and 24.6% less than 2017.

**Table 4.** Monthly total precipitation (mm) at Lesser Slave watershed, April-October, 2017 to 2020. Refer to Figure 2 for station locations.

Weather Station	Year	April	May	June	July	August	September	October	Total
Peavine	2017	37.5	41.6	43.4	42.6	53.0	54.9	42.7	315.7
	2018	18.3	9.9	127.0	119.4	52.9	23.1	19.4	370.0
	2019	14.7	4.7	87.5	148.2	44.3	32.8	27.0	359.2
	2020	8.6	35.4	134.0	67.9	39.5	16.6	32.3	<b>334.3</b>
High Prairie AGDM	2017	36.8	61.8	66.6	82.2	50.3	62.7	36.6	397.0
	2018	18.9	14.6	108.5	119.5	31.5	26.7	30.3	350.0
	2019	27.7	17.9	98.6	120.5	56.4	44.7	38.4	404.2
	2020	8.9	62.1	117.3	93.3	83.2	10.7	25.6	<b>401.1</b>
High Prairie Banana Belt	2017	63.3	68.5	52.5	52.0	39.7	103.9	38.4	418.3
	2018	26.3	22.5	133.0	135.3	35.2	31.0	37.4	420.7
	2019	21.1	23.4	155.8	90.1	53.4	43.2	44.7	431.7
	2020	11.3	67.3	115.2	96.4	49.5	12.9	22.4	<b>375.0</b>
Slave Lake RCS	2017	57.1	36.4	72.9	169.1	17.6	32.1	54.5	439.7
	2018	18.5	9.1	128.7	76.0	50.4	38.6	26.3	347.6
	2019	14.2	4.2	76.6	130.5	88.6	37.2	49.2	400.5
	2020	3.9	50.5	90.1	86.2	34.2	10	43.1	<b>318.0</b>
Slave Lake	2017	73.5	42.3	86.9	170.4	20.7	34.9	54.0	482.7
	2018	13.8	11.3	134.9	85.4	56.2	40.3	21.1	363.0
	2019	12.3	4.9	91.3	156.3	105.9	46.5	missing	417.2
	2020	3.0	58.8	104.2	64.8	44.7	14.1	38.5	<b>328.1</b>
Flattop Lookout	2017	119.0	61.7	86.2	153.8	20.8	86.5	105.6	633.6
	2018	29.8	27.3	169.2	119.1	60.9	66.8	45.6	518.7
	2019	25.6	32.2	103.9	168.5	81.8	49.8	71	532.8
	2020	26	72.9	132.4	127.3	37.1	12	69.7	<b>477.4</b>
House Mountain Lookout	2017	103.2	80.9	151.9	140.6	45.7	132.7	112.1	767.1
	2018	41.4	32.9	249.3	144.1	91.6	77.3	66.8	703.4
	2019	57	42.6	194.1	199.7	77	64.1	77.4	711.9
	2020	39	96	136	168	46	16.1	54.6	<b>555.7</b>

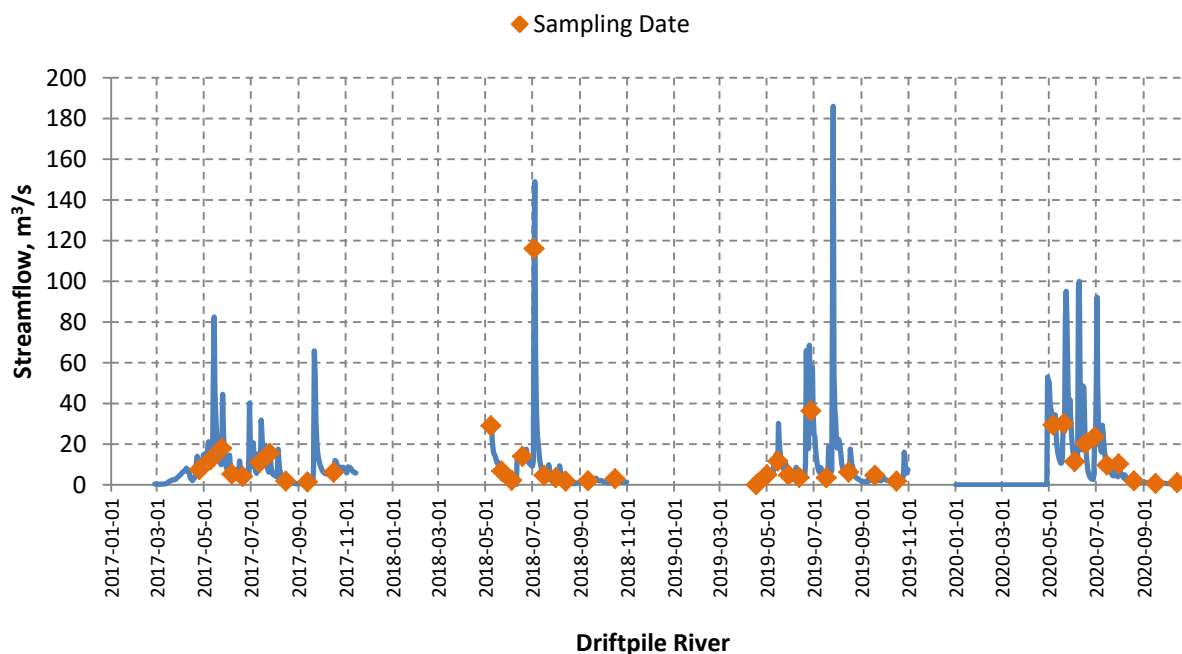


## 4.2 Streamflow

Average daily streamflow data for 2017 through 2020 are shown in Figures 3 to 7 for the main tributaries to Lesser Slave Lake. Note that the streamflow results should be considered interim until the Water Survey of Canada completes the validation process.

At the Driftpile River (near Driftpile) in 2020, average daily streamflow for the May-October monitoring period was  $14.0 \text{ m}^3/\text{s}$  (Figure 3). This was the highest average daily flow recorded during the monitoring period 2017-2020 (table inset). Peak flow was  $100.0 \text{ m}^3/\text{s}$  and occurred on June 9. Generally, peak flows result from snowmelt (May in 2017), or following rain events (in July in 2018 and 2019 and June 2020). In 2020, other significant high flows ( $>90 \text{ m}^3/\text{s}$ ) occurred on May 23 ( $95.1 \text{ m}^3/\text{s}$ ), on June 8 ( $96.9 \text{ m}^3/\text{s}$ ) and on July 2 ( $92.1 \text{ m}^3/\text{s}$ ). Low flows ( $<3 \text{ m}^3/\text{s}$ ) prevailed for from August 9 through to October 16.

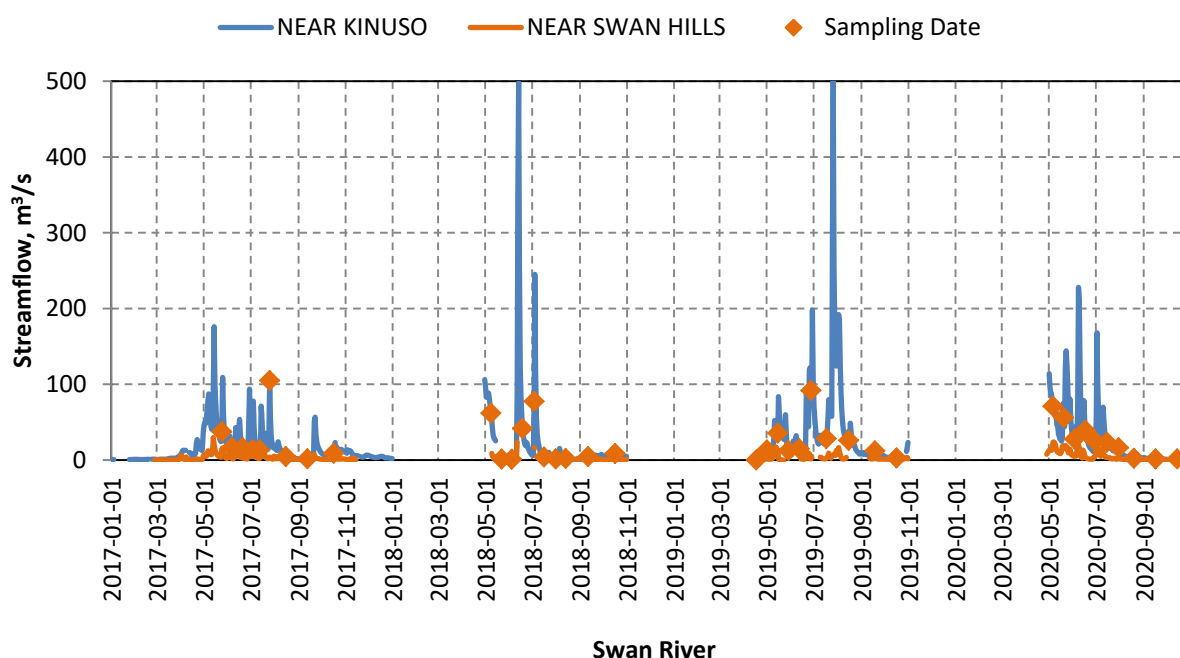
Year	Driftpile River Streamflow (May-Oct)	
	Average Daily	Peak Discharge
2017	9.7	82.5
2018	7.0	149.0
2019	10.6	186.0
2020	14.0	100.0



**Figure 3.** Average daily streamflow at Driftpile River, 2017-2020 (Near real-time flows (NRT) provided by AEP 2018, 2019, 2020, 2021).

At Swan River, average daily streamflow for the 2020 May-October monitoring period was 4.7 m<sup>3</sup>/s at the Swan Hills site and 27.3 m<sup>3</sup>/s at the Kinuso site (Figure 4). The average daily flow at the Swan Hills site in 2020 was the highest of the four years. Peak discharge occurred on May 8 at the Swan Hills site (22.7 m<sup>3</sup>/s), and on June 8 at the Kinuso site (228.0 m<sup>3</sup>/s). Generally, peak discharge occurs in mid-May (2017, 2019) or early-to-mid June (2018, 2020). Note there were larger periods of missing data at the Swan Hills sites periodically through 2018 and 2019. In 2020, other significant flows at Kinuso (>100 m<sup>3</sup>/s) occurred in response to snowmelt (May 1), and rainfall events May 22-24, June 9-10 and July 2-3. In 2020, a period of prolonged low streamflow (<3 m<sup>3</sup>/s) occurred generally from August 16 through to October 25 at Swan River near Kinuso.

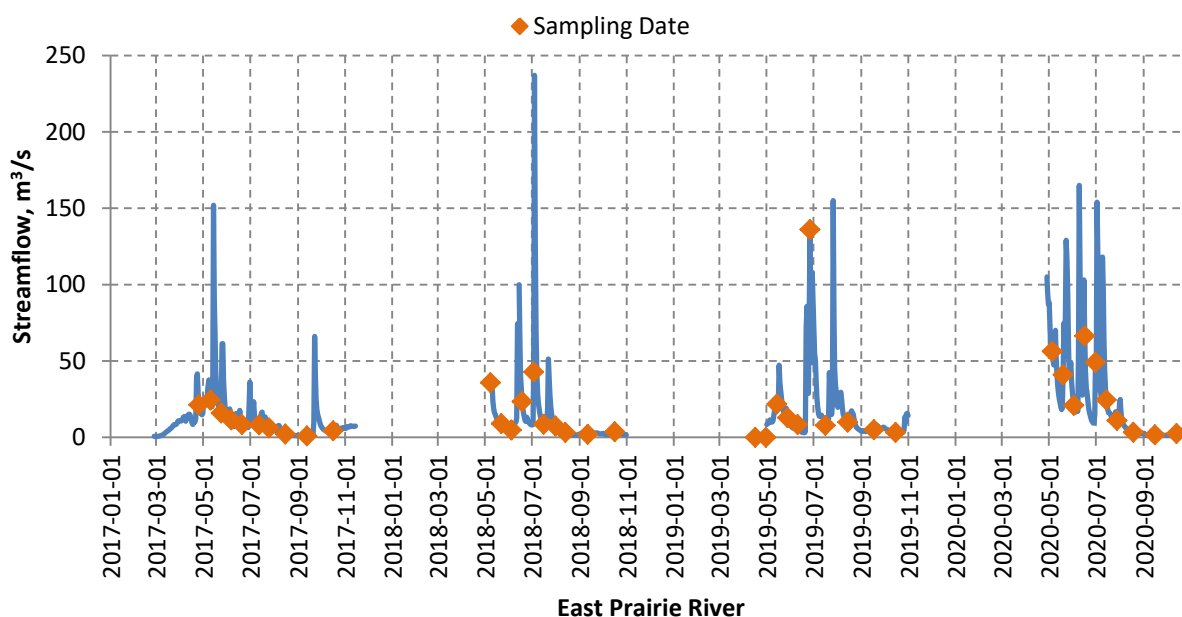
Year	Swan River Streamflow (May-Oct)			
	Average Daily		Peak Discharge	
	Swan Hills	Kinuso	Swan Hills	Kinuso
2017	3.8	22.9	29.7	176.0
2018	1.47	23.3	23.4	498.0
2019	3.2	37.9	17.4	507.0
2020	4.7	27.3	22.7	228.0



**Figure 4.** Average daily streamflow at Swan River, 2017-2020 (NRT-Flows provided by AEP, 2018, 2019, 2020, 2021).

At the East Prairie River (near Enilda), average daily streamflow for the May-October monitoring period was 23.5 m<sup>3</sup>/s in 2020, and nearly twice the average flow from previous years (table inset). Peak discharge occurred on June 9 (165.0 m<sup>3</sup>/s). In previous years, peak discharge occurred in May (2017) and July (2018 and 2019). In 2020, other significant flows (>100 m<sup>3</sup>/s) were recorded on April 28 (105 m<sup>3</sup>/s), May 23-24 (129 and 117 m<sup>3</sup>/s), June 9-10 (165 and 106 m<sup>3</sup>/s), June 15 (103 m<sup>3</sup>/s), July 2-3 (154 and 120 m<sup>3</sup>/s) and July 9 (118 m<sup>3</sup>/s). The April high flow was due to snowmelt and high flows from May to July were due to rainfall. In 2020, a period of prolonged low streamflow (<3 m<sup>3</sup>/s) occurred from August 23 through October 25. Overall, stream flows at East Prairie River in 2020 fluctuated considerably during the open water season compared to previous years.

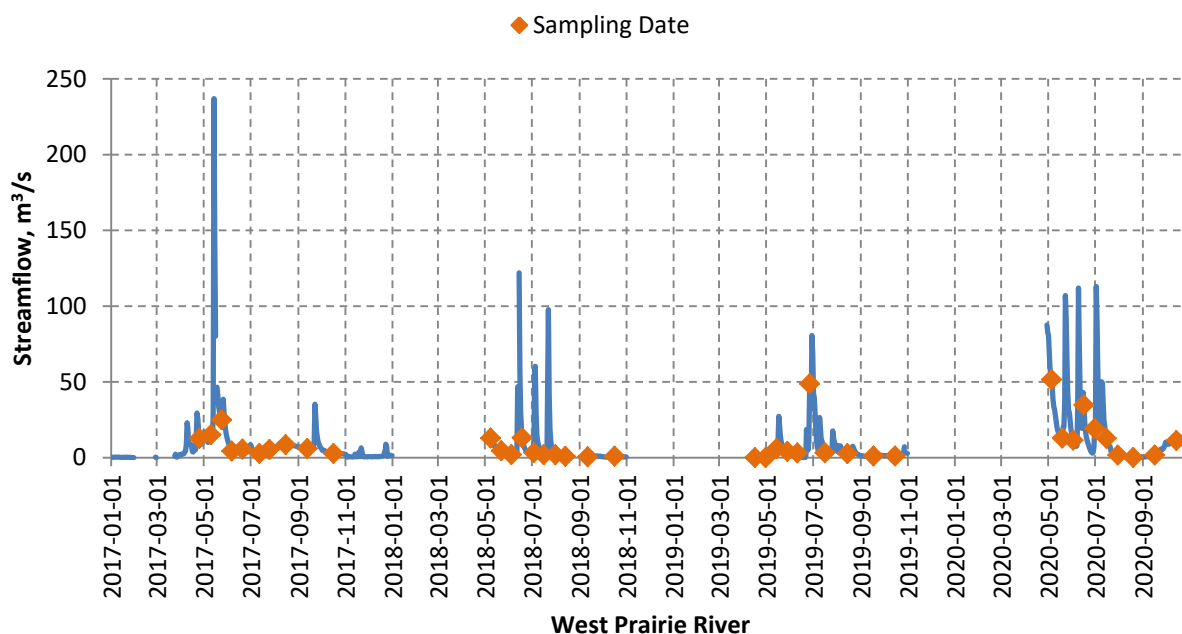
Year	East Prairie River Streamflow (May-Oct)	
	Average Daily	Peak Discharge
2017	12.8	152.0
2018	11.6	234.0
2019	16.8	155.0
2020	23.5	165.0



**Figure 5.** Average daily streamflow at East Prairie River, 2017-2020 (NRT-Flows provided by AEP, 2018, 2019, 2020, 2021).

At West Prairie River (near High Prairie), average daily streamflow for the May-October monitoring period was 15.6 m<sup>3</sup>/s in 2020. The average daily flow at the West Prairie River site in 2020 was the highest of the four years. Peak discharge occurred on July 2 (113.0 m<sup>3</sup>/s) in response to a rainfall event. In 2020, other significant flows (>100 m<sup>3</sup>/s) were recorded on May 23 (107 m<sup>3</sup>/s) and June 9 (112 m<sup>3</sup>/s) due to rainfall. Flows were considerably higher (>3 m<sup>3</sup>/s) in September/October in 2020 compared to previous years.

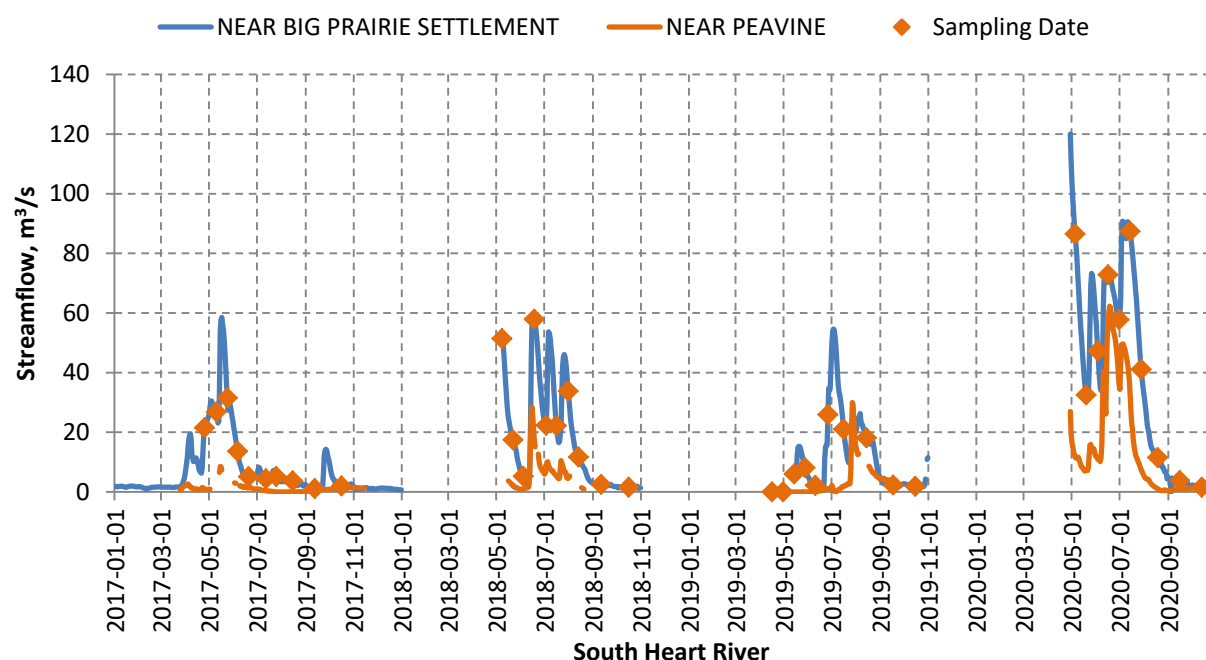
Year	West Prairie River Streamflow (May-Oct)	
	Average Daily	Peak Discharge
2017	10.7	237.0
2018	6.9	122
2019	6.3	80.6
2020	15.6	113.0



**Figure 6.** Average daily streamflow at West Prairie River, 2017-2020 (NRT-Flows provided by AEP, 2018, 2019, 2020, 2021).

At South Heart River, average daily streamflow for the May-October monitoring period was 14.3 m<sup>3</sup>/s at Peavine, and 36.6 m<sup>3</sup>/s at Big Prairie Settlement. Peak discharge occurred on June 18 (62.3 m<sup>3</sup>/s) at Peavine, and on April 29 (120.0 m<sup>3</sup>/s) at Big Prairie Settlement. The average daily flow and peak discharge at both South Heart River sites in 2020 was the highest of the four years. In 2020, additional significant flows at Big Prairie Settlement (>90 m<sup>3</sup>/s) occurred April 30 - May 4 (90.1 to 111.0 m<sup>3</sup>/s), July 4-5 (90.7 m<sup>3</sup>/s) and July 11-12 (90.2 to 90.6 m<sup>3</sup>/s).

Year	South Heart River Streamflow (May-Oct)			
	Average Daily		Peak Discharge	
	Peavine	Big P Settle.	Peavine	Big P Settle.
2017	1.0	10.4	8.4	57.8
2018	6.4	16.5	28.5	57.9
2019	3.4	11.7	30.0	53.8
2020	14.3	36.6	62.3	120.0



**Figure 7.** Average daily streamflow at South Heart River, 2017-2020 (NRT-Flows provided by AEP, 2018, 2019, 2020, 2021).

### 4.3 Routine Parameters

#### 4.3.1 Swan River

In 2020, the median water temperature ranged from 10.0 to 11.7°C at the Swan River sites (maximum water temperature range: 18.3 to 22.5°C) (Table 5). Maximum water temperatures in 2020 were the warmest of the four years at the Swan River sites and the median temperature was the coolest at the Lower site in the four years. The maximum water temperature at the Lower site (22.5°C) exceeded the water temperature objective (<22°C) on July 30<sup>th</sup>.

Median pH ranged from 7.88 to 8.01 and met the provincial aquatic life guideline in 2020 (Table 6). Maximum pH values ranged from 8.01 to 8.37. In 2020, all of the pH samples from the three Swan River sites met the provincial guideline for the protection of aquatic life (≥6.5 to ≤9.0).

In 2020, median dissolved oxygen concentrations ranged from 9.79 to 10.32 mg/L (minimum DO range: 7.97 to 8.79 mg/L) (Table 7). The medians and all dissolved oxygen samples complied with provincial guidelines for the protection of aquatic life at the three Swan River sites. Maximum dissolved oxygen concentrations in 2020 were the highest of the four years at the three Swan River sites.

Median specific conductivity values ranged from 135 to 152  $\mu\text{S}/\text{cm}$  at the Swan River sites in 2020 (maximum conductivity range: 232 to 311  $\mu\text{S}/\text{cm}$ ) (Table 8). The maximum conductivity at each of the three sites in 2020 was the highest of the four years. In 2020, all samples met the provincial guideline for safe irrigation ( $\leq 1,000$   $\mu\text{S}/\text{cm}$ , GoA 2018) at the three Swan River sites.

#### 4.3.2 Driftpile River

In 2020, median water temperature ranged from 11.5 to 12.9°C at the Driftpile River sites (maximum water temperature range: 21.0 to 22.9°C) (Table 5). Maximum water temperatures in 2020 were the warmest of the four years at the Middle and Lower sites and the median temperature at the Upper site was the coolest of the four years. The maximum water temperature at the Lower site (22.9°C) exceeded the water temperature guideline ( $<22^\circ\text{C}$ ) on July 30<sup>th</sup>.

In 2020, median pH ranged from 7.74 to 7.87 at the Driftpile River sites (Table 6) and met the provincial guideline for the protection of aquatic life (PAL) ( $\geq 6.5$  to  $\leq 9.0$ ). Maximum pH values ranged from 8.10 to 8.16. All pH samples in 2020 met the PAL guideline at the Upper, Middle and Lower Driftpile River sites.

In 2020, median dissolved oxygen concentrations ranged from 9.38 to 10.10 mg/L at the Driftpile River sites (minimum DO range: 7.70 to 9.19 mg/L) (Table 7). The medians and all dissolved oxygen samples complied with provincial guideline for the protection of aquatic life at the Driftpile River sites. Maximum dissolved oxygen concentrations in 2020 were the highest of the four years at the Driftpile River sites.

In 2020, median specific conductivity ranged from 109 to 155  $\mu\text{S}/\text{cm}$  at the Driftpile River sites (maximum conductivity range: 249 to 312  $\mu\text{S}/\text{cm}$ ) (Table 8). The maximum conductivity at each of the three sites in 2020 was the highest of the four years. All samples met the provincial guideline for safe irrigation ( $<1,000$   $\mu\text{S}/\text{cm}$ ) (GoA 2018) in 2020.

#### 4.3.3 East Prairie River

In 2020, the median water temperature ranged from 11.9 to 13.8°C at the East Prairie River sites (Table 5). Maximum water temperatures at the Upper site (23.2°C) and Middle site (24.4°C) exceeded the water temperature guideline ( $<22^\circ\text{C}$ ) on July 28<sup>th</sup>. One of 10 samples at the Upper site and two of 10 samples at the Middle site exceeded the temperature guideline. The maximum water temperature at the Middle site (24.4°C) in 2020 was the highest (warmest) of the four monitoring years.

In 2020, median pH ranged from 7.89 to 7.95 at the East Prairie River sites and met the provincial guideline for the protection of aquatic life (PAL) ( $\geq 6.5$  to  $\leq 9.0$ ) (Table 6). Maximum pH values ranged from 8.24 to 8.29. In 2020, 1 of 10 samples (pH: 6.47, May 5) from Upper East Prairie River did not meet the provincial guideline for the protection of aquatic life.

In 2020, the median dissolved oxygen concentration ranged from 9.66 to 9.48 mg/L at the East Prairie River sites (minimum DO range: 8.05 to 7.67 mg/L) (Table 7). The medians and all samples of dissolved oxygen complied with provincial guideline for the protection of aquatic life at the East Prairie River sites.

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**Table 5.** Water temperatures at Lesser Slave Lake tributaries, April to October, 2017 to 2020. Red values indicate a guideline exceedance.

Site	2017				2018				2019				2020			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	10	11.1	0.3	13.8	10	12.3	2.8	17.8	10	9.90	1.60	14.20	10	10.0	2.2	18.3
Middle Swan	10	12.8	1.4	17.4	10	14.9	3.9	20.6	10	11.30	2.80	16.90	10	11.7	4.3	21.3
Lower Swan	10	13.6	2.7	17.5	9	17.5	4.9	20.5	9	13.50	3.70	19.70	8	11.6	3.6	22.5
Upper Driftpile	10	14.9	4.2	18.1	10	16.1	5.6	22.1	10	12.30	2.30	20.30	9	11.5	4.7	21.0
Middle Driftpile	10	14.3	2.9	17.4	10	16.0	4.7	21.5	10	11.95	2.30	20.80	10	12.9	4.2	22.7
Lower Driftpile	10	15.1	3.6	16.7	10	15.6	4.7	20.4	10	12.00	3.00	20.80	10	12.7	3.1	22.9
Upper East Prairie	10	15.4	4.4	19.0	10	16.0	4.0	24.0	10	11.55	2.70	21.10	10	11.9	3.9	23.2
Middle East Prairie	10	17.2	4.0	21.8	10	16.1	4.1	23.6	10	12.60	3.60	21.50	10	13.8	4.4	24.4
Lower East Prairie	9	17.1	2.0	18.3	9	14.6	3.9	22.3	10	13.55	3.30	20.10	-	-	-	-
Upper West Prairie	10	13.0	1.6	18.4	10	13.8	4.0	20.2	10	10.65	0.80	16.70	10	11.6	2.2	18.2
Middle West Prairie	10	14.3	2.2	20.3	10	14.6	3.7	21.4	10	12.05	1.80	18.40	10	13.1	4.1	21.4
Upper South Heart	10	17.1	4.6	19.9	10	16.0	3.8	21.0	10	14.70	4.90	20.20	10	15.3	7.3	21.6
Middle South Heart	10	16.0	3.7	19.7	10	16.0	3.3	21.3	10	14.00	3.40	20.90	10	14.6	4.3	20.4
Lower South Heart	10	15.1	2.0	23.5	10	15.6	4.0	22.0	10	13.00	2.70	21.00	10	14.3	5.1	21.8
Grouard Channel	10	17.3	1.3	21.7	10	16.2	3.7	21.5	10	14.65	3.10	20.70	10	15.4	4.8	21.7

**Table 6.** pH at Lesser Slave Lake tributaries, April to October, 2017 to 2020. Red values indicate a guideline exceedance.

Site	2017				2018				2019				2020			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	10	8.02	7.34	8.72	10	8.14	7.59	8.51	10	8.47	7.65	8.97	10	8.01	7.46	8.37
Middle Swan	10	8.14	7.88	11.56	10	7.95	7.44	8.94	10	8.35	7.59	9.44	10	7.84	6.65	8.08
Lower Swan	10	7.96	7.68	8.23	9	7.85	7.29	8.33	9	8.34	7.64	8.66	8	7.88	7.72	8.01
Upper Driftpile	10	8.09	7.51	8.79	10	8.07	7.26	8.48	10	8.44	7.47	8.76	9	7.84	7.19	8.16
Middle Driftpile	9	8.15	7.70	9.67	10	8.03	7.27	8.31	10	8.22	7.38	8.93	10	7.74	6.96	8.14
Lower Driftpile	10	8.00	7.70	8.82	10	7.65	7.12	8.04	10	8.26	7.36	8.69	10	7.87	7.04	8.10
Upper East Prairie	10	8.18	7.64	8.74	10	8.15	7.67	8.50	10	8.60	7.64	9.43	10	7.95	6.47	8.24
Middle East Prairie	10	7.98	7.71	8.18	10	8.12	7.66	8.74	10	8.42	7.58	9.07	10	7.89	6.89	8.29
Lower East Prairie	9	7.68	7.32	8.27	9	7.84	7.13	8.65	10	8.08	7.49	9.51	-	-	-	-
Upper West Prairie	10	7.76	7.45	10.01	10	7.86	7.45	8.46	10	8.42	7.15	9.15	10	7.80	7.16	8.08
Middle West Prairie	10	7.87	7.59	8.04	10	7.99	7.62	8.36	10	8.45	6.94	8.92	10	7.93	7.36	8.11
Upper South Heart	10	8.11	7.50	8.57	10	8.00	7.69	8.12	10	8.72	7.39	9.65	10	7.82	6.93	8.13
Middle South Heart	10	8.01	7.79	8.22	10	8.06	7.87	8.27	10	8.55	7.83	9.46	10	7.89	7.43	8.13
Lower South Heart	10	7.85	7.50	8.95	10	7.83	7.38	8.56	10	8.32	7.91	10.00	10	7.87	6.88	8.53
Grouard Channel	10	7.76	7.56	9.25	10	7.71	7.11	8.13	10	8.24	7.27	8.99	10	7.83	6.53	8.10



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**Table 7.** Dissolved oxygen at Lesser Slave Lake tributaries, April to October, 2017 to 2020. Red values indicate a guideline exceedance.

Site	2017				2018				2019				2020			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	10	9.90	9.40	11.90	10	10.31	8.21	11.86	10	10.71	9.16	12.59	10	10.32	8.79	12.59
Middle Swan	10	9.70	8.72	11.20	10	9.45	7.38	11.73	10	10.33	8.75	12.18	10	9.99	8.33	12.22
Lower Swan	10	8.90	8.51	11.60	9	8.49	7.08	11.56	9	9.45	8.13	11.52	8	9.79	7.97	12.40
Upper Driftpile	10	9.35	8.70	11.90	10	9.45	7.74	12.13	10	10.28	8.36	12.56	9	10.10	9.19	12.90
Middle Driftpile	10	10.01	8.80	11.60	10	9.25	7.50	11.70	10	10.18	8.19	12.38	10	9.68	8.11	12.54
Lower Driftpile	10	8.90	8.10	11.40	10	8.73	6.88	11.52	10	9.77	7.83	11.74	10	9.38	7.70	12.34
Upper East Prairie	10	10.54	8.70	11.36	10	9.48	7.30	11.74	10	10.49	8.30	12.66	10	9.66	8.05	12.55
Middle East Prairie	10	9.83	8.20	11.69	10	8.98	7.20	11.94	10	9.78	8.08	12.32	10	9.48	7.67	12.80
Lower East Prairie	9	8.77	7.43	11.69	9	7.70	4.61	11.44	10	9.24	6.02	12.11	-	-	-	-
Upper West Prairie	10	10.25	8.40	11.76	10	9.04	7.19	10.80	10	9.65	8.26	12.50	10	9.43	7.87	12.13
Middle West Prairie	10	10.20	8.40	11.00	10	9.12	7.46	11.62	10	9.85	8.37	12.37	10	9.35	8.15	12.52
Upper South Heart	10	9.98	8.90	11.29	10	9.39	7.80	11.58	10	10.24	8.58	12.12	10	9.78	8.38	11.36
Middle South Heart	10	9.05	8.00	10.56	10	8.39	6.87	11.55	10	8.79	7.20	12.51	10	8.27	6.92	11.99
Lower South Heart	10	8.34	7.34	10.01	10	7.44	4.05	11.38	10	8.26	5.31	12.25	10	6.89	4.63	11.64
Grouard Channel	10	8.69	7.00	10.61	10	6.93	3.88	11.20	10	8.15	5.96	11.57	10	5.14	1.86	10.44

**Table 8.** Conductivity at Lesser Slave Lake tributaries, April to October, 2017 to 2020.

Site	2017				2018				2019				2020			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	130	85	217	10	175	66	215	10	136	102	172	10	144	80	232
Middle Swan	9	119	64	226	10	168	65	212	10	121	80	174	10	135	75	247
Lower Swan	9	111	65	268	9	186	66	256	9	138	92	215	8	152	76	311
Upper Driftpile	8	114	65	245	10	169	58	217	10	134	71	195	8	109	78	249
Middle Driftpile	10	113	69	269	10	183	63	249	10	143	66	211	10	132	83	318
Lower Driftpile	9	120	63	297	10	194	64	300	10	148	68	229	9	155	84	312
Upper East Prairie	9	197	114	313	10	271	89	339	10	188	89	263	10	175	91	344
Middle East Prairie	10	186	93	362	10	250	93	378	10	191	104	297	10	186	99	407
Lower East Prairie	9	197	111	374	9	247	160	377	10	197	113	305	-	-	-	-
Upper West Prairie	10	149	71	352	10	191	73	394	10	144	71	229	10	134	67	407
Middle West Prairie	10	188	88	457	10	243	90	490	10	184	90	332	10	224	91	509
Upper South Heart	10	336	294	419	10	266	253	422	10	345	281	432	10	236	199	424
Middle South Heart	10	359	300	407	10	327	252	422	10	353	298	501	10	321	237	451
Lower South Heart	10	232	126	337	10	274	136	388	10	271	169	386	10	285	150	347
Grouard Channel	10	217	146	289	10	276	152	367	10	237	167	351	10	296	170	337

Median specific conductivity ranged from 175 to 186  $\mu\text{S}/\text{cm}$  at the East Prairie River sites (maximum conductivity range: 344 to 407  $\mu\text{S}/\text{cm}$ ) (Table 8). The maximum conductivity at each of the East Prairie River sites in 2020 was the highest of the four years. In 2020, all samples at the East Prairie River met the provincial guideline for safe irrigation ( $<1,000 \mu\text{S}/\text{cm}$ ) (GoA 2018).

#### 4.3.4 West Prairie River

In 2020, the median water temperature ranged from 11.6 to 13.1°C at the West Prairie River sites (maximum water temperature range: 18.2 to 21.4°C) (Table 5). The maximum water temperature in 2020 (and 2018) at the Middle site was 21.4°C and the warmest of the four monitoring years.

In 2020, median pH was 7.80 at the Upper West Prairie River site and 7.93 at the Middle West Prairie River site, and met the provincial guideline for the protection of aquatic life (PAL) ( $\geq 6.5$  to  $\leq 9.0$ ) (Table 6). The maximum pH was 8.08 at the Upper site and 8.11 at the Middle site. In 2020, all pH samples from West Prairie River sites met the provincial guideline for the protection of aquatic life ( $\geq 6.5$  to  $\leq 9.0$ ).

In 2020, the median dissolved oxygen ranged from 9.43 to 9.35 mg/L at the West Prairie River sites (minimum DO range: 7.87 to 8.15 mg/L) (Table 7). The medians and all samples of dissolved oxygen complied with guidelines for the protection of aquatic life at the West Prairie River sites.

The median specific conductivity ranged from 134 to 224  $\mu\text{S}/\text{cm}$  at the West Prairie River sites in 2020 (maximum conductivity range: 407 to 509  $\mu\text{S}/\text{cm}$ ) (Table 8). The maximum conductivity at each of the West Prairie River sites in 2020 was the highest of the four years. In 2020, all samples met the provincial guideline for safe irrigation ( $<1,000 \mu\text{S}/\text{cm}$ ) (GoA 2018).

#### 4.3.5 South Heart River and Grouard Channel

Median water temperature ranged from 14.3°C at the Lower South Heart River site to 15.3°C at the Upper South Heart River site in 2020 (Table 5). Maximum water temperatures ranged from 20.4°C at the Middle site to 21.8°C at the Lower site. The maximum water temperature in 2020 at the Upper South Heart River site was the highest (warmest) of the four monitoring years.

In 2020, median pH ranged from 7.82 to 7.89 at the South Heart River sites, and met the provincial guideline for the protection of aquatic life (Table 6). Maximum pH values ranged from 8.13 to 8.53. In 2020, all of the pH samples met the provincial guideline for the protection of aquatic life ( $\geq 6.5$  to  $\leq 9.0$ ) at each of the three sites.

Median dissolved oxygen concentrations ranged from 6.89 to 9.78 mg/L South Heart River sites in 2020 (minimum DO range: 4.63 to 8.38 mg/L) (Table 7). The medians and all individual samples complied with provincial guidelines for the protection of aquatic life with the exception of three samples on June 30, July 14 and July 28 (5.65 mg/L, 6.32 mg/L and 4.60 mg/L, respectively) at the Lower South Heart River that exceeded chronic and acute guidelines.

In 2020, median specific conductivity ranged from 236 to 321  $\mu\text{S}/\text{cm}$  at the South Heart River sites (maximum conductivity range: 347 to 451  $\mu\text{S}/\text{cm}$ ) (Table 8). All conductivity samples met the provincial guideline for safe irrigation ( $\leq 1,000 \mu\text{S}/\text{cm}$ ) (GoA 2018).

At the Grouard Channel in 2020, the median water temperature was 15.4°C (range: 4.8°C to 21.70°C) (Table 5). The maximum water temperature in 2020 (and 2017) was 21.7°C and the warmest of the four

monitoring years at the Grouard Channel. The median pH was 7.83 (range: 6.53 to 8.10) (Table 6). The median dissolved oxygen concentration was 5.14 mg/L (range: 1.86 to 10.44 mg/L) in 2020 (Table 7). The median dissolved oxygen concentration did not meet the provincial chronic guideline for the protection of aquatic life ( $\geq 6.5$ ). Five of ten samples did not meet the acute guideline ( $\geq 5.0$  mg/L) and two of ten samples did not meet the chronic guideline at the Grouard Channel in 2020. The median conductivity was 296  $\mu\text{S}/\text{cm}$  (range: 170 to 337  $\mu\text{S}/\text{cm}$ ) (Table 8). The median conductivity in 2020 was the highest of the four years. All pH and conductivity values met the provincial guidelines for the protection of aquatic life and irrigation water quality, respectively.

## 4.4 Phosphorus

### 4.4.1 Swan River

In 2020, the median total phosphorus (TP) concentration ranged from 0.050 to 0.053 mg/L at the Swan River sites (Maximum TP range: 0.172 to 0.230 mg/L) (Table 9). Total dissolved phosphorus was often less than the detection limit of the analytical equipment (0.020 mg/L) at the three sites. The median and minimum total dissolved phosphorus was 0.010 mg/L at all three sites and the maximum TDP increased from the Upper to Lower site, ranging from 0.012 to 0.025 mg/L (Table 10).

At the Middle Swan River site, the median TP concentration from 2017 to 2020 (0.034 to 0.053 mg/L) was generally lower compared to the historic<sup>3</sup> 1991-92 median (0.048 mg/L, Table 3 and 9). The maximum TP concentrations from 2017 to 2020 (0.137 to 0.940 mg/L) at the Middle Swan River site were generally higher compared and the historic 1991-92 maximum TP (0.173 mg/L).

At the Lower Swan River site, median TP concentrations from 2017 to 2020 (0.044 to 0.050 mg/L) were lower than the historic 2012-13 median (0.060 mg/L, Table 3 and 9). The maximum TP concentrations at the Lower Swan River site from 2017 to 2020 (0.172 to 2.38 mg/L) were substantially higher than the historic maximum TP from 2012-13 (0.084 mg/L). There was a strong, positive linear relationship between total phosphorus and total suspended solids at the Swan River (Pearson's correlation:  $r=0.96$ ). Similarly, there was a strong correlation between streamflow and total phosphorus ( $r=0.91$ ) and streamflow and total suspended solids ( $r=0.89$ ).

### 4.4.2 Driftpile River

In 2020, the median TP concentration ranged from 0.051 to 0.078 mg/L at the Driftpile River sites (maximum TP range: 0.294 to 0.357 mg/L) (Table 9). There was a strong, positive linear relationship between total phosphorus and total suspended solids at the Driftpile River (Pearson's correlation:  $r=0.82$ ). Similarly, there was a strong correlation between streamflow and total phosphorus ( $r=0.76$ ) and streamflow and total suspended solids ( $r=0.76$ ). In 2020, total phosphorus tended to increase from upstream to downstream, similar to 2017 to 2019.

The median total dissolved phosphorus ranged from 0.010 to 0.017 mg/L at the Driftpile River. The maximum total dissolved phosphorus was similar at all Driftpile River sites (0.031 to 0.034 mg/L) (Table 10).

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<sup>3</sup> For the Swan River, samples were collected at Hwy 2 near Kinuso (AB07BJ0010) in 1991-92, corresponding to the Middle site from 2017 to 2020. In 2012-13, samples were collected near the confluence with Lesser Slave Lake (AB07BHJ0020), corresponding to the Lower site from 2017 to 2020.

At the Middle Driftpile River site, the median TP concentration from 2017 to 2020 (0.040 to 0.062 mg/L) was generally higher than the historical 1991-92 median (0.040 mg/L, Table 3 and 9). The maximum TP concentrations from 2017 to 2020 (0.118 to 1.290 mg/L) at the Middle Driftpile River site were generally higher than the historical 1991-92 maximum (0.129 mg/L).

The median TP concentrations at the Lower Driftpile River site from 2017 to 2020 (0.043 to 0.078 mg/L) were generally lower than the historical<sup>4</sup> 2012-13 median (0.051 mg/L, Table 3 and 9). The maximum TP concentrations from 2017 to 2020 (0.108 to 1.280 mg/L) were generally lower than the historical TP maximum 2012-13 (0.873 mg/L).

#### 4.4.3 East Prairie River

In 2020, the median TP concentration ranged from 0.059 to 0.271 mg/L at the East Prairie River sites (maximum TP range: 0.540 to 0.604 mg/L) (Table 9). Total dissolved phosphorus (TDP) was often less than the detection limit of the analytical equipment (0.020 mg/L) at the two East Prairie River sites. The median total dissolved phosphorus was 0.010 mg/L at the Upper and Middle sites. The maximum TDP was 0.052 at the Upper site and 0.064 mg/L at the Middle site (Table 10). There was a strong, positive linear relationship between total phosphorus and total suspended solids at the East Prairie River (Pearson's correlation:  $r=0.94$ ). Similarly, there was a strong correlation between streamflow and total phosphorus ( $r=0.73$ ) and streamflow and total suspended solids ( $r=0.77$ ).

The median TP concentrations at the Middle East Prairie River from 2017 to 2020 (0.076 to 0.271 mg/L) were higher compared to the historic median<sup>5</sup> (2012-13: 0.076 mg/L, Table 3 and 9). The maximum TP concentrations at the Middle East Prairie River site from 2017 to 2020 (0.241 to 0.983 mg/L) were lower compared to the historical 2012-13 maximum (1.120 mg/L).

#### 4.4.4 West Prairie River

The median TP ranged from 0.093 to 0.110 mg/L at the West Prairie River sites in 2020 (maximum TP range: 0.293 to 0.504 mg/L) (Table 9). The median total dissolved phosphorus ranged from 0.016 to 0.017 (maximum TDP range: 0.103 to 0.248 mg/L). There was a strong, positive linear relationship between total phosphorus and total suspended solids at the West Prairie River (Pearson's correlation:  $r=0.96$ ). Similarly, there was a strong correlation between streamflow and total phosphorus ( $r=0.81$ ) and streamflow and total suspended solids ( $r=0.88$ ).

The median TP concentrations at the Middle West Prairie River site from 2017 to 2020 (0.055 to 0.110 mg/L) were higher than the historic<sup>6</sup> 2012-13 median (0.053 mg/L, Table 3 and 9). The maximum TP concentrations from 2017 to 2020 (0.333 to 1.050 mg/L) were lower than the historic maximum TP concentration from 2012-13 (1.150 mg/L) at the Middle West Prairie River site.

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<sup>4</sup> For the Driftpile River, samples were collected at Hwy 2 (AB07BH0010) in 1991-92, corresponding to the Middle site from 2017 to 2020. In 2012-13, samples were collected at the Driftpile River near the confluence with Lesser Slave Lake (AB07BH0020), corresponding to the Lower site from 2017 to 2020.

<sup>5</sup> For the East Prairie River, samples were collected at Hwy 2 (AB07BF0285) in 2012-13.

<sup>6</sup> For the West Prairie River, samples were collected near High Prairie WSC gauge (AB07BF0165) in 2012-13. This is the same location as Middle West Prairie River sampled from 2017 to 2020.

#### 4.4.5 South Heart River and Grouard Channel

In 2020 at the South Heart River sites, the median TP ranged from 0.144 to 0.242 mg/L (maximum TP range: 0.215 to 0.386 mg/L) (Table 9). The median total dissolved phosphorus ranged from 0.054 to 0.146 mg/L (maximum TDP range: 0.149 to 0.216 mg/L). There was a moderate, positive linear relationship between total phosphorus and total suspended solids at the South Heart River (Pearson's correlation:  $r=0.60$ ). There was a weak correlation between streamflow and total phosphorus ( $r=0.36$ ) and streamflow and total suspended solids ( $r=0.30$ ).

The median TP concentrations at the Lower South Heart River site from 2017 to 2020 (0.118 to 0.153 mg/L) were higher than the historical<sup>7</sup> median from 1991-92 (0.094 mg/L) and similar to the historical 2012-13 TP median (0.143 mg/L) (Table 3 and 9). The maximum TP concentrations at the Lower South Heart River site from 2017 to 2020 (0.215 to 0.602 mg/L) were higher than the 1991-92 median (0.190 mg/L) and lower than the 2012-13 median (0.838 mg/L) (Table 3 and 9).

At the Grouard Channel site, the median TP was 0.137 mg/L and ranged from 0.071 to 0.245 mg/L (Table 5). The median, minimum and maximum TP at the Grouard Channel in 2020 were similar to the Lower South Heart River site. The median TDP at Grouard Channel in 2020 was 0.056 mg/L (range: 0.010 to 0.181 mg/L) (Table 10). There was a weak, positive linear relationship between total phosphorus and total suspended solids at the Grouard Channel (Pearson's correlation:  $r=0.47$ ).

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<sup>7</sup> For the South Heart River, samples were collected about 3 km upstream of Buffalo Bay (AB07BF0030) in 1991-92 and 2012-13 which corresponds to the Lower South Heart River sample location from 2017 to 2020.

**Table 9.** Total phosphorus concentrations at Lesser Slave Lake tributaries, April to October, 2017 to 2020.

Site	2017				2018				2019				2020			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	0.034	0.010	0.127	10	0.030	0.010	0.619	10	0.026	0.010	0.091	10	0.052	0.010	0.230
Middle Swan	9	0.034	0.010	0.410	10	0.039	0.029	0.940	10	0.035	0.010	0.137	10	0.053	0.010	0.172
Lower Swan	9	0.050	0.029	1.060	9	0.048	0.034	0.170	9	0.044	0.027	0.172	8	0.050	0.025	0.227
Upper Driftpile	8	0.039	0.010	0.148	10	0.047	0.028	0.970	10	0.039	0.026	0.160	9	0.051	0.022	0.294
Middle Driftpile	10	0.053	0.020	0.118	10	0.051	0.030	1.290	10	0.040	0.027	0.217	10	0.062	0.010	0.345
Lower Driftpile	9	0.045	0.024	0.108	10	0.046	0.031	1.280	10	0.043	0.030	0.305	10	0.078	0.010	0.357
Upper East Prairie	9	0.025	0.010	0.110	10	0.029	0.010	1.590	10	0.035	0.010	0.304	10	0.059	0.010	0.540
Middle East Prairie	10	0.086	0.010	0.241	10	0.076	0.032	0.480	10	0.090	0.043	0.983	10	0.271	0.021	0.604
Lower East Prairie	9	0.073	0.025	0.129	9	0.071	0.031	0.180	10	0.125	0.037	0.413	-	-	-	-
Upper West Prairie	10	0.051	0.037	0.500	10	0.062	0.016	1.060	10	0.052	0.022	0.761	10	0.093	0.026	0.293
Middle West Prairie	10	0.055	0.030	0.362	10	0.065	0.024	0.333	10	0.061	0.023	1.050	10	0.110	0.025	0.504
Upper South Heart	10	0.092	0.064	0.239	10	0.097	0.019	0.137	10	0.078	0.035	0.114	10	0.223	0.103	0.317
Middle South Heart	10	0.094	0.072	0.193	10	0.144	0.043	0.282	10	0.074	0.056	0.195	10	0.242	0.189	0.386
Lower South Heart	10	0.153	0.109	0.602	10	0.138	0.089	0.229	10	0.118	0.080	0.218	10	0.144	0.109	0.215
Grouard Channel	10	0.118	0.039	0.248	10	0.107	0.046	0.341	10	0.104	0.069	0.199	10	0.137	0.071	0.245

**Table 10.** Total dissolved phosphorus concentrations at Lesser Slave Lake tributaries, April to October, 2017 to 2020.

Site	2017				2018				2019				2020			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	0.010	0.010	0.031	10	0.010	0.010	0.028	10	0.010	0.010	0.024	10	0.010	0.010	0.012
Middle Swan	9	0.010	0.010	0.026	10	0.016	0.010	0.030	10	0.010	0.010	0.027	10	0.010	0.010	0.025
Lower Swan	9	0.010	0.010	0.028	9	0.023	0.010	0.035	9	0.010	0.010	0.028	8	0.010	0.010	0.025
Upper Driftpile	8	0.010	0.010	0.080	10	0.025	0.010	0.032	10	0.010	0.010	0.030	9	0.010	0.010	0.034
Middle Driftpile	9	0.010	0.010	0.028	10	0.025	0.010	0.035	10	0.010	0.010	0.029	10	0.017	0.010	0.031
Lower Driftpile	9	0.010	0.010	0.041	10	0.025	0.010	0.033	10	0.016	0.010	0.026	10	0.016	0.010	0.034
Upper East Prairie	9	0.010	0.010	0.021	10	0.010	0.010	0.238	10	0.010	0.010	0.025	10	0.010	0.010	0.052
Middle East Prairie	10	0.010	0.010	0.067	10	0.024	0.010	0.054	10	0.016	0.010	0.264	10	0.010	0.010	0.064
Lower East Prairie	9	0.010	0.010	0.010	9	0.037	0.010	0.092	10	0.010	0.010	0.054	-	-	-	-
Upper West Prairie	10	0.023	0.010	0.042	10	0.025	0.010	0.047	10	0.022	0.010	0.033	10	0.017	0.010	0.103
Middle West Prairie	10	0.022	0.010	0.132	10	0.028	0.010	0.066	10	0.022	0.010	0.039	10	0.016	0.010	0.248
Upper South Heart	10	0.051	0.010	0.165	10	0.069	0.010	0.187	10	0.040	0.010	0.075	10	0.146	0.010	0.216
Middle South Heart	10	0.034	0.010	0.165	10	0.052	0.010	0.082	10	0.037	0.010	0.147	10	0.100	0.010	0.202
Lower South Heart	10	0.023	0.010	0.169	10	0.050	0.010	0.088	10	0.038	0.021	0.052	10	0.054	0.010	0.149
Grouard Channel	10	0.010	0.010	0.120	10	0.051	0.010	0.279	10	0.036	0.010	0.059	10	0.056	0.010	0.181

## 4.5 Nitrogen

The most significant portion of total nitrogen concentrations observed at all sites was in the organic form (as indicated by total Kjeldahl nitrogen). Therefore, the following section focuses on total nitrogen (Table 13). Nitrate-nitrite nitrogen and total Kjeldahl nitrogen results are presented in Table 11 and Table 12, respectively.

### 4.5.1 Swan River

The median total nitrogen (TN) ranged from 0.490 to 0.600 mg/L at the Swan River sites (maximum TN range: 0.860 to 1.660 mg/L) (Table 13).

At the Lower Swan River site, the median TN concentrations from 2017 to 2020 (0.400 to 0.500 mg/L) were lower than the historic 2012-13 median (0.518 mg/L, Table 3 and 13). At the Lower Swan River site, the maximum TN concentrations from 2017 to 2020 (0.790 to 3.430 mg/L) were generally lower than the historic 2012-13 maximum (2.110 mg/L, Table 3 and 13).

At the Middle Swan River site, the median TN concentrations from 2017 to 2020 (0.270 to 0.600 mg/L) ranged around the historic 1991-92 median (0.431 mg/L, Table 3 and 13). The maximum TN concentrations from 2017 to 2020 (0.860 to 1.570 mg/L) were higher than the 1991-92 maximum TN (0.832 mg/L).

### 4.5.2 Driftpile River

The median TN ranged from 0.580 to 0.645 mg/L at the Driftpile River sites in 2020 (maximum TN range: 1.480 to 1.970 mg/L) (Table 13).

The median TN concentrations at Lower Driftpile River site from 2017 to 2020 (0.450 to 0.645 mg/L) ranged around the historic<sup>8</sup> 2012-13 median (0.546 mg/L, Table 3 and 13). Maximum TN concentrations from 2017 to 2020 (1.120 to 1.970 mg/L) at the Lower Driftpile River were considerably lower than the historic maximum TN in 2012-13 (7.878 mg/L).

At the Middle Driftpile River site, the median TN concentrations from 2017 to 2020 (0.455 to 0.685 mg/L) were generally higher than the historic 1991-92 median (0.482 mg/L, Table 3 and 13). The maximum TN concentrations from 2017 to 2020 (1.030 to 1.710 mg/L) were higher compared to the historic 1991-92 maximum TN (0.976 mg/L).

### 4.5.3 East Prairie River

In 2020, the median TN ranged from 0.580 to 1.105 mg/L at the East Prairie River site (maximum TN range: 0.900 to 2.000 mg/L) (Table 13).

The median TN concentrations at Middle East Prairie from 2017 to 2020 (0.485 to 1.105 mg/L) were generally similar to the historic median<sup>9</sup> (2012-13: 0.565 mg/L, Table 3 and 13). The maximum TN

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<sup>8</sup> For the Driftpile River, samples were collected at Hwy 2 (AB07BH0010) in 1991-92, corresponding to the Middle site from 2017 to 2020. In 2012-13, samples were collected near the confluence with Lesser Slave Lake (AB07BH0020), corresponding to the Lower site from 2017 to 2020.

<sup>9</sup> For the East Prairie River, samples were collected at Hwy 2 (AB07BF0285) in 2012-13.



concentration from 2017 to 2020 (1.160 to 3.290 mg/L) were generally lower compared to the historic 2012-13 median (2.972 mg/L).

#### **4.5.4 West Prairie River**

In 2020, the median TN ranged from 0.925 to 1.215 mg/L at the West Prairie River sites (maximum TN range: 1.560 to 1.890 mg/L) (Table 13).

The median TN concentrations at Middle West Prairie River from 2017 to 2020 (0.655 to 1.215 mg/L) was generally lower compared to the historic<sup>10</sup> 2012-13 median (0.859 mg/L, Table 3 and 13). The maximum TN concentration from 2017 to 2020 (1.550 to 1.930 mg/L) was substantially lower compared to the historical 2012-13 median TN (3.786 mg/L).

#### **4.4.5 South Heart River and Grouard Channel**

At the South Heart River in 2020, the median TN ranged from 1.380 to 1.660 mg/L at the South Heart River sites (maximum TN range: 1.980 to 4.000 mg/L) (Table 13).

Compared to historic data<sup>11</sup>, the median TN concentration at the Lower South Heart River site from 2017 to 2020 (1.055 to 1.380 mg/L) was similar to the 1991-92 median (1.197 mg/L, Table 3) and the 2012-13 median (1.187 mg/L, Table 3). The maximum TN concentration from 2017 to 2020 (1.630 to 5.770 mg/L) was generally higher compared to 1991-92 (1.955 mg/L) and 2012-13 (2.762 mg/L) (Table 3 and 13).

At Grouard Channel in 2020, the median TN concentration was 1.320 mg/L, and ranged from 0.700 to 1.560 mg/L. Median and maximum TN concentrations were lower at the Grouard Channel compared to the Lower South Heart River site (Table 13).

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<sup>10</sup> For the West Prairie River, samples were collected near High Prairie WSC gauge (AB07BF0165) in 2012-13. This is the same location as Middle West Prairie River sampled from 2017 to 2020.

<sup>11</sup> For the South Heart River, samples were collected about 3 km upstream of Buffalo Bay (AB07BF0030) in 1991-92 and 2012-13 and corresponded to the Lower South Heart River sample location from 2017 to 2020.

**Table 11.** Nitrate+nitrite nitrogen concentrations at the Lesser Slave Lake tributaries, April to October, 2017 to 2020.

Site	2017				2018				2019				2020			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	0.011	0.011	0.025	10	0.011	0.003	0.011	10	0.011	0.003	0.011	10	0.011	0.011	0.034
Middle Swan	9	0.011	0.011	0.044	10	0.011	0.003	0.040	10	0.011	0.011	0.067	10	0.011	0.011	0.084
Lower Swan	9	0.011	0.011	0.045	9	0.011	0.003	0.041	9	0.011	0.011	0.028	8	0.011	0.011	0.091
Upper Driftpile	8	0.011	0.010	0.025	10	0.011	0.011	0.049	10	0.011	0.011	0.054	9	0.011	0.011	0.052
Middle Driftpile	10	0.011	0.011	0.027	10	0.011	0.011	0.031	10	0.011	0.011	0.049	10	0.011	0.011	0.059
Lower Driftpile	9	0.011	0.011	0.198	10	0.011	0.011	0.025	10	0.011	0.011	0.062	10	0.011	0.011	0.059
Upper East Prairie	9	0.011	0.011	0.057	10	0.011	0.011	0.080	10	0.011	0.011	0.062	10	0.011	0.011	0.102
Middle East Prairie	10	0.011	0.011	0.075	10	0.011	0.011	0.075	10	0.011	0.011	0.340	10	0.011	0.011	0.115
Lower East Prairie	9	0.011	0.011	0.040	9	0.011	0.011	0.044	10	0.011	0.011	0.068	-	-	-	-
Upper West Prairie	10	0.011	0.011	0.061	10	0.011	0.011	0.030	10	0.011	0.011	0.025	10	0.011	0.011	0.038
Middle West Prairie	10	0.011	0.011	0.040	10	0.011	0.011	0.035	10	0.011	0.011	0.062	10	0.011	0.011	0.045
Upper South Heart	10	0.011	0.011	0.111	10	0.022	0.011	0.081	10	0.011	0.010	0.084	10	0.053	0.011	0.138
Middle South Heart	10	0.011	0.010	0.239	10	0.032	0.011	0.146	10	0.011	0.010	0.124	10	0.081	0.011	0.196
Lower South Heart	10	0.023	0.011	0.095	10	0.011	0.011	0.239	10	0.011	0.011	0.025	10	0.038	0.011	0.103
Grouard Channel	10	0.011	0.011	0.067	10	0.011	0.011	0.054	10	0.011	0.010	0.027	10	0.011	0.011	0.041

**Table 12.** Total Kjeldahl nitrogen concentrations at Lesser Slave Lake tributaries, April to October, 2017 to 2020.

Site	2017				2018				2019				2020			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	0.230	0.100	0.690	10	0.325	0.100	1.280	10	0.415	0.100	0.900	10	0.540	0.100	1.660
Middle Swan	9	0.270	0.100	1.570	10	0.395	0.100	1.370	10	0.550	0.260	1.150	10	0.570	0.200	0.860
Lower Swan	9	0.400	0.100	3.430	9	0.410	0.100	0.780	9	0.500	0.400	1.140	8	0.490	0.100	0.930
Upper Driftpile	8	0.370	0.100	0.990	10	0.610	0.300	2.980	10	0.575	0.100	1.420	9	0.580	0.100	1.480
Middle Driftpile	10	0.455	0.100	1.030	10	0.675	0.220	1.100	10	0.500	0.100	1.710	10	0.580	0.100	1.670
Lower Driftpile	9	0.450	0.100	1.120	10	0.520	0.240	1.290	10	0.545	0.100	1.400	10	0.645	0.100	1.970
Upper East Prairie	9	0.100	0.100	0.830	10	0.390	0.100	1.010	10	0.425	0.100	1.100	10	0.535	0.300	0.900
Middle East Prairie	10	0.485	0.100	1.700	10	0.555	0.280	1.090	10	0.565	0.100	3.250	10	1.080	0.450	1.970
Lower East Prairie	9	0.520	0.380	1.800	9	0.500	0.240	1.260	10	0.765	0.100	1.730	-	-	-	-
Upper West Prairie	10	0.760	0.490	1.710	10	0.715	0.310	1.100	10	0.755	0.500	1.600	10	0.925	0.500	1.890
Middle West Prairie	10	0.805	0.560	1.890	10	0.725	0.360	1.520	10	0.655	0.300	1.860	10	1.215	0.450	1.560
Upper South Heart	10	1.425	0.670	2.240	10	1.150	0.890	1.620	10	1.330	0.640	2.040	10	1.445	0.950	1.940
Middle South Heart	10	1.295	0.720	2.070	10	1.295	0.910	1.900	10	1.155	0.370	2.030	10	1.550	0.840	2.130
Lower South Heart	10	1.240	0.910	3.650	10	1.205	0.960	1.570	10	1.055	0.700	5.750	10	1.375	1.150	2.150
Grouard Channel	10	0.860	0.340	2.420	10	1.040	0.560	1.520	10	0.870	0.100	1.820	10	1.300	0.700	1.520

**Table 13.** Total nitrogen concentrations at Lesser Slave Lake tributaries, April to October, 2017 to 2020.

Site	2017				2018				2019				2020			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	0.230	0.100	0.690	10	0.325	0.100	1.280	10	0.415	0.100	0.900	10	0.555	0.100	1.660
Middle Swan	9	0.270	0.100	1.570	10	0.395	0.100	1.370	10	0.550	0.260	1.150	10	0.600	0.200	0.860
Lower Swan	9	0.400	0.100	3.430	9	0.410	0.100	0.790	9	0.500	0.400	1.140	8	0.490	0.100	1.020
Upper Driftpile	8	0.370	0.100	0.990	10	0.610	0.300	2.980	10	0.575	0.100	1.420	9	0.580	0.100	1.480
Middle Driftpile	10	0.455	0.100	1.030	10	0.685	0.220	1.130	10	0.500	0.100	1.710	10	0.610	0.100	1.670
Lower Driftpile	9	0.450	0.100	1.120	10	0.520	0.240	1.290	10	0.545	0.100	1.460	10	0.645	0.100	1.970
Upper East Prairie	9	0.100	0.100	0.830	10	0.390	0.100	1.010	10	0.425	0.100	1.100	10	0.580	0.300	0.900
Middle East Prairie	10	0.485	0.100	1.730	10	0.555	0.280	1.160	10	0.565	0.100	3.290	10	1.105	0.450	2.000
Lower East Prairie	9	0.520	0.380	1.800	9	0.500	0.240	1.310	10	0.765	0.100	1.730	-	-	-	-
Upper West Prairie	10	0.760	0.490	1.710	10	0.715	0.310	1.130	10	0.755	0.500	1.600	10	0.925	0.520	1.890
Middle West Prairie	10	0.805	0.560	1.930	10	0.725	0.360	1.550	10	0.655	0.300	1.920	10	1.215	0.450	1.560
Upper South Heart	10	1.425	0.780	2.350	10	1.165	0.920	1.700	10	1.370	0.660	2.040	10	1.545	0.980	1.980
Middle South Heart	10	1.295	0.720	2.310	10	1.305	1.030	2.050	10	1.155	0.370	2.150	10	1.660	1.040	2.170
Lower South Heart	10	1.260	0.910	3.700	10	1.220	0.980	1.630	10	1.055	0.700	5.770	10	1.380	1.210	4.000
Grouard Channel	10	0.860	0.340	2.420	10	1.070	0.560	1.520	10	0.870	0.100	1.820	10	1.320	0.700	1.560

## 4.6 Total Suspended Solids (TSS)

### 4.6.1 Swan River

In 2020, the median total suspended solids (TSS) ranged from 28 to 60 mg/L at the Swan River sites (maximum TSS range: 305 to 354 mg/L) (Table 14). Although no TSS samples were obtained from the Lower site on June 17<sup>th</sup> and 29<sup>th</sup>, the maximum TSS concentrations at the Upper site and Middle site occurred on May 6<sup>th</sup>; therefore, the maximum TSS concentration at the Lower site also likely occurred on May 6<sup>th</sup>.

At the Middle Swan River site, the median TSS concentration from 2017 to 2020 (11 to 43 mg/l) was similar to the historic 1991-92 median (21 mg/L, Table 3). The maximum TSS concentrations from 2017 to 2020 (196 to 2,110 mg/L) were higher than the 1991-92 TSS maximum (187 mg/L).

### 4.6.2 Driftpile River

In 2020, the median TSS ranged from 32 to 60 mg/L at the Driftpile River sites (maximum TSS range: 172 to 504 mg/L) (Table 14). Maximum TSS concentrations occurred during May and June.

At the Middle Driftpile River site, the median TSS concentrations from 2017 to 2020 (18 to 47 mg/L) were higher compared to the 1991-92 median (14 mg/L, Table 3). The maximum TSS concentrations at the Middle Driftpile River site from 2017 to 2020 (153 to 3,570 mg/L) were higher than the 1991-92 maximum (128 mg/L).

### 4.6.3 East Prairie River

The median TSS ranged from 55 to 177 mg/L at the East Prairie River sites in 2020 (maximum TSS range: 923 to 971 mg/L) (Table 14). Maximum TSS concentrations occurred in May and June at the East Prairie River sites.

Compared to historic data<sup>12</sup>, minimum TSS concentrations at the Middle East Prairie River from 2017 to 2020 (2 to 7 mg/L) were lower compared to 2012-13 (12 mg/L, Table 3). Maximum TSS concentrations at the Middle site from 2017 to 2020 (445 to 1,410 mg/L) were generally lower compared to historical 2012-13 data (1,150 mg/L) (Table 3, Table 14).

### 4.6.4 West Prairie River

In 2020, the median TSS ranged from 98 to 104 mg/L at the West Prairie River sites (maximum TSS range: 438 to 735 mg/L) (Table 14). The maximum TSS concentrations occurred in May and June at the West Prairie River sites.

The minimum TSS concentrations at Middle West Prairie River from 2017 to 2020 (2 to 6 mg/L) were similar to the historic<sup>13</sup> 2012-13 minimum (6 mg/L, Table 3). The maximum TSS concentration from 2017 to 2020 (440 to 1,280 mg/L) was generally lower compared to 2012-13 maximum TSS (1,170 mg/L).

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<sup>12</sup> For the East Prairie River, samples were collected at Hwy 2 (AB07BF0285) in 2012-13.

<sup>13</sup> For the West Prairie River, samples were collected near High Prairie WSC gauge (AB07BF0165) in 2012-13. This is the same location as Middle West Prairie River sampled from 2017 to 2020.

**Table 14.** Total suspended solids concentrations (mg/L) at Lesser Slave Lake tributaries, April to October, 2017 to 2020.

Site	2017				2018				2019				2020			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	8	2	183	10	19	2	1,160	10	29	2	130	10	60	2	305
Middle Swan	9	12	2	1,030	10	11	5	2,110	10	22	2	196	10	43	2	354
Lower Swan	9	31	3	3,060	9	16	7	257	9	36	4	271	8	28	2	342
Upper Driftpile	8	15	2	254	10	14	3	2,230	10	18	2	220	9	32	2	172
Middle Driftpile	10	39	2	153	10	18	6	3,570	10	19	2	315	10	47	2	504
Lower Driftpile	9	37	5	136	10	16	4	3,380	10	28	7	551	10	60	2	259
Upper East Prairie	9	15	2	168	10	9	4	3,200	10	35	2	737	10	55	2	923
Middle East Prairie	10	83	2	445	10	37	5	576	10	85	7	1,410	10	177	2	971
Lower East Prairie	9	36	6	125	9	21	9	65	10	98	12	769	-	-	-	-
Upper West Prairie	10	24	7	200	10	31	7	541	10	33	4	1,650	10	104	3	438
Middle West Prairie	10	18	2	451	10	17	6	440	10	38	4	1,280	10	98	6	735
Upper South Heart	10	3	2	16	10	5	4	12	10	5	2	9	10	4	2	11
Middle South Heart	10	15	7	75	10	72	8	125	10	13	6	79	10	93	11	294
Lower South Heart	10	75	26	818	10	30	21	144	10	39	12	450	10	27	2	84
Grouard Channel	10	25	5	270	10	15	4	143	10	21	6	230	10	10	2	79

**Table 15.** Fecal coliform bacteria counts (cfu/100 mL) at Lesser Slave Lake tributaries, April to October 2017 to 2020. Red values indicate a guideline exceedance.

Site	2017				2018				2019				2020			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	22	1	120	10	13	1	420	10	11	1	73	10	21	3	160
Middle Swan	9	46	5	250	10	31	9	620	10	32	1	64	10	45	10	210
Lower Swan	9	110	5	870	9	20	7	65	9	42	8	64	8	43	10	90
Upper Driftpile	8	20	8	160	10	12	1	2,400	10	9	1	72	9	10	1	120
Middle Driftpile	10	20	3	200	10	16	1	220	10	10	1	52	10	39	8	200
Lower Driftpile	9	71	3	210	10	15	1	1,100	10	15	1	90	10	31	5	110
Upper East Prairie	9	11	1	44	10	30	1	520	10	22	1	50	9	12	3	90
Middle East Prairie	10	45	5	200	10	43	7	110	10	38	17	210	9	64	10	120
Lower East Prairie	9	64	20	220	9	25	2	190	10	73	4	460	-	-	-	-
Upper West Prairie	10	110	20	330	10	48	10	810	10	68	16	256	9	60	26	100
Middle West Prairie	10	145	20	330	10	98	11	330	10	66	17	810	9	64	10	130
Upper South Heart	10	5	1	10	10	1	1	4	10	2	1	10	9	6	1	50
Middle South Heart	10	64	5	200	10	30	1	330	10	14	1	41	9	20	12	160
Lower South Heart	10	67	10	1,400	10	17	2	360	10	44	10	580	9	30	10	126
Grouard Channel	10	20	5	48	10	3	1	54	10	11	1	100	9	10	2	140

#### 4.6.5 South Heart River and Grouard Channel

In 2020, the median TSS ranged from 4 to 93 mg/L at the South Heart River sites (maximum TSS range: 11 to 294 mg/L) (Table 14). In 2020, the maximum TSS concentrations occurred in May and June at the South Heart River sites.

The median TSS concentration at the Lower South Heart River site from 2017 to 2020 (27 to 75 mg/L) was higher compared to the historic<sup>14</sup> 1991-92 median (10 mg/L). Maximum TSS from 2017 to 2020 (84 to 818 mg/L) were generally higher compared to 1991-92 maximum (132 mg/L) (Table 3 and 14).

At Grouard Channel in 2020, the median TSS concentration was 10 mg/L, and ranged from 2 to 79 mg/L (Table 14). The maximum TSS occurred on June 16 at the Grouard Channel. The median, minimum and maximum TSS at the Grouard Channel in 2020 was the lowest from 2017 to 2020 (Table 14).

### 4.7 Fecal Coliform Bacteria (FCB)

#### 4.7.1 Swan River

The median fecal coliform bacteria (FCB) ranged from 21 to 45 cfu/100 mL at the Swan River sites (maximum FCB range: 90 to 210 cfu/100 mL) (Table 15). The median FCB counts at the three Swan River sites met the guideline for irrigation ( $\leq 100$  cfu/100 mL). One of 10 samples at the Upper site and three of 10 samples at the Middle site exceeded the irrigation guideline. Maximum FCB concentrations occurred in June and July at the Swan River sites.

The median FCB counts at the Middle Swan River site from 2017 to 2020 (31 to 46 cfu/100 mL) was slightly lower compared to the historic 1991-92 median (60 cfu/100 mL) (Table 3). Maximum FCB counts from 2017 to 2020 (64 to 620 cfu/100 mL) were higher compared to 1991-92 data (200 cfu/100 mL) (Table 3 and 15).

#### 4.7.2 Driftpile River

The median FCB ranged from 10 to 39 cfu/100 mL at the Driftpile River sites in 2020 (maximum FCB range: 110 to 200 cfu/100 mL) (Table 15). The median FCB counts at the three Driftpile River sites met the guideline for irrigation ( $\leq 100$  cfu/100 mL). One of 9 samples at the Upper site, one of 10 samples at the Middle site and two of 10 samples at the Lower site exceeded the irrigation guideline. Maximum FCB concentrations occurred on June 29 at all Driftpile River sites.

The median FCB counts at the Middle Driftpile River site from 2017 to 2020 (10 to 39 cfu/100 mL) was similar compared to the 1991-92 median (15 cfu/100 mL, Table 3). Maximum FCB counts from 2017 to 2020 (52 to 220 cfu/100 mL) were similar to 1991-92 data (200 cfu/100 mL) (Table 3 and 15).

#### 4.7.3 East Prairie River

In 2020, the median FCB ranged from 12 to 64 cfu/100 mL at the East Prairie River sites (maximum FCB range: 90 to 120 cfu/100 mL) (Table 15). The median FCB counts at the East Prairie River sites met the

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<sup>14</sup> For the South Heart River, samples were collected about 3 km upstream of Buffalo Bay (AB07BF0030) in 1991-92 and 2012-13 and corresponds to the Lower South Heart River sample location from 2017 to 2020.

guideline for irrigation ( $\leq 100$  cfu/100 mL). Two of 9 samples at the Middle site exceeded the irrigation guideline. Maximum FCB concentrations occurred on June 16 at the Upper and Middle site.

The 2020 median and maximum FCB counts at Upper site and the maximum FCB count at the Middle site were within the range of FCB counts from 2017 to 2019. The 2020 median FCB count at the Middle site (64 cfu/100 mL) was higher compared to 2017 to 2019 (38 to 45 cfu/100 mL) (Table 15).

#### **4.7.4 West Prairie River**

In 2020, the median FCB ranged from 60 to 64 cfu/100 mL at the West Prairie River sites (maximum FCB range: 100 to 130 cfu/100 mL) (Table 15). The median FCB counts at the West Prairie River sites met the guideline for irrigation ( $\leq 100$  cfu/100 mL). Two of 9 samples exceeded the irrigation guideline at the Middle site. Maximum FCB counts occurred on June 16 at the West Prairie River sites.

The 2020 median FCB count (60 cfu/100 mL) at Upper West Prairie River site was within the range of FCB counts from 2017 to 2019 (48 to 110 cfu/100 mL). The 2020 median and maximum FCB count at the Middle site and the maximum FCB count at the Upper site were the lower compared to 2017 to 2019 (Table 15).

#### **4.7.5 South Heart River and Grouard Channel**

In 2020, the median fecal coliform count ranged from 6 cfu/100 mL at the Upper South Heart River site to 30 cfu/100 mL at the Lower South Heart River site (Table 15). The maximum FCB count ranged from 50 cfu/100 mL at the Upper site to 160 cfu/100 mL at the Middle site. The median FCB counts at the three South Heart River sites met the guideline for irrigation ( $\leq 100$  cfu/100 mL). One of 9 samples at the Middle site and one of 9 samples at the Lower site exceeded the irrigation guideline.

The median FCB counts at the Lower South Heart River site from 2017 to 2020 (17 to 67 cfu/100 mL) were generally higher compared to the historic 1991-92 median (20 cfu/100 mL, Table 3). Maximum FCB counts from 2017 to 2020 (126 to 1400 cfu/100 mL) were generally higher compared to the 1991-92 maximum (264 cfu/100 mL) (Table 3 and 15).

In 2020 at the Grouard Channel, the median fecal coliform count was 10 cfu/100 mL, and ranged from 2 to 140 cfu/100 mL (Table 15). The median FCB count at the Grouard Channel met the guideline for irrigation ( $\leq 100$  cfu/100 mL); however, one of 9 samples exceeded the irrigation guideline. The maximum FCB concentration occurred on June 16 at the Grouard Channel. The median FCB count in 2020 (10 cfu/100 mL) at the Grouard Channel was within the range of 2017 to 2019 FCB counts (3 to 20 cfu/100 mL); however, the maximum FCB count in 2020 (140 cfu/100 mL) was higher compared to 2017 to 2019 (48 to 100 cfu/100 mL) (Table 15).

### **4.8 Metals**

Appendix B-2 and B-3 provides the data for metals analysis at the Upper, Lower and Middle Swan River sites, Upper West Prairie River, Middle East Prairie River and Middle Driftpile River. The following discussion highlights the metals that exceeded the chronic or acute provincial aquatic life guidelines (PAL) where guidelines have been specified (GoA 2018).



Metal analysis results showed that the same 6 metals exceeded the provincial guideline for the protection of aquatic life (PAL) at each of the Swan River sites (total mercury, total cadmium, total copper, total lead, dissolved aluminum and dissolved iron) (Figure 8). There were no guideline exceedances of total arsenic, total boron, hexavalent chromium, total nickel, total selenium, total silver, total uranium, total zinc, dissolved zinc or dissolved manganese at the Swan River sites.

Metal analysis results showed that 7 metals exceeded the provincial guidelines for the protection of aquatic life (PAL) at the Upper West Prairie River site, 7 metals exceeded guidelines at the Middle East Prairie River site and 8 metals exceeded guidelines at the Middle Driftpile River site (Figure 8). Six metal exceedances were common to the three sites: total mercury, total cadmium, total copper, total lead, total zinc and dissolved iron. Total arsenic and dissolved aluminum exceeded guidelines at two sites. The Upper West Prairie River had dissolved aluminum exceedances, the Middle East Prairie River had total arsenic exceedances and the Middle Driftpile River had total arsenic and dissolved aluminum exceedances. There were no guideline exceedances of total boron, hexavalent chromium, total nickel, total selenium, total silver, total uranium, dissolved zinc or dissolved manganese at the West Prairie, East Prairie or Driftpile river sites.

### **Total Arsenic**

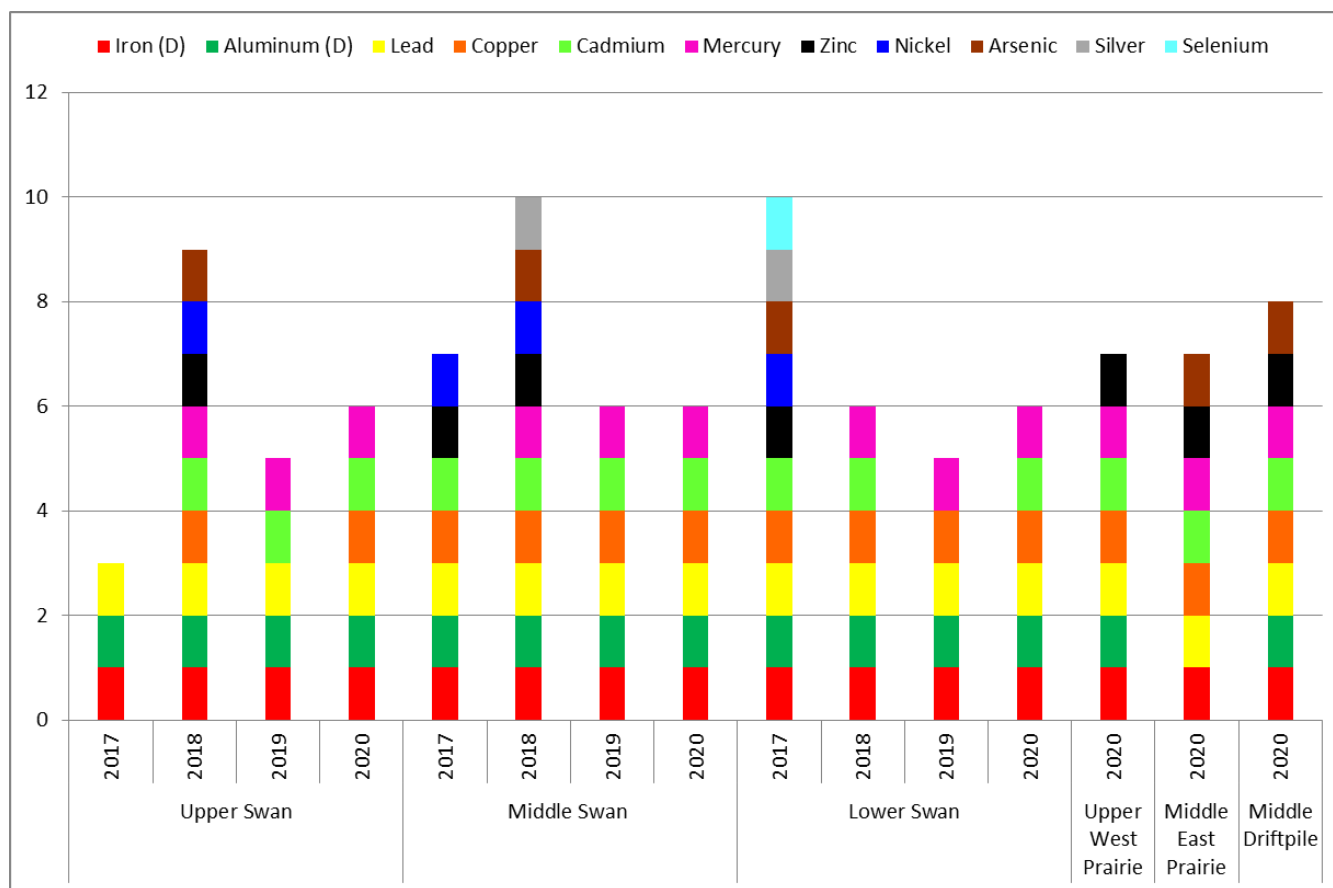
In 2020, total arsenic ranged from 1.06 to 3.91 µg/L with a median of 1.63 µg/L at the three Swan River sites. There were no exceedances of the total arsenic chronic guideline at the Swan River sites in 2020 (Appendix B-2).

In 2020 at Upper West Prairie River, total arsenic ranged from 0.92 to 4.42 µg/L (median: 1.71 µg/L) and no samples (0%) exceeded the chronic total arsenic guideline (5 µg/L). None of the 7 samples (0%) had total arsenic concentrations below the detection limit of the analytical equipment (Appendix B-3).

In 2020 at Middle East Prairie River, total arsenic ranged from 1.24 to 6.71 µg/L with a median of 2.43 µg/L and two of 7 samples (29%) exceeded the guideline by a factor of 1.2 to 1.3 times. None of the 7 samples (0%) had total arsenic concentrations below the detection limit (Appendix B-3).

In 2020 at Middle Driftpile River, total arsenic ranged from 1.32 to 6.15 µg/L with a median of 2.16 µg/L and one of 7 samples (14%) exceeded the guideline by a factor of 1.3 times. None of the 7 samples (43%) had total arsenic concentrations below the detection limit. The total arsenic exceedances at the two river sites occurred in early-May or late-June and corresponded with the highest total suspended solids (TSS) ranging from 504 to 632 mg/L (Appendix B-3).

Arsenic ranks as the 53rd element in abundance in the earth's crust, and is more common in the earth's crust than are other common elements such as mercury, cadmium and silver (CCREM 1987). Smelting, refining industries and combustion of fossil fuels, especially coal are anthropogenic sources of arsenic. Arsenic is used in metallurgical applications and in manufacturing wood preservatives. Arsenic compounds are also used in herbicide, pharmaceutical, and glass manufacturing. The largest natural source of arsenic entering surface waters is that from weathered rocks and soils. Levels of total arsenic in uncontaminated surface waters are generally less than 2 µg/L (CCME 2001). The estimated amount of arsenic released to the global environment annually as a result of human activities is about twice that reaching the environment from weathering. Most of the arsenic reaching the environment is sorbed by soils and sediment (CCREM 1987).



**Figure 8.** Number of metals that exceeded PAL guidelines at tributaries to Lesser Slave Lake, 2017 to 2020. Sample sizes: 2017 N=5, 2018 N=7, 2019 (N=7) and 2020 (N=7).

### Total Cadmium

In 2020, total cadmium concentrations at the Swan River sites ranged from 0.0069 to 0.147 µg/L with a median of 0.0311 µg/L. Three of 20 samples (15%) exceeded the chronic total cadmium guideline in 2020 at the Swan River sites on May 6 by a factor of 2.2 to 2.9 times. None of the samples had total cadmium concentrations below the detection limit of the analytical equipment (Appendix B-2).

In 2020 at Upper West Prairie River, total cadmium ranged from 0.0225 to 0.198 µg/L with a median of 0.0345 µg/L and two of 7 samples (29%) exceeded the chronic total cadmium guideline by a factor of 2.5 to 4.0 times. None of the 7 samples (0%) had total cadmium concentrations below the detection limit of the analytical equipment (Appendix B-3).

In 2020 at Middle East Prairie River, total cadmium ranged from 0.0158 to 0.272 µg/L with a median of 0.0367 µg/L and three of 7 samples (43%) exceeded the chronic guideline by a factor of 1.0 to 3.6 times. None of the 7 samples (0%) had total cadmium concentrations below the detection limit (Appendix B-3).

In 2020 at Middle Driftpile River, total cadmium ranged from 0.0184 to 0.243 µg/L with a median of 0.0466 µg/L and two of 7 samples (29%) exceeded the chronic guideline by a factor of 1.7 and 2.9 times. None of the 7 samples (0%) had total cadmium concentrations below the detection limit (Appendix B-3).

Cadmium is a naturally occurring metal found in mineral deposits and is distributed widely at low concentrations in the environment. Across the Prairie Provinces, cadmium concentrations in freshwater range from <0.1 to 112 µg/L (an extreme value) and average concentrations range from 0.2 to 0.3 µg/L (CCME 2014). Typical background dissolved cadmium concentrations in freshwaters of the United States ranged from 0.002 to 0.08 µg/L (Mebane 2010). Total cadmium in the Slave Lake watershed may be due to industrial uses and natural occurrences. Cadmium enters the environment as a result of both natural processes (weathering and erosion of rock and soils, natural combustion from volcanoes and forest fires) anthropogenic sources (mining, agriculture, urban activities, and waste streams from industrial processes, manufacturing, coal ash ponds/pits, fossil fuel combustion, incineration and municipal effluent) (USEPA 2016). Primary industrial uses are for the manufacturing of batteries, pigments, plastic stabilizers, metal plating, alloys and electronics. Human sources, such as mining and urban areas are responsible for contributing approximately 90% of cadmium found in surface waters (USEPA 2016).

Fathead minnows had a 96 h LC50<sup>15</sup> (acute) when exposed to 10.1 µg/L of cadmium (CCME 2014). Salmonids appear more sensitive to cadmium with Rainbow Trout, Brown Trout and Bull Trout having a 96 h LC50 at cadmium concentrations from 0.47 to 1.97 µg/L while Arctic Grayling and Mountain Whitefish have a 96 h LC50 with cadmium concentrations between 4.89 to 4.92 µg/L (CCME 2014).

### **Total Copper**

The median total copper concentration at the Swan River sites in 2020 was 3.80 µg/L (range: 0.87 to 12.4 µg/L). Three of 20 samples (15%) exceeded the acute total copper guideline in 2020 at the Swan River sites on May 6 by a factor of 2.5 to 3.0 times. None of the 20 samples had total copper concentrations below the detection limit of the analytical equipment. Elevated total copper concentrations at the Swan River corresponded with the highest total suspended solids (TSS) ranging from 305 to 354 mg/L (Appendix B-2).

In 2020 at Upper West Prairie River, total copper ranged from 0.97 to 13.9 µg/L with a median of 5.42 µg/L and two of 7 samples (29%) exceeded the acute total copper guideline by a factor of 2.1 and 3.0 times. None of the 7 samples (0%) had total copper concentrations below the detection limit of the analytical equipment (Appendix B-3).

In 2020 at Middle East Prairie River, total copper ranged from 0.138 to 21.2 µg/L with a median of 4.96 µg/L. Two of 7 samples (29%) exceeded the chronic guideline and three of 7 (43%) exceeded the acute guideline by a factor of 1.1 to 3.4 times. None of the 7 samples (0%) had total copper concentrations below the detection limit (Appendix B-3).

In 2020 at Middle Driftpile River, total copper ranged from 0.95 to 18.5 µg/L with a median of 4.08 µg/L and two of 7 samples (29%) exceeded the acute guideline by a factor of 1.6 and 2.4 times. None of the 7 samples (0%) had total copper concentrations below the detection limit (Appendix B-3).

Total copper in the Slave Lake watershed may be due to natural occurrences and industrial uses. Copper is an abundant trace element found in the earth's crust and is a naturally occurring element that is generally present in surface waters. Copper enters aquatic systems through aerial deposition or surface runoff. Because of its affinity for particulate matter, mainly fractions of iron, manganese oxides, and organic matter, copper tends to accumulate in sediments (CCME 1999). At 11 interprovincial border

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<sup>15</sup> 96 h LC50 - Standard measure of the toxicity used to determine the lethal concentration (LC) of the surrounding medium that will kill half of the sample population (50%) of a specific test-animal in a specified period (96 hours) through exposure.

sites in the prairies, total copper concentrations varied from below detection to 85 µg/L; most median values were around 3 µg/L with some median values as high as 8 µg/L (AEP 1996).

### **Total Lead**

The median total lead concentration at the Swan River sites in 2020 was 0.372 µg/L (range: <0.050 to 5.11 µg/L). Seven of 20 samples (35%) exceeded the chronic total lead guideline in 2020 at the Swan River sites by a factor of 1.2 to 5.1 times. Total lead exceedances occurred from May 6 to July 30 concurrent with higher suspended solids concentrations (72.5 to 354 mg/L) and higher flows (16.2 to 71.1 m<sup>3</sup>/s). No lead exceedances occurred during periods of lower TSS concentrations (<3 to 54.5 mg/L) and lower flow (1.55 to 2.33 m<sup>3</sup>/s) from August 19 to October 14. One of the 20 samples (5%) had total lead concentrations below the detection limit of the analytical equipment (Appendix B-2).

In 2020 at Upper West Prairie River, total lead ranged from <0.050 to 6.59 µg/L with a median of 0.778 µg/L and three of 7 samples (43%) exceeded the chronic total lead guideline by a factor of 1.3 to 6.6 times. One of the 7 samples (14%) had total lead concentrations below the detection limit of the analytical equipment (Appendix B-3).

In 2020 at Middle East Prairie River, total lead ranged from 0.094 to 9.38 µg/L with a median of 1.110 µg/L. Three of 7 samples (43%) exceeded the chronic guideline by a factor of 2.5 to 8.5 times. None of the 7 samples (0%) had total lead concentrations below the detection limit (Appendix B-3).

In 2020 at Middle Driftpile River, total lead ranged from <0.050 to 7.14 µg/L with a median of 0.840 µg/L and three of 7 samples (43%) exceeded the chronic guideline by a factor of 1.3 and 7.1 times. One of the 7 samples (14%) had total lead concentrations below the detection limit (Appendix B-3).

Lead ranks as the 36th element in order of abundance based on its concentration in the earth's crust (igneous rocks). Anthropogenic input of lead to the environment outweighs all natural sources. In Canada, the primary use of lead is in the production of acid-storage batteries. The second largest use was in the manufacture of chemical compounds, particularly alkyl lead additives (i.e., leaded gasoline). Leaded gasoline was largely phased out of use in Canada by 1990. Lead and its compounds are also used in electroplating, metallurgy, construction materials, coatings and dyes, electronic equipment, plastics, veterinary medicines, fuels, radiation shielding, ammunition, corrosive-liquid containers, paints, glassware, fabricating storage tank linings, transporting radioactive materials, solder, piping, cable sheathing, roofing and sound attenuators (CCREM 1987). Soluble lead, whether natural or from industrial sources is removed from solution by association with sediments and suspended particulates, such as organic matter, hydrous oxides and clays.

### **Total Mercury**

Total mercury at the Swan River sites in 2020 ranged from 0.0025 to 0.0218 µg/L with a median of 0.0025 µg/L. Seven of 20 samples (35%) exceeded the chronic total mercury guideline (0.005 µg/L) in 2020 at the Swan River sites by a factor of 1.5 to 4.4 times from early-May to late-July. Two samples exceeded the acute total mercury guideline (0.013 µg/L) by a factor of 1.5 to 1.7 times on May 6. Thirteen of the 20 samples (65%) had total mercury concentrations below the detection limit of the analytical equipment (Appendix B-2).

In 2020 at Upper West Prairie River, total mercury ranged from <0.005 to 0.0211 µg/L with a median of 0.0061 µg/L and one of 7 samples (14%) exceeded the acute total mercury guideline (0.013 µg/L). The sample exceeded the acute total mercury guideline by a factor of 1.6 times. Five of seven samples (71%)

exceeded the chronic total mercury guideline at Upper West Prairie River. Two of the 7 samples (29%) had total mercury concentrations below the detection limit of the analytical equipment (Appendix B-3).

In 2020 at Middle East Prairie River, total mercury ranged from <0.005 to 0.0123 µg/L with a median of 0.0025 µg/L and three of 7 samples (43%) exceeded the chronic guideline by a factor of 1.1 to 2.5 times. Four of the 7 samples (57%) had total mercury concentrations below the detection limit (Appendix B-3).

In 2020 at Middle Driftpile River, total mercury ranged from <0.005 to 0.0094 µg/L with a median of 0.0025 µg/L and two of 7 samples (29%) exceeded the chronic guideline by a factor of 1.1 and 1.9 times. Five of the 7 samples (71%) had total mercury concentrations below the detection limit (Appendix B-3).

Mercury occurs naturally, but significant amounts enter ecosystems through anthropogenic emissions and discharges. Natural sources of mercury include geological mercury deposits, rock weathering, forest fires and other wood burning. The primary anthropogenic sources of mercury in Canada include: metal smelting; coal-burning power plants; municipal waste incineration; sewage and hospital waste incineration; fossil fuel combustion; cement manufacturing; and, mercury waste in landfills (CCME 2003a). Total mercury concentrations in surface waters of western Canada have been recorded to range from <0.02 to 0.24 µg/L (CCREM 1987). In freshwater habitats, mercury compounds sorb to particulate matter and to sediment. Mercury sorption onto sediments is an important process for determining its abiotic fate in the aquatic environment. Sediment binding capacity is related to organic content. Mercury tends to combine with sulphur in anaerobic bottom sediments (CCREM 1987).

### **Total Zinc**

In 2020, total zinc ranged from <3.0 to 28.7 µg/L with a median of 3.6 µg/L at the three Swan River sites. There were no exceedances of the total zinc guideline at the Swan River sites in 2020 (Appendix B-2).

In 2020 at Upper West Prairie River, total zinc ranged from <3.0 to 37.9 µg/L with a median of 5.0 µg/L and two of 7 samples (29%) exceeded the chronic total zinc guideline (30 µg/L) by a factor of 1.2 to 1.3 times. Three of the 7 samples (43%) had total zinc concentrations below the detection limit of the analytical equipment (Appendix B-3).

In 2020 at Middle East Prairie River, total zinc ranged from <3.0 to 50.4 µg/L with a median of 6.8 µg/L and two of 7 samples (29%) exceeded the guideline by a factor of 1.7 to 1.8 times. Three of the 7 samples (43%) had total zinc concentrations below the detection limit (Appendix B-3).

In 2020 at Middle Driftpile River, total zinc ranged from <3.0 to 49.3 µg/L with a median of 6.5 µg/L and one of 7 samples (14%) exceeded the guideline by a factor of 1.6 times. Three of the 7 samples (43%) had total zinc concentrations below the detection limit. The total zinc exceedances at the three river sites occurred in early-May or late-June and corresponded with the highest total suspended solids (TSS) ranging from 395 to 632 mg/L (Appendix B-3).

Zinc is the fourth most common metal in use, after iron, aluminum, and copper. Approximately half of mined zinc is used as an anti-corrosion agent by coating (galvanizing) iron or steel to protect the metals against corrosion. Galvanization is used on chain-link fencing, culverts, guard rails, cathodic anodes, suspension bridges, light posts, metal roofs, heat exchangers, and car bodies. The presence of elevated levels of total zinc at the West Prairie, East Prairie and Driftpile river sites in 2020 is probably due to anthropogenic uses. Surface water total zinc concentrations have been found to range from 0.1 to 139 µg/L in the Athabasca region of Alberta (CCME 2018).

### **Dissolved Aluminum**

At the Swan River sites in 2020, dissolved aluminum ranged from 3.3 to 90.4 µg/L with a median of 27.6 µg/L. Five of 20 samples (25%) exceeded the chronic dissolved aluminum guideline (50 µg/L) by a factor of 1.1 to 1.8 times. The dissolved aluminum exceedances occurred in early-May and early-June (Appendix B-2).

In 2020 at Upper West Prairie River, dissolved aluminum ranged from 2.5 to 145 µg/L with a median of 53 µg/L and two of 7 samples (29%) exceeded the acute dissolved aluminum guideline (100 µg/L) and four of 7 samples (57%) exceeded the chronic dissolved aluminum guideline (50 µg/L). The two samples exceeded the acute dissolved aluminum guideline by a factor of 1.4 to 1.5 times (Appendix B-3).

In 2020 at Middle East Prairie River, dissolved aluminum ranged from 1.6 to 36.5 µg/L with a median of 21.4 µg/L and none of the 7 samples (0%) exceeded the guideline (Appendix B-3).

In 2020 at Middle Driftpile River, dissolved aluminum ranged from 3.5 to 90.1 µg/L (median: 35.7 µg/L) and three of 7 samples (43%) exceeded the chronic guideline by a factor of 1.4 to 1.8 times (Appendix B-3).

In the Earth's crust, aluminum is the most abundant metallic element (8.1% by weight) and the third most abundant of all elements (after oxygen and silicon). The amount of aluminum found naturally in the environment exceeds aluminum from anthropogenic sources (CCME 2003b). The high aluminum concentrations in the Swan River are probably naturally occurring. Research indicates that aluminum is substantially less toxic at higher pH (>6.6) and water hardness (>10 mg/L) (USEPA 2009). At the Swan River sites, pH and water hardness in 2020 ranged between 6.7 to 8.4 and 26 to 129 mg/L, respectively. At the West Prairie, East Prairie and Driftpile river sites, pH and water hardness in 2020 ranged between 6.5 to 8.3 and 26 to 198 mg/L, respectively.

### **Dissolved Iron**

At the Swan River sites in 2020, dissolved iron ranged from 234 to 2,040 µg/L with a median of 766 µg/L. Seventeen of 20 samples (85%) exceeded the chronic dissolved iron guideline by a factor of 1.0 to 6.8 times. Dissolved iron exceeded the chronic PAL guideline (300 µg/L) at the Middle and Lower sites on all sample dates. Iron ranged from 234 to 977 µg/L at the Upper site, from 343 to 1,540 µg/L at the Middle site and from 355 to 1,820 µg/L at the Lower site (Appendix B-2).

In 2020 at Upper West Prairie River, dissolved iron ranged from 371 to 1330 µg/L with a median of 441 µg/L and seven of 7 samples (100%) exceeded the chronic dissolved iron guideline (300 µg/L) by a factor of 1.2 to 4.4 times (Appendix B-3).

In 2020 at Middle East Prairie River, dissolved iron ranged from 252 to 405 µg/L with a median of 294 µg/L and three of 7 samples (43%) exceeded the guideline by a factor of 1.0 to 1.4 times (Appendix B-3).

In 2020 at Middle Driftpile River, dissolved iron ranged from 375 to 1,600 µg/L (median: 704 µg/L) and seven of 7 samples (100%) exceeded the guideline by a factor of 1.3 to 6.6 times (Appendix B-3).

Iron is the fourth most common element in the earth's crust and is the most widely used of all the metals, accounting for 95% of worldwide metal production. Iron is naturally released into the environment from weathering of sulphide ores (pyrite, FeS<sub>2</sub>) and igneous, sedimentary and metamorphic rocks. Iron is also released into the environment by human activities, mainly from the



burning of coke and coal, acid mine drainage, mineral processing, sewage, landfill leachates, iron-related industries and the corrosion of iron and steel (CCREM 1987). The presence of elevated concentrations of iron at the Swan River is probably due to natural occurrences and industrial uses.

### Metals Discussion

Hutchinson *et al.* (2015) reported on metal concentrations in Lesser Slave Lake tributaries for samples collected in May and July (2008-2010). Hutchinson *et al.* (2015) found that the Swan River had fewer metals exceeding guidelines (8) compared to the Driftpile River (10 metals exceeding guidelines) and West Prairie and East Prairie rivers (9 metals exceeding guidelines). Metals commonly exceeding guidelines in all rivers were total cadmium, total copper, total lead, total manganese, total mercury, total silver, dissolved aluminum and dissolved copper (Hutchinson *et al.* 2015). Metals sampling in 2020 yielded similar results to the 2008-2010 study. There were fewer metal exceedances at the Swan River. Six metals (the same at each site) exceeded the provincial guidelines at each of the Swan River sites in 2020 (total mercury, total cadmium, total copper, total lead, dissolved aluminum and dissolved iron). Seven metals each exceeded the provincial guidelines at the Upper West Prairie River and the Middle East Prairie River sites and 8 metals exceeded guidelines at the Middle Driftpile River site. Six metal exceedances were common to the three sites: total mercury, total cadmium, total copper, total lead, total zinc and dissolved iron. In addition, the Upper West Prairie River had dissolved aluminum exceedances, the Middle East Prairie River had total arsenic exceedances and the Middle Driftpile River had both total arsenic and dissolved aluminum exceedances.

Hutchinson *et al.* (2015) noted a strong correlation between metal concentrations and elevated suspended solids concentrations, which tended to increase with high streamflows ( $R^2$  ranged from 0.92 to 0.99). This corresponds to the most recent findings (2017 to 2020) as the highest metal concentrations and largest number of metals exceeding the protection of aquatic life (PAL) guidelines occurred on dates with the highest suspended solids.

Hutchinson *et al.* (2015) noted an increasing trend in total metal concentrations and a decreasing trend in dissolved metal concentrations from upstream to downstream in 2008-2010 for the Swan River. This trend was not observed in 2020 for total or dissolved metals at the Swan River. The authors suggested that changes in metal concentrations may be due to changes in soil characteristics. The Swan River originates in the upper foothills where soils are dominated by brunisolic gray luvisol, and flows north into the central mixed-wood natural region where soils are primarily organic.

## 5.0 SUMMARY

This report summarizes the fourth year of data collected as part of the Lesser Slave Lake Tributary Monitoring Program. Variations in water quality were observed between the five tributaries to Lesser Slave Lake from 2017 to 2020. These differences are likely due to a combination of channel morphology, river gradients, and differences in land use/human disturbance between catchments (Hutchinson *et al.* 2015). Spatial trends (upstream, middle and downstream sites) were also observed in individual tributaries. Multiple years of data, representing wet, dry and average precipitation years are needed to firmly establish water quality trends at the tributaries to Lesser Slave Lake. The following summarizes the Year 4 monitoring results. Table 16 compares the 2017 to 2020 water quality to historic water quality at each of the five main tributaries.



### Weather and Streamflow

- Precipitation varied across the watershed in 2020. Overall, as measured by the 7 weather stations, precipitation in 2020 was 17.4% less than 2019, 13.3% less than 2018 and 24.6% less than 2017.
- Average daily flow at the Driftpile, Swan (Swan Hills), East Prairie, West Prairie and South Heart rivers increased in 2020 compared to 2019 and was the highest of the four years at these sites. The average daily flow at the Swan River (Kinuso) in 2020 was less than 2019 but greater than 2017 and 2018.
- The peak discharge at the South Heart River (both sites) in 2020 was the highest of the four years. Peak discharges in 2020 were higher at the Swan (Swan Hills), East Prairie and West Prairie rivers compared to 2019. Conversely, peak discharges in 2020 were lower at the Driftpile and Swan (Kinuso) rivers compared to 2019.

### Swan River

- The median water temperatures were below the temperature objective (22°C) in 2020 at the Swan River. The maximum water temperature at the Lower site (22.5°C) exceeded the water temperature objective on July 30<sup>th</sup>.
- All pH, dissolved oxygen and conductivity samples met guidelines.
- Median total phosphorus concentrations (0.050 to 0.052 mg/L) in 2020 were the highest of the four years at the Swan River sites.
- From 2017 to 2019, total phosphorus concentrations were highest at the Lower Swan River site and tended to increase from upstream to downstream. This trend did not occur in 2020 and the median and maximum total phosphorus concentrations were similar from Upper to Lower sites.
- Median TSS concentrations at the Upper and Middle Swan River sites were the highest of the four years.
- A strong correlation was observed between total phosphorus and total suspended solids ( $r=0.96$ ) in 2020.
- Median fecal coliform bacteria (FCB) counts at the Swan River sites were similar from 2017 to 2020 ( $\leq 46$  cfu/100 mL) with the exception of the Lower site in 2017 (110 cfu/100 mL). One FCB sample at the Upper site and three samples at the Middle site exceeded the FCB guideline in 2020.
- There was a trend for degrading minimum temperature and maximum nitrate-nitrite at the middle Swan River (increasing temperature and concentration) and degrading minimum fecal coliform bacteria (increasing counts) at the lower Swan River (Table 16).
- Most water quality parameters had a 'stable trend' or 'no trend' at the Swan River (Table 16). Small sample sizes ( $n=4$  to 5) may limit the probability of detecting a trend when one is present.

### Driftpile River

- The median water temperatures were below the temperature objective (22°C) in 2020 at the Driftpile River. The maximum water temperature at the Lower site (22.9°C) exceeded the water temperature objective on July 30<sup>th</sup>.
- Routine parameters (dissolved oxygen, pH and conductivity) met guidelines in 2020.
- Median total phosphorus concentrations (0.051 to 0.078 mg/L) in 2020 were the highest of the four years at the Driftpile River sites.
- Median TSS concentrations at the Driftpile River sites in 2020 were the highest of the four years. The maximum TSS (504 mg/L) occurred at the Middle site.

- A strong correlation was observed between total phosphorus and total suspended solids ( $r=0.82$ ) in 2020.
- Median fecal coliform bacteria (FCB) counts at the Driftpile River sites were similar from 2017 to 2020 ( $\leq 71$  cfu/100 mL). There was at least one exceedance of the FCB guidelines at each Driftpile River site.
- There was a trend for degrading maximum total nitrogen and maximum nitrate-nitrite (increasing concentrations) at the middle Driftpile River site (Table 16).
- Most water quality parameters had a 'stable trend' or 'no trend' at the Driftpile River (Table 16). Small sample sizes ( $n=4$  to 5) may limit the probability of detecting a trend when one is present.

#### East Prairie River

- The median water temperatures were below the temperature objective ( $22^{\circ}\text{C}$ ) in 2020 at the Upper and Middle sites at the East Prairie River. The maximum water temperatures at the Upper site ( $23.2^{\circ}\text{C}$ ) and Middle site ( $24.4$  and  $23.3^{\circ}\text{C}$ ) exceeded the water temperature objective on July 28<sup>th</sup> and August 18<sup>th</sup>.
- All conductivity samples met the irrigation guideline at East Prairie River.
- All dissolved oxygen samples met the chronic and acute dissolved oxygen guidelines at the East Prairie River in 2020.
- In 2020, 1 of 10 samples (pH: 6.47) from Upper East Prairie River did not meet the guideline for the protection of aquatic life.
- Median total phosphorus concentrations (0.059 and 0.271 mg/L) in 2020 were the highest of the four years at the Upper and Middle East Prairie River sites.
- The median TSS concentrations at the Upper and Middle sites (55 and 177 mg/L) in 2020 was the highest of the four years.
- A strong correlation was observed between total phosphorus and total suspended solids ( $r=0.94$ ) in 2020.
- Median fecal coliform bacteria (FCB) counts at the East Prairie River sites were similar from 2017 to 2020 ( $<65$  cfu/100 mL). Two of 10 samples at the Middle site exceeded the irrigation guideline for fecal coliform bacteria.
- There was a trend for 'probably degrading' median total phosphorus (probably increasing concentration) at the East Prairie River (Table 16).
- Most water quality parameters had a 'stable trend' or 'no trend' at the East Prairie River (Table 16). Small sample sizes ( $n=4$  to 5) may limit the probability of detecting a trend when one is present.

#### West Prairie River

- All temperature, pH, dissolved oxygen and conductivity samples met objectives and guidelines in 2020 at West Prairie River.
- Median total phosphorus concentrations (0.093 and 0.110 mg/L) in 2020 were the highest of the four years at the West Prairie River sites.
- The median TSS (104 to 98 mg/L) at the Upper and Middle West Prairie River sites in 2020 was the highest of the four years (2017 to 2020).
- A strong correlation was observed between total phosphorus and total suspended solids ( $r=0.96$ ) in 2020.
- The median fecal coliform bacteria count was below the irrigation guideline at both West Prairie River sites. Two of 9 FCB samples at the Middle site exceeded the irrigation guideline.

- There was a trend for improving median fecal coliform bacteria (decreasing counts) at the Middle West Prairie River site (Table 16).
- There was a trend for 'degrading' median total phosphorus (increasing concentration) at the the Middle West Prairie River site (Table 16).
- Most water quality parameters had a 'stable trend' or 'no trend' at the West Prairie River (Table 16). Small sample sizes (n=4 to 5) may limit the probability of detecting a trend when one is present.

#### **South Heart River and Grouard Channel**

- All temperature, pH and conductivity samples at the South Heart River met objectives and guidelines in 2020.
  - At the Lower South Heart River, three dissolved oxygen samples (4.63 to 6.32 mg/L) did not meet PAL guidelines in 2020; however, the median dissolved oxygen concentration met the guideline.
  - The median and maximum total phosphorus concentration at the Upper and Middle South Heart River sites was the highest of the four years (2017 to 2020).
  - Total phosphorus and total suspended solids were moderately correlated at the South Heart River ( $r=0.60$ ) in 2020.
  - In 2020, the highest median (933 mg/L) and maximum (294 mg/L) TSS concentrations occurred at the Middle site whereas in previous years TSS concentrations increased in the downstream direction at the South Heart River. Median and maximum TSS at the Lower site was the lowest of the four years.
  - Median fecal coliform bacteria (FCB) counts at the South Heart River sites were similar from 2017 to 2020 ( $<100$  cfu/100 mL). Maximum fecal coliform bacteria counts increased from upstream to downstream at the South Heart River from 2017 to 2019 but this trend did not occur in 2020. One of 9 samples each at the Middle and Lower site exceeded the irrigation guideline in 2020.
  - There was a trend for 'degrading' median dissolved oxygen (decreasing concentration) and 'probably degrading' minimum nitrate-nitrite (probably increasing concentration) at the South Heart River (Table 16).
  - Most water quality parameters had a 'stable trend' or 'no trend' at the South Heart River (Table 16). Small sample sizes (n=5 to 6) may limit the probability of detecting a trend when one is present.
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- All temperature, pH and conductivity samples at the Grouard Channel met objectives and guidelines in 2020; however, the median dissolved oxygen did not meet the chronic guideline, 5 of 10 samples did not meet the acute guideline and 2 of 10 samples exceeded the chronic guideline.
  - The median total phosphorus at the Grouard Channel was the highest of the four years.
  - Total phosphorus and total suspended solids were weakly correlated at the Grouard Channel ( $r=0.47$ ) in 2020.
  - The median (10 mg/L) and maximum (79 mg/L) TSS concentrations at the Grouard Channel in 2020 was the lowest of the four years.
  - Median fecal coliform bacteria (FCB) counts at the Grouard Channel were similar from 2017 to 2020 ( $\leq 20$  cfu/100 mL). One of 9 fecal coliform bacteria samples at the Grouard Channel exceeded the irrigation guideline in 2020 and was the only exceedance from 2017 to 2020.

**Table 16.** Comparison of 2017-2020 water quality results at middle or lower sites with historic data, Lesser Slave Lake tributaries.

Indicator	Statistic	Driftpile River (lower) <sup>a</sup>					Trend	Driftpile River (middle) <sup>b</sup>					Trend
		2012-13	2017 <sup>c</sup>	2018	2019	2020		1991-92	2017	2018	2019	2020	
		N=12	N=9	N=10	N=10	N=10		N=11	N=10	N=9	N=10	N=10	
Temperature, °C	Median	13.9	15.1	15.6	12.0	12.7	–	16.2	14.3	16.0	11.95	12.9	–
	Min	1.6	3.6	4.7	3.0	3.1	NT	0.7	2.9	4.7	2.30	4.2	NT
	Max	23.1	16.7	20.4	20.8	22.9	NT	21.7	17.4	21.5	20.80	22.7	NT
Dissolved Oxygen, mg/L	Median	9.72	8.90	8.73	9.77	9.38	–	9.00	10.01	9.25	10.18	9.68	NT
	Min	7.54	8.10	6.88	7.83	7.70	–	8.00	8.80	7.50	8.19	8.11	–
	Max	15.32	11.40	11.52	11.74	12.34	NT	13.8	11.60	11.70	12.38	12.54	NT
Total Phosphorus, mg/L	Median	0.051	0.045	0.046	0.043	0.078	–	0.040	0.053	0.051	0.040	0.062	NT
	Min	0.020	0.024	0.031	0.030	0.010	–	0.022	0.020	0.030	0.027	0.010	–
	Max	0.873	0.108	1.280	0.305	0.357	–	0.129	0.118	1.290	0.217	0.345	NT
Total Dissolved Phosphorus, mg/L	Median	0.012	0.010	0.025	0.016	0.016	NT	0.016	0.010	0.025	0.010	0.017	NT
	Min	0.005	0.010	0.010	0.010	0.010	NT	0.007	0.010	0.010	0.010	0.010	NT
	Max	0.025	0.041	0.033	0.026	0.034	NT	0.021	0.028	0.035	0.029	0.031	NT
Total Nitrogen, mg/L	Median	0.546	0.450	0.520	0.545	0.645	NT	0.482	0.455	0.685	0.500	0.610	NT
	Min	0.262	0.100	0.240	0.100	0.100	–	0.281	0.100	0.220	0.100	0.100	–
	Max	7.878	1.120	1.290	1.460	1.970	NT	0.976	1.030	1.130	1.710	1.670	↑
Nitrate+Nitrite Nitrogen, mg/L	Median	0.006	0.011	0.011	0.011	0.011	NT	0.003	0.011	0.011	0.011	0.011	NT
	Min	0.003	0.011	0.011	0.011	0.011	NT	0.001	0.011	0.011	0.011	0.011	NT
	Max	0.148	0.198	0.025	0.062	0.059	–	0.026	0.027	0.031	0.049	0.059	↑
Total Suspended Solids, mg/L	Median	-	37	16	28	60	NT	14	39	18	19	47	NT
	Min	-	5	4	7	2	–	2	2	6	2	2	–
	Max	-	136	3,380	551	259	NT	128	153	3,570	315	504	NT
Fecal Coliform Bacteria, cfu/100 mL	Median	-	71	15	15	31	–	15	20	16	10	39	NT
	Min	-	3	1	1	5	NT	2	3	1	1	8	NT
	Max	-	210	1,100	90	110	NT	200	200	220	52	200	–
<sup>a</sup> Lower site data from 2017-2020 is comparable 2012-13 historic data. <sup>b</sup> Middle site data from 2017-2020 is comparable to 1991-92 historic data. <b>Trends (Mann-Kendall):</b> ↑ Degrading trend, ↗ probably degrading trend (increasing concentration with exception of dissolved oxygen where an increase in concentration represents an improving trend); ↓ Improving trend, ↘ probably improving trend (decreasing concentration with the exception of dissolved oxygen where a decrease in concentration represents a degrading trend); – Stable trend; NT No Trend													

**Table 16 cont'd.** Comparison of 2017-2020 water quality results at middle or lower sites with historic data, Lesser Slave Lake tributaries.

Indicator	Statistic	Swan River (lower) <sup>c</sup>					Trend	Swan River (middle) <sup>d</sup>					Trend
		2012-13	2017	2018	2019	2020		1991-92	2017	2018	2019	2020	
		N=11	N=9	N=9	N=9	N=8		N=11	N=9	N=10	N=10	N=10	
Temperature, °C	Median	14.5	13.6	17.5	13.5	11.6	–	15.6	12.8	14.9	11.30	11.7	–
	Min	2.5	2.7	4.9	3.7	3.6	NT	0.8	1.4	3.9	2.80	4.3	↑
	Max	22.6	17.5	20.5	19.7	22.5	–	20.0	17.4	20.6	16.90	21.3	NT
Dissolved Oxygen, mg/L	Median	9.60	8.90	8.49	9.45	9.79	NT	8.60	9.70	9.45	10.33	9.99	NT
	Min	7.80	8.51	7.08	8.13	7.97	–	8.16	8.72	7.38	8.75	8.33	NT
	Max	12.18	11.60	11.56	11.52	12.40	–	12.89	11.20	11.73	12.18	12.22	NT
Total Phosphorus, mg/L	Median	0.060	0.050	0.048	0.044	0.050	–	0.048	0.034	0.039	0.035	0.053	NT
	Min	0.031	0.029	0.034	0.027	0.025	–	0.026	0.010	0.029	0.010	0.010	–
	Max	0.084	1.060	0.170	0.172	0.227	NT	0.173	0.410	0.940	0.137	0.172	–
Total Dissolved Phosphorus, mg/L	Median	0.012	0.010	0.023	0.010	0.010	–	0.015	0.010	0.016	0.010	0.010	–
	Min	0.009	0.010	0.010	0.010	0.010	NT	0.010	0.010	0.010	0.010	0.010	–
	Max	0.023	0.028	0.035	0.028	0.025	NT	0.016	0.026	0.030	0.027	0.025	NT
Total Nitrogen, mg/L	Median	0.518	0.400	0.410	0.500	0.490	–	0.431	0.270	0.395	0.550	0.600	NT
	Min	0.201	0.100	0.100	0.400	0.100	NT	0.275	0.100	0.100	0.260	0.200	–
	Max	2.110	3.430	0.790	1.140	1.020	–	0.832	1.570	1.370	1.150	0.860	–
Nitrate+Nitrite Nitrogen, mg/L	Median	0.012	0.011	0.011	0.011	0.011	–	0.002	0.011	0.011	0.011	0.011	NT
	Min	0.003	0.011	0.003	0.011	0.011	NT	0.001	0.011	0.003	0.011	0.011	NT
	Max	0.093	0.045	0.041	0.028	0.091	–	0.032	0.044	0.040	0.067	0.084	↑
Total Suspended Solids, mg/L	Median	-	31	16	36	28	–	21	12	11	22	43	NT
	Min	-	3	7	4	2	–	4	2	5	2	2	–
	Max	-	3060	257	271	342	NT	187	1,030	2,110	196	354	NT
Fecal Coliform Bacteria, cfu/100 mL	Median	-	110	20	42	43	–	60	46	31	32	45	–
	Min	-	5	7	8	10	↑	20	5	9	1	10	–
	Max	-	870	65	64	90	NT	200	250	620	64	210	–

<sup>c</sup>Lower site data from 2017-2020 is comparable to 2012-13 historic data. <sup>d</sup>Middle site data from 2017-2020 is comparable to 1991-92 historic data.

**Trends (Mann-Kendall):** ↑ Degrading trend, ↗ probably degrading trend (increasing concentration with exception of dissolved oxygen where an increase in concentration represents an improving trend); ↓ Improving trend, ↘ probably improving trend (decreasing concentration with the exception of dissolved oxygen where a decrease in concentration represents a degrading trend); – Stable trend; NT No Trend

**Table 16 cont'd.** Comparison of 2017-2020 water quality results at middle or lower sites with historic data, Lesser Slave Lake tributaries.

Indicator	Statistic	South Heart River (lower) <sup>e</sup>							Trend	West Prairie River <sup>f</sup>					Trend	East Prairie River <sup>f</sup>					Trend
		1991-92	2012-13	2017	2018	2019	2020	2012-13		2017	2018	2019	2020	2012-13		2017	2018	2019	2020		
		N=9	N=12	N=10	N=10	N=10	N=10	N=12		N=10	N=10	N=10	N=10	N=12		N=10	N=10	N=10	N=10		
Temperature, °C	Median	16.5	12.7	15.1	15.6	13.0	14.3	—	12.8	14.3	14.6	12.1	13.1	—	13.4	17.2	16.1	12.6	13.8	—	
	Min	12.0	0.9	2.0	4.0	2.7	5.1	NT	3.3	2.2	3.7	1.8	4.1	NT	1.3	4	4.1	3.6	4.4	NT	
	Max	21.5	21.3	23.5	22.0	21.0	21.8	—	21.7	20.3	21.4	18.4	21.4	—	22.6	21.8	23.6	21.5	24.4	NT	
Dissolved Oxygen, mg/L	Median	-	8.36	8.34	7.44	8.26	6.89	↓	9.95	10.20	9.12	9.85	9.35	—	9.62	9.83	8.98	9.78	9.48	—	
	Min	-	6.05	7.34	4.05	5.31	4.63	—	8.23	8.40	7.46	8.37	8.15	—	7.94	8.20	7.20	8.08	7.67	—	
	Max	-	15.87	10.01	11.38	12.25	11.64	—	13.85	11.00	11.62	12.37	12.52	NT	16.04	11.69	11.94	12.32	12.80	NT	
Total Phosphorus, mg/L	Median	0.094	0.143	0.153	0.138	0.118	0.144	NT	0.053	0.055	0.065	0.061	0.110	↑	0.076	0.086	0.076	0.090	0.271	↗	
	Min	0.050	0.079	0.109	0.089	0.080	0.109	NT	0.028	0.030	0.024	0.023	0.025	—	0.028	0.010	0.032	0.043	0.021	NT	
	Max	0.190	0.838	0.602	0.229	0.218	0.215	—	1.150	0.362	0.333	1.050	0.504	—	1.120	0.241	0.480	0.983	0.604	—	
Total Dissolved Phosphorus, mg/L	Median	0.027	0.024	0.023	0.050	0.038	0.054	NT	0.018	0.022	0.028	0.022	0.016	—	0.013	0.010	0.024	0.016	0.010	—	
	Min	0.015	0.012	0.010	0.010	0.021	0.010	—	0.006	0.010	0.010	0.010	0.010	NT	0.004	0.010	0.010	0.010	0.010	NT	
	Max	0.058	0.064	0.162	0.088	0.052	0.149	NT	0.033	0.132	0.066	0.390	0.248	NT	0.032	0.067	0.054	0.264	0.064	NT	
Total Nitrogen, mg/L	Median	1.197	1.187	1.260	1.220	1.055	1.380	NT	0.859	0.805	0.725	0.655	1.215	—	0.565	0.485	0.555	0.565	1.105	NT	
	Min	1.052	0.724	0.910	0.980	0.700	1.210	NT	0.411	0.560	0.360	0.300	0.450	—	0.249	0.100	0.280	0.100	0.450	NT	
	Max	1.955	2.762	3.700	1.630	5.770	4.000	NT	3.786	1.930	1.550	1.920	1.560	—	2.972	1.730	1.160	3.290	2.000	—	
Nitrate+Nitrite Nitrogen, mg/L	Median	0.039	0.032	0.023	0.011	0.011	0.038	—	0.009	0.011	0.011	0.011	0.011	NT	0.009	0.011	0.011	0.011	0.011	NT	
	Min	0.002	0.003	0.011	0.011	0.011	0.011	↗	0.003	0.011	0.011	0.011	0.011	NT	0.003	0.011	0.011	0.011	0.011	NT	
	Max	0.083	0.072	0.095	0.239	0.025	0.103	NT	0.086	0.040	0.035	0.062	0.045	—	0.152	0.075	0.075	0.340	0.115	NT	
Total Suspended Solids, mg/L	Median	10	-	75	30	39	27	—	-	18	17	38	98	NT	-	83	37	85	177	NT	
	Min	5	-	26	21	12	2	—	6	2	6	4	6	NT	12	2	5	7	2	—	
	Max	132	-	818	144	450	84	—	1,170	451	440	1,280	735	—	1,150	445	576	1,410	971	NT	
Fecal Coliform Bacteria, cfu/100 mL	Median	20	-	67	17	44	30	—	-	145	98	66	64	↓	-	45	43	38	64	—	
	Min	4	-	10	2	10	10	NT	-	20	11	17	10	—	-	5	7	17	10	NT	
	Max	264	-	1400	360	580	126	—	-	330	330	810	130	—	-	200	110	210	120	—	

<sup>e</sup> Lower site data from 2017-2020 is comparable to 1991-92 and 2012-13 historic data. <sup>f</sup> Middle site data from 2017-2020 is comparable to 2012-13 historic data.

**Trends (Mann-Kendall):** ↑ Degrading trend, ↗ probably degrading trend (increasing concentration with exception of dissolved oxygen where an increase in concentration represents an improving trend); ↓ Improving trend, ↘ probably improving trend (decreasing concentration with the exception of dissolved oxygen where a decrease in concentration represents a degrading trend); — Stable trend; NT No Trend

### Metals

- The same six metals exceeded the PAL guidelines at the Upper, Middle and Lower Swan River sites in 2020: total cadmium, total copper, total lead, total mercury, dissolved aluminum and dissolved iron.
- The Upper West Prairie River site had 7 metal exceedances, the Middle East Prairie River site had 7 exceedances and the Middle Driftpile River site had 8 metal exceedances.
- Six metal exceedances were common to the Driftpile, East Prairie and West Prairie rivers: total cadmium, total copper, total lead, total mercury, total zinc and dissolved iron. Additional exceedances included dissolved aluminum at the Upper West Prairie River, total arsenic at Middle East Prairie River and total arsenic and dissolved aluminum at the Middle Driftpile River.
- There were fewer metal exceedances at the Swan River in 2020 compared to the Driftpile, East Prairie and West Prairie rivers, the difference being the absence of zinc and arsenic. The observation of fewer exceedances at the Swan River compared to other tributaries was a similar finding to the 2008-10 metals study (Hutchinson et al. 2015).
- From 2017 to 2020, the metals most often exceeding guidelines at all sites were total cadmium, total copper, total lead and total mercury, dissolved aluminum, and dissolved iron.

## 6.0 RECOMMENDATIONS

### Monitoring Program

- A series of wet, dry and average precipitation years are needed to adequately characterize water quality trends for tributaries in the Lesser Slave watershed. The same water monitoring program completed from 2017 to 2020 should be undertaken in 2021.
- Poor road access to the Lower Swan River from 2018 to 2020 has resulted in at least one missed sample. Missed samples typically occur from Mid-April to early-July when flows are high and water quality generally poorest (i.e., high concentrations of total phosphorus, TSS and total metals). Missed samples may lead to an under-estimation of water quality parameters, and limit trend detection between sites on the same river, and between the main tributaries to Lesser Slave Lake. The LSWC may want to consider a short-term rental of a UTV or ATV during the early part of the sampling season that would allow access on any road that is in poor condition for truck access.
- The East Prairie River has shown exceedances of the temperature objective ( $<22^{\circ}\text{C}$ ) in 2018 and 2020. A 'spot' measurement of water temperature provides limited data due to infrequent samples and the daily fluctuations that temperatures undergo. The LSWC may want to consider installing temperature data loggers (e.g. Hobo®) at each of the East Prairie River sites to determine seasonal temperature trends. The temperature data could be compared to the general water temperature objective for Lesser Slave Lake tributaries ( $<22^{\circ}\text{C}$ ) and as well to temperature preferences for fish species inhabiting East Prairie River.

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## APPENDIX A. WATER MONITORING SAMPLE LOCATIONS, 2017-2020.

Location	Northing	Easting
Upper Swan River	54°59'33.05"N	115°17'59.99"W
Middle Swan River	55°14'38.66"N	115°21'37.15"W
Lower Swan River	55°22'49.72"N	115°19'59.54"W
Upper Driftpile River	55°17'53.64"N	115°51'7.59"W
Middle Driftpile River	55°20'45.84"N	115°47'45.08"W
Lower Driftpile River	55°22'3.04"N	115°41'40.59"W
Upper East Prairie River	55° 6'51.26"N	116° 5'14.94"W
Middle East Prairie River	55°25'4.98"N	116°20'22.00"W
Lower East Prairie River	55°32'29.50"N	116°15'6.29"W
Upper West Prairie River	55°12'29.69"N	116°26'7.68"W
Middle West Prairie River	55°26'55.62"N	116°29'36.91"W
Upper South Heart River	55°40'57.20"N	116°35'44.34"W
Middle South Heart River	55°30'31.71"N	116°31'34.40"W
Lower South Heart River	55°34'47.24"N	116°17'41.27"W
Grouard Channel	55°30'48.13"N	116° 9'54.21"W

## APPENDIX B. WATER QUALITY DATA, 2020.

**B-1. Routine Water Quality Data** (Cells shaded green show corrected data entries; cells shaded yellow were analysed passed the recommended laboratory hold time; blue values are half the detection limit when reported values were less than the detection limit). Cells shaded green are derived values (Appendix C-1), and cells shaded yellow were analysed after the recommended hold time.

Site	Date	Time	pH	TDS	Cond µS/cm	DO mg/L	DO %	Temp °C	TP mg/L	TDP mg/L	NO3-N mg/L	NO3- N+NO2-N mg/L	NO2-N mg/L	TKN mg/L	TSS mg/L	TN mg/L	FC cfu/100 mL
Upper West Prairie River	05-May-20	09:00:00	7.16		67.1	11.74	95.5	3.8	0.293	0.01	0.033	0.033	0.005	1.03	395	1.06	40
Mid West Prairie River	05-May-20	09:35:00	7.38		90.7	11.26	95.1	5.3	0.504	0.01	0.045	0.045	0.005	1.42	735	1.46	10
Mid South Heart River	05-May-20	10:20:00	7.46		451	10.14	91.9	8.5	0.386	0.01	0.079	0.079	0.005	1.79	145	1.87	20
Upper South Heart River	05-May-20	10:50:00	6.93		424	9.86	87.9	7.3	0.317	0.01	0.01	0.01	0.005	1.23	11	1.23	50
Lower South Heart River	05-May-20	11:30:00	6.88		149.8	7.97	75.5	10.3	0.171	0.01	0.053	0.053	0.005	1.15	83.6	1.21	10
Grouard Channel	05-May-20	12:00:00	6.53		169.9	5.73	55.7	11.5	0.152	0.01	0.041	0.041	0.005	0.73	48.8	0.73	10
Upper East Prairie River	05-May-20	13:00:00	6.47		91.3	12.37	100.6	3.9	0.201	0.01	0.102	0.102	0.005	0.66	293	0.76	5
Mid East Prairie River	05-May-20	13:40:00	6.89		98.9	10.71	96	8	10:39	0.01	0.115	0.115	0.005	1.27	632	1.38	10
Upper Swan River	06-May-20	09:40:00	7.46		80	12.41	100.2	3.6	0.23	0.01	0.034	0.034	0.005	0.51	305	0.54	20
Mid Swan River	06-May-20	10:20:00	6.65		74.7	11.79	99.4	5.4	0.172	0.01	0.084	0.084	0.005	0.59	354	0.67	10
Lower Swan River	06-May-20	11:00:00	7.96		75.9	11.78	95	7.4	0.217	0.01	0.091	0.091	0.005	0.93	342	1.02	20
Lower Driftpile River	06-May-20	12:10:00	7.04		84	10.79	95.2	7.3	0.216	0.01	0.056	0.056	0.005	0.77	259	0.83	20
Mid Driftpile River	06-May-20	12:35:00	6.96		82.5	11.4	99.1	6.4	0.148	0.01	0.059	0.059	0.005	0.57	201	0.63	10
Upper Driftpile River	06-May-20	13:10:00	7.19		78	11.34	100.9	7	0.115	0.01	0.052	0.052	0.005	0.61	147	0.66	5
Upper West Prairie River	19-May-20	8:45	7.95		133.9	10.53	95.3	7.4	0.177	0.01	0.028	0.028	0.005	0.5	207	0.52	100
Mid West Prairie River	19-May-20	9:20	7.95		202	10.5	96.8	9.2	0.086	0.01	0.01	0.01	0.005	0.45	76.6	0.45	30
Mid South Heart River	19-May-20	9:40	8.11		373	9.73	91.9	10.1	0.22	0.01	0.01	0.01	0.005	2.13	90.6	2.13	80
Badger Creek Mid South Heart - Field Duplicate									0.223	0.01	0.01	0.01	0.005	1.2	87.3	1.2	40
Upper South Heart River	19-May-20	10:20	7.91		299	10.73	102.4	10.2	0.15	0.01	0.01	0.01	0.005	1.93	7.5	1.93	50
Lower South Heart River	19-May-20	10:45	7.87		290	7.96	75	10	0.121	0.01	0.01	0.01	0.005	1.37	19.6	1.37	10
Grouard Channel	19-May-20	11:20	7.96		275	8.34	79.4	10.2	0.099	0.01	0.01	0.01	0.005	1.49	11.9	1.49	20
Upper East Prairie River	19-May-20	13:20	7.97		99.3	11.85	99	4.7	0.54	0.01	0.091	0.091	0.005	0.53	923	0.62	40
Mid East Prairie River	19-May-20	12:20	8.01		178.4	10.19	96.1	9.9	0.397	0.01	0.03	0.03	0.005	1.67	382	1.7	20
Upper Swan River	20-May-20	9:35	8.37		94.5	11.29	102.2	6	0.118	0.01	0.01	0.01	0.005	0.31	114	0.31	20
Mid Swan River	20-May-20	10:10	7.61		91.7	10.95	99.5	8.1	0.126	0.01	0.044	0.044	0.005	0.26	199	0.3	40

## Lesser Slave Watershed 2020 Water Monitoring Report

Site	Date	Time	pH	TDS	Cond µS/cm	DO mg/L	DO %	Temp °C	TP mg/L	TDP mg/L	NO3-N mg/L	NO3- N+NO2-N mg/L	NO2-N mg/L	TKN mg/L	TSS mg/L	TN mg/L	FC cfu/100 mL
Lower Swan River	20-May-20	10:50	7.86		95.5	10.27	96.9	9.8	0.227	0.01	0.061	0.061	0.005	0.24	310	0.3	30
Lower Driftpile River	20-May-20	11:45	7.62		96.6	10.6	96.6	8.8	0.25	0.01	0.059	0.059	0.005	0.5	165	0.56	20
Mid Driftpile River	20-May-20	12:10	7.57		87.5	11.1	100.1	7.7	0.19	0.01	0.053	0.053	0.005	0.42	278	0.47	20
Upper Driftpile River	20-May-20	15:00	7.59		81.8	10.79	102.4	10.8	0.117	0.01	0.044	0.044	0.005	0.38	172	0.42	10
Upper West Prairie River	02-Jun-20	9:00	7.38		118.3	9.12	92.6	12.5	0.082	0.039	0.01	0.011	0.005	0.59	101	0.59	84
Mid West Prairie River	02-Jun-20	9:40	7.82		150.5	9.2	95.1	13.7	0.118	0.034	0.01	0.011	0.005	1.08	119	1.08	47
Mid South Heart River	02-Jun-20	10:10	8.05		253	8.64	91.3	14.4	0.1947	0.061	0.028	0.028	0.005	1.36	96.4	1.39	38
Upper South Heart River	02-Jun-20	10:35	7.79		209.4	9.71	104.1	15	0.119	0.068	0.01	0.011	0.005	1.13	8	1.13	17
Lower South Heart River	02-Jun-20	11:15	7.45		190.2	6.81	72	14.5	0.134	0.06	0.01	0.011	0.005	1.32	25.8	1.32	22
Grouard Channel	02-Jun-20	12:25	7.68		199	4.45	48.3	15.8	0.131	0.055	0.024	0.024	0.005	1.4	14.2	1.42	2
Upper East Prairie River	02-Jun-20	13:20	7.73		150.7	9.55	98.7	12.8	0.063	0.01	0.01	0.011	0.005	0.71	64.6	0.71	38
Mid East Prairie River	02-Jun-20	14:15	7.28		135.6	9.48	97.3	15.2	0.386	0.026	0.01	0.011	0.005	0.78	193	0.78	28
Upper Swan River	03-Jun-20	9:50	7.97	104	104.3	10.32	99.7	9.3	0.087	0.01	0.01	0.011	0.005	0.43	143	0.43	44
Mid Swan River	03-Jun-20	10:50	8.02	109	102.9	9.9	98.2	11.7	0.058	0.021	0.01	0.011	0.005	0.43	54.5	0.43	78
Lower Swan River	03-Jun-20	12:00	7.72	117	110.5	9.3	95.6	13.3	0.065	0.022	0.01	0.011	0.005	0.52	46.9	0.52	56
Lower Driftpile River	03-Jun-20	13:15	7.85		115.8	9.14	94.3	13.4	0.074	0.024	0.01	0.011	0.005	0.61	57.5	0.61	64
Mid Driftpile River	03-Jun-20	13:40	7.66	109	115.9	9.44	97.8	13.8	0.061	0.025	0.01	0.011	0.005	0.59	55.4	0.59	42
Upper Driftpile River	03-Jun-20	14:15	7.84		108.3	9.62	99.6	13.7	0.051	0.023	0.01	0.011	0.005	0.51	31.8	0.51	38
Upper West Prairie River	16-Jun-20	9:00	7.75		96.6	9.73	95.8	10.6	0.193	0.01	0.01	0.011	0.005	0.9	279	0.9	100
Mid West Prairie River	16-Jun-20	9:40	7.36		129.2	9.5	95.9	12.4	0.457	0.022	0.01	0.011	0.005	1.46	565	1.46	130
Mid South Heart River	16-Jun-20	10:05	7.48		316	7.34	77.8	14.7	0.378	0.046	0.065	0.065	0.005	1.47	294	1.54	160
Badger Creek - Field duplicate of Mid South Heart									0.369	0.054	0.068	0.068	0.005	1.59	304	1.66	160
Upper South Heart River	16-Jun-20	10:50	8.13		271	9.47	102.5	15.5	0.103	0.095	0.031	0.031	0.005	0.95	3.9	0.98	10
Lower South Heart River	16-Jun-20	11:30	7.59		245	6.58	69.8	14.1	0.138	0.049	0.078	0.078	0.005	1.16	31.6	1.23	60
Grouard Channel	16-Jun-20	13:00	7.81		316	6.91	73.4	14.9	0.226	0.087	0.037	0.037	0.005	1.25	79.4	1.29	140
Upper East Prairie River	16-Jun-20	13:45	7.41		120.1	9.76	95.5	11	0.192	0.01	0.01	0.011	0.005	0.9	352	0.9	90
Mid East Prairie River	16-Jun-20	14:20	7.67		123.4	9.48	95.3	12.4	0.604	0.01	0.01	0.011	0.005	1.66	971	1.66	120
Upper Swan River	17-Jun-20	9:50	7.65		115.8	10.32	100	10.6	0.055	0.01	0.01	0.011	0.005	1.66	47.1	1.66	21
Mid Swan River	17-Jun-20	10:35	7.75		110.3	10.08	99.5	11.7	0.057	0.01	0.01	0.011	0.005	0.55	36.4	0.55	50
Lower Swan River Not accessible	17-Jun-20										0.01	0.011	0.005				

# Lesser Slave Watershed 2020 Water Monitoring Report

Site	Date	Time	pH	TDS	Cond µS/cm	DO mg/L	DO %	Temp °C	TP mg/L	TDP mg/L	NO3-N mg/L	NO3- N+NO2-N mg/L	NO2-N mg/L	TKN mg/L	TSS mg/L	TN mg/L	FC cfu/100 mL
Lower Driftpile River	17-Jun-20	12:35	7.89		109.6	9.62	95.4	12	0.142	0.01	0.01	0.011	0.005	1.97	183	1.97	50
Mid Driftpile River	17-Jun-20	13:10	7.58		112.2	9.92	97.8	11.9	0.116	0.01	0.01	0.011	0.005	0.83	39.3	0.83	41
Upper Driftpile River	17-Jun-20	13:30	7.69		107.9	10.1	99.1	11.4	0.083	0.01	0.01	0.011	0.005	1.48	47.9	1.48	32
Upper West Prairie River	30-Jun-20	8:50	7.48	152	105.4	9.12	96.2	14	0.292	0.103	0.01	0.011	0.005	1.89	438	1.89	NA
Mid West Prairie River	30-Jun-20	9:30	7.93		248	8.5	94	16.8	0.362	0.248	0.01	0.011	0.005	1.56	302	1.56	NA
Mid South Heart River	30-Jun-20	9:50	7.83		326	7.16	81.4	18	0.264	0.202	0.07	0.082	0.013	2.09	94.9	2.17	NA
Upper South Heart River	30-Jun-20	10:30	7.69		252	8.6	99.2	18.6	0.201	0.162	0.037	0.037	0.005	1.94	1.5	1.98	NA
Lower South Heart River	30-Jun-20	11:10	7.86		323	5.65	64.9	18.5	0.17	0.137	0.072	0.072	0.005	1.44	1.51	4	NA
Grouard Channel	30-Jun-20	11:40	7.62		319	4.03	46.4	18.6	0.143	0.139	0.037	0.037	0.005	1.52	5.1	1.56	NA
Upper East Prairie River	30-Jun-20	12:50	7.63		131	9.46	99.7	14	0.113	0.052	0.01	0.011	0.005	0.3	132	0.3	NA
Mid East Prairie River	30-Jun-20	13:40	7.61	236	192.6	8.51	93.1	16.2	0.546	0.064	0.022	0.022	0.005	1.97	630	2	NA
Upper Swan River	29-Jun-20	9:45	7.8	128	153.1	9.5	99.9	12.1	0.085	0.012	0.01	0.011	0.005	0.66	117	0.66	44
Mid Swan River	29-Jun-20	10:25	7.75	129	157.4	9.62	99	13.5	0.094	0.025	0.01	0.011	0.005	0.86	111	0.86	210
Badger Creek (used Lower Swan bottles, report says L. Swan) – Field D Mid Drift				170					0.409	0.033	0.01	0.011	0.005	1.8	597	1.8	190
Lower Driftpile River	29-Jun-20	12:10	7.83		187.3	8.64	93.2	15.4	0.357	0.034	0.01	0.011	0.005	1.5	155	1.5	110
Mid Driftpile River	29-Jun-20	12:35	7.68	179	127.9	9.34	97.4	13.8	0.345	0.031	0.01	0.011	0.005	1.67	504	1.67	200
Upper Driftpile River	29-Jun-20	13:05	7.64		109	9.6	99.7	13.9	0.294	0.034	0.01	0.011	0.005	1.27	154	1.27	120
Upper West Prairie River	14-Jul-20	9:05	7.24		133.1	8.95	94.6	14.4	0.103	0.024	0.01	0.011	0.005	0.95	106	0.95	46
Mid West Prairie River	14-Jul-20	9:40	7.5		167	8.93	96.4	16.5	0.237	0.054	0.01	0.011	0.005	1.35	171	1.35	86
Mid South Heart River	14-Jul-20	10:05	7.43		331	6.92	78	17.6	0.319	0.172	0.112	0.125	0.013	1.5	70.4	1.62	15
Upper South Heart River	14-Jul-20	11:00	7.79		251	8.95	102.3	18	0.245	0.216	0.068	0.068	0.005	1.44	4	1.51	1
Lower South Heart River	14-Jul-20	11:45	8.53		275	6.32	70.5	17.1	0.215	0.121	0.089	0.089	0.005	1.38	27.9	1.47	15
Grouard Channel	14-Jul-20	12:25	7.85		305	4.07	45.8	17.5	0.202	0.136	0.01	0.011	0.005	1.35	14.7	1.35	3
Badger Crk - field D Grouard									0.204	0.137	0.01	0.011	0.005	1.35	3.7	1.35	2
Upper East Prairie River	14-Jul-20	13:30	7.94		198.7	9.21	100.9	15.9	0.054	0.01	0.01	0.011	0.005	0.67	46	0.67	12
Mid East Prairie River	14-Jul-20	14:25	7.94		173.1	8.79	99.6	17.5	0.156	0.028	0.01	0.011	0.005	1.32	160	1.32	64
Upper Swan River	15-Jul-20	9:50	8.18		147.9	9.6	101.7	14.1	0.026	0.01	0.01	0.011	0.005	0.72	14	0.72	10
Mid Swan River	15-Jul-20	10:40	7.85		135.8	9.33	101.1	15.8	0.038	0.01	0.01	0.011	0.005	0.65	20.7	0.65	40
Lower Swan River	15-Jul-20	11:20	7.84		146.9	8.74	97.2	17.1	0.054	0.022	0.01	0.011	0.005	0.66	36.8	0.66	90
Lower Driftpile River	15-Jul-20	13:10	7.92		157.5	8.51	96.2	17.4	0.057	0.026	0.01	0.011	0.005	0.68	36.7	0.68	5

## Lesser Slave Watershed 2020 Water Monitoring Report

Site	Date	Time	pH	TDS	Cond µS/cm	DO mg/L	DO %	Temp °C	TP mg/L	TDP mg/L	NO3-N mg/L	NO3- N+NO2-N mg/L	NO2-N mg/L	TKN mg/L	TSS mg/L	TN mg/L	FC cfu/100 mL
Mid Driftpile River	15-Jul-20	13:40	7.79		152.9	9.04	100.9	17.1	0.051	0.028	0.01	0.011	0.005	0.57	31.2	0.57	100
Upper Driftpile River	15-Jul-20	0:00	8.04		142.9	9.19	102.7	17	0.043	0.025	0.01	0.011	0.005	0.58	17.9	0.58	5
Upper West Prairie River	28-Jul-20	9:20	7.84	162	166.8	7.87	95.1	18.2	0.056	0.029	0.01	0.011	0.005	0.99	24.7	0.99	60
Mid West Prairie River	28-Jul-20	10:00	7.93		246	8.15	99.4	21.4	0.102	0.067	0.01	0.011	0.005	1.07	19.8	1.07	130
Mid South Heart River	28-Jul-20	10:25	7.91		278	7.39	88.7	20.4	0.315	0.169	0.168	0.196	0.029	0.84	103	1.04	16
Upper South Heart River	28-Jul-20	11:00	7.76		198.6	8.38	103.2	21.6	0.233	0.203	0.104	0.104	0.005	1.65	1.5	1.76	0.5
Lower South Heart River	28-Jul-20	11:40	7.81		279	4.63	51.7	21.8	0.215	0.149	0.103	0.103	0.005	2.15	10.9	2.26	30
Grouard Channel	28-Jul-20	13:00	7.71		254	1.86	22.8	21.7	0.245	0.181	0.01	0.011	0.005	1.44	4.2	1.44	3
Upper East Prairie River	28-Jul-20	14:00	7.95		203.2	8.05	102.8	23.2	0.027	0.01	0.01	0.011	0.005	0.51	14.1	0.51	15
Mid East Prairie River	28-Jul-20	15:00	7.84	143	196.9	7.67	99.8	24.4	0.09	0.031	0.01	0.011	0.005	0.89	53.1	0.89	120
Upper Swan River	30-Jul-20	10:15	7.78	124	140.5	8.79	102.4	18.1	0.048	0.01	0.01	0.011	0.005	0.57	72.5	0.57	160
Mid Swan River	30-Jul-20	12:50	7.82	122	135	8.33	101.4	21.3	0.049	0.01	0.01	0.011	0.005	0.81	49.4	0.81	150
Lower Swan River	30-Jul-20	13:35	7.8	150	158	7.97	98.5	22.5	0.045	0.01	0.01	0.011	0.005	0.46	19.7	0.46	65
Lower Driftpile River	30-Jul-20	14:15	7.78		154.9	7.7	95.6	22.9	0.082	0.021	0.01	0.011	0.005	0.58	62.6	0.58	110
Mid Driftpile River	30-Jul-20	14:45	7.91	170	136	8.11	100.9	22.7	0.063	0.023	0.01	0.011	0.005	0.66	86.4	0.66	90
Upper Driftpile River (no sample)	30-Jul-20																
Upper West Prairie River	18-Aug-20	9:05	8.05	228	300	8.78	96.6	17.2	0.072	0.046	0.038	0.038	0.005	1.27	6.4	1.31	57
Mid West Prairie River	18-Aug-20	9:45	8.11		394	8.66	100	19	0.044	0.01	0.01	0.011	0.005	1.37	8.1	1.37	66
Mid South Heart River	18-Aug-20	10:10	8.13		345	7.89	88.9	17.8	0.214	0.117	0.146	0.157	0.011	1.74	42.4	1.9	12
Upper South Heart River	18-Aug-20	10:45	8		208.7	9.84	102.7	17.5	0.223	0.172	0.084	0.084	0.005	1.69	1.5	1.77	0.5
Lower South Heart River	18-Aug-20	11:25	8.11		327	6.97	82	19.9	0.133	0.059	0.022	0.022	0.005	1.35	22.2	1.37	68
Grouard Channel	18-Aug-20	11:50	8.02		289	5.72	67.5	20	0.091	0.056	0.01	0.011	0.005	0.7	1.5	0.7	10
Upper East Prairie River	18-Aug-20	13:05	8.24		314	8.77	107.2	21.4	0.01	0.01	0.01	0.011	0.005	0.33	1.5	0.33	3
Mid East Prairie River	18-Aug-20	13:45	8.29	206	352	8.59	108.4	23.3	0.043	0.01	0.01	0.011	0.005	0.53	12	0.53	51
Upper Swan River	19-Aug-20	9:50	8.04	101	206.6	9.24	106.8	18.3	0.01	0.01	0.01	0.011	0.005	0.7	1.5	0.7	91
Mid Swan River	19-Aug-20	10:25	8.05	119	226	8.43	99.3	19.6	0.024	0.01	0.01	0.011	0.005	0.65	1.5	0.65	190
Lower Swan River	19-Aug-20	11:10	7.95	148	268	8.52	98	18.9	0.04	0.01	0.01	0.011	0.005	0.61	6.1	0.61	73
Lower Driftpile River	19-Aug-20	12:45	7.95		312	7.84	90.5	18.9	0.043	0.01	0.01	0.011	0.005	0.88	7.3	0.88	20
Mid Driftpile River	19-Aug-20	13:10	8.07	169	279	8.84	104.7	20.2	0.044	0.01	0.01	0.011	0.005	0.69	8.7	0.69	37
Upper Driftpile River	19-Aug-20	13:35	8.05		249	9.42	113.5	21	0.033	0.01	0.01	0.011	0.005	0.61	4.9	0.61	9



## Lesser Slave Watershed 2020 Water Monitoring Report

Site	Date	Time	pH	TDS	Cond µS/cm	DO mg/L	DO %	Temp °C	TP mg/L	TDP mg/L	NO3-N mg/L	NO3- N+NO2-N mg/L	NO2-N mg/L	TKN mg/L	TSS mg/L	TN mg/L	FC cfu/100 mL
Upper West Prairie River	15-Sep-20	8:50	8.08	256	407	10.36	95.4	8.6	0.032	0.01	0.01	0.011	0.005	0.58	3.8	0.58	90
Mid West Prairie River	15-Sep-20	9:40	8.04		331	10.65	97.3	9	0.027	0.01	0.01	0.011	0.005	0.45	10.4	0.45	64
Mid South Heart River	15-Sep-20	10:00	7.87		237	10.08	93.1	9.4	0.204	0.099	0.041	0.041	0.005	1.22	15.6	1.26	20
Upper South Heart River	15-Sep-20	10:40	7.85		220	10.04	98.9	11.8	0.235	0.164	0.089	0.089	0.005	1.36	5.8	1.45	6
Lower South Heart River	15-Sep-20	11:15	8.15		347	10.84	97.6	8.5	0.149	0.022	0.01	0.011	0.005	1.39	47	1.39	126
Grouard Channel	15-Sep-20	11:45	7.9		337	4.55	43.8	10.4	0.084	0.034	0.01	0.011	0.005	1.09	3	1.09	12
Upper East Prairie River	15-Sep-20	13:10	8.18		344	11.32	105.8	9.7	0.01	0.01	0.01	0.011	0.005	0.3	4	0.3	5
Mid East Prairie River	15-Sep-20	14:45	8.19	274	407	11.35	106.6	9.9	0.021	0.01	0.01	0.011	0.005	0.56	1.5	0.56	88
Upper Swan River	16-Sep-20	9:50	8.04	147	232	11.81	103.1	6.2	0.01	0.01	0.01	0.011	0.005	0.1	1.5	0.1	10
Mid Swan River	16-Sep-20	11:25	8.08	132	247	11.09	101.3	8.7	0.01	0.01	0.01	0.011	0.005	0.4	1.5	0.4	34
Lower Swan River	16-Sep-20	12:15	8.01	187	311	10.75	99.7	9.2	0.031	0.01	0.01	0.011	0.005	0.1	1.5	0.1	10
Lower Driftpile River	16-Sep-20	13:30	8.1			10.3	93.7	8.6	0.01	0.03	0.01	0.011	0.005	0.47	1.5	0.47	6
Mid Driftpile River	16-Sep-20	14:00	8.14	210	318	10.39	104.6	10.8	0.01	0.024	0.01	0.011	0.005	0.1	1.5	0.1	8
Upper Driftpile River	16-Sep-20	14:20	8.16			11.97	117.1	11.5	0.027	0.01	0.01	0.011	0.005	0.1	6.4	0.1	10
Upper West Prairie River	13-Oct-20	9:10	8.08	239	391	12.13	96.4	2.2	0.026	0.01	0.01	0.011	0.005	0.88	3.4	0.88	26
Mid West Prairie River	13-Oct-20	9:40	8.11		509	12.52	102.7	4.1	0.025	0.01	0.01	0.011	0.005	0.77	6	0.77	30
Mid South Heart River	13-Oct-20	10:00	7.96		242	11.99	98.7	4.3	0.189	0.101	0.092	0.092	0.005	1.6	10.8	1.7	22
Upper South Heart River	13-Oct-20	10:30	7.9		207	11.36	101.5	7.3	0.223	0.129	0.138	0.138	0.005	1.45	4.2	1.58	6
Lower South Heart River	13-Oct-20	11:05	8.21		313	11.64	98	5.1	0.109	0.025	0.01	0.011	0.005	1.65	42.6	1.65	72
Badger Creek - duplicate of Lower South Heart			8.21		315				0.122	0.033	0.01	0.011	0.005	1.35	39.8	1.35	68
Grouard Channel	13-Oct-20	11:30	8.1		302	10.44	87	4.8	0.071	0.034	0.01	0.011	0.005	1.24	7.2	1.24	18
Upper East Prairie River	13-Oct-20	12:35	8.17		300	12.55	104.7	4.4	0.01	0.01	0.01	0.011	0.005	0.54	5	0.54	5
Mid East Prairie River	13-Oct-20	13:10	8.23		354	12.8	106	4.4	0.024	0.01	0.01	0.011	0.005	0.45	5	0.45	68
Upper Swan River	14-Oct-20	10:10	8.1	157	212	12.59	103.5	2.2	0.01	0.01	0.01	0.011	0.005	0.1	1.5	0.1	3
Badger creek - field duplicate of Upper Swan			8.06	141	219				0.027	0.01	0.01	0.011	0.005	0.1	1.5	0.1	3
Mid Swan River	14-Oct-20	10:50	7.96	125	206	12.22	100	4.3	0.01	0.01	0.01	0.011	0.005	0.2	1.5	0.2	34
Lower Swan River	14-Oct-20	11:30	7.89	159	243	12.4	99.4	3.6	0.025	0.025	0.01	0.011	0.005	0.1	3	0.1	10
Lower Driftpile River	14-Oct-20	13:00	7.96		297	12.34	97.5	3.1	0.027	0.01	0.01	0.011	0.005	0.1	3.6	0.1	42
Mid Driftpile River	14-Oct-20	13:20	8.08	190	270	12.54	102.3	4.2	0.024	0.01	0.01	0.011	0.005	0.1	1.5	0.1	8
Upper Driftpile River	14-Oct-20	13:45	8.03		247	12.9	106.7	4.7	0.022	0.01	0.01	0.011	0.005	0.22	1.5	0.22	0.5

**Appendix B-2: Total Metals Data at Swan River Sites, May-October 2020.**

Site	Date	Time	TOTAL METALS										
			Mercury (µg/L)	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Calcium (mg/L)	Hexavalent Chromium (µg/L)	Chromium (µg/L)	Copper (µg/L)
Upper Swan River	06-May-20	9:40	0.0189	4720	0.24	3.91	138	5	0.129	12.8	0.25	6.45	12.4
Middle Swan River	06-May-20	10:30	0.0218	3750	0.23	3.07	118	5	0.121	10.7	0.25	5.48	10.2
Lower Swan River	06-May-20	11:05	0.0101	4420	0.26	3.77	133	5	0.147	11	0.25	6.35	12.1
Upper Swan River	03-Jun-20	9:50	0.0025	1280	0.27	1.78	73.9	5	0.0546	14.6	0.25	2.02	5.42
Middle Swan River	03-Jun-20	10:50	0.0082	740	0.22	1.32	61.2	11	0.0315	13.1	0.25	1.35	4.32
Lower Swan River	03-Jun-20	12:00	0.0025	708	0.23	1.37	65.3	11	0.0307	15.8	0.25	1.19	4.12
Upper Swan River	29-Jun-20	9:45	0.0088	1180	0.23	1.98	82.4	11	0.0549	17.1	0.25	2.31	5.17
Middle Swan River	29-Jun-20	10:25	0.0073	1190	0.25	2.13	90.1	15	0.0731	16.9	0.25	2.61	5.99
Upper Swan River	30-Jul-20	10:15	0.0025	878	0.23	1.99	80.3	5	0.0422	19.4	0.25	1.41	4.76
Middle Swan River	30-Jul-20	12:50	0.0078	716	0.21	2.07	77.2	13	0.0457	18	0.25	1.24	4.61
Lower Swan River	30-Jul-20	13:35	0.0025	270	0.21	1.8	76.9	13	0.0445	20.6	0.8	0.63	3.48
Upper Swan River	19-Aug-20	9:50	0.0025	41.7	0.05	1.38	79	36	0.0135	26.8	0.25	0.19	1.62
Middle Swan River	19-Aug-20	10:25	0.0025	28.5	0.13	1.63	87.9	47	0.0168	28.8	0.25	0.29	1.67
Lower Swan River	19-Aug-20	11:10	0.0025	44.8	0.12	1.84	116	34	0.0266	31.2	0.25	0.21	1.68
Upper Swan River	16-Sep-20	9:50	0.0025	23.4	0.11	1.21	70.6	5	0.0107	28.8	0.25	0.13	0.89
Middle Swan River	16-Sep-20	11:25	0.0025	20.2	0.11	1.28	79.5	15	0.0168	30.9	0.25	0.17	0.88
Lower Swan River	16-Sep-20	12:15	0.0025	27.5	0.12	1.42	111	14	0.0256	39.9	0.25	0.19	1.95
Upper Swan River	14-Oct-20	10:10	0.0025	26.3	0.12	1.09	75.6	5	0.0069	28.9	0.25	0.1	0.87
Replicate Sample: Upper Swan R.			0.0025	25.6	0.11	1.06	72.3	5	0.0074	29.7	0.25	0.05	0.75
Middle Swan River	14-Oct-20	10:50	0.0025	54.8	0.05	1.06	74.5	18	0.0119	27.2	0.25	0.14	0.93
Lower Swan River	14-Oct-20	11:30	0.0025	28.7	0.05	1.19	94.9	17	0.0214	34.7	0.25	0.13	0.96

**Notes:**

0.0183	Red fill indicates exceedance of chronic and acute Protection of Aquatic Life guidelines
	Red shading indicates exceedance of acute Protection of Aquatic Life guidelines
0.019	Red font indicates exceedance of chronic Protection of Aquatic Life guidelines
Total cadmium, total copper, total lead, total nickel, dissolved zinc and dissolved manganese PAL guidelines vary with hardness (see GoA 2018, CCME 2018 and CCME 2019 to determine appropriate PAL guidelines)	
Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L CaCO <sub>3</sub>	

**Appendix B-2: Total Metals Data at Swan River Sites, May-October 2020.**

Site	Date	Time	TOTAL METALS										
			Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Potassium (µg/L)	Selenium (µg/L)	Silver (µg/L)	Sodium (mg/L)	Uranium (µg/L)	Zinc (µg/L)
Upper Swan River	06-May-20	9:40	7280	5.11	3330	224	12.4	2150	0.203	0.053	3.96	0.833	28.7
Middle Swan River	06-May-20	10:30	6070	4.05	2860	178	11.4	2100	0.205	0.044	3.99	0.712	23.4
Lower Swan River	06-May-20	11:05	7590	4.60	3120	210	14.1	2330	0.18	0.05	4	0.802	28.5
Upper Swan River	03-Jun-20	9:50	2570	1.70	3010	91	5.82	1420	0.173	0.029	6.72	0.442	10.2
Middle Swan River	03-Jun-20	10:50	1880	0.862	2690	81.2	5.35	1500	0.198	0.016	6.34	0.312	6.2
Lower Swan River	03-Jun-20	12:00	1770	0.77	3320	65.4	5.79	1620	0.179	0.013	6.29	0.418	5.3
Upper Swan River	29-Jun-20	9:45	2530	1.60	3570	106	6.11	1450	0.12	0.015	7.15	0.436	9.6
Middle Swan River	29-Jun-20	10:25	3150	1.64	3740	136	7.86	1900	0.129	0.019	8.13	0.475	1.1
Upper Swan River	30-Jul-20	10:15	2110	1.23	3560	102	4.69	1390	0.151	0.015	6.96	0.418	8.8
Middle Swan River	30-Jul-20	12:50	2460	0.942	3580	130	5.82	1750	0.161	0.018	7.13	0.371	6.4
Lower Swan River	30-Jul-20	13:35	1990	0.515	4050	81.8	4.67	1650	0.146	0.014	7.55	0.387	6.3
Upper Swan River	19-Aug-20	9:50	1150	0.054	4870	50.1	3.09	1650	0.098	0.005	12	0.367	3.6
Middle Swan River	19-Aug-20	10:25	2030	0.228	5760	76.3	3.97	2020	0.099	0.005	12.4	0.441	1.5
Lower Swan River	19-Aug-20	11:10	2610	0.187	7430	168	4.11	2260	0.11	0.005	11.3	0.789	1.5
Upper Swan River	16-Sep-20	9:50	1410	0.072	4830	67.1	2.88	1540	0.085	0.005	12	0.35	1.5
Middle Swan River	16-Sep-20	11:25	2150	0.118	6020	84.6	3.47	1960	0.084	0.005	12	0.36	1.5
Lower Swan River	16-Sep-20	12:15	2720	0.161	7620	296	4.721	2180	0.109	0.005	10.8	0.942	3.3
Upper Swan River	14-Oct-20	10:10	1320	0.025	5000	74.5	2.58	1690	0.066	0.005	14.1	0.459	1.5
Replicate Sample: Upper Swan R.			1330	0.025	4910	74.2	2.57	1680	0.025	0.005	13.7	0.472	1.5
Middle Swan River	14-Oct-20	10:50	2190	0.086	5070	65.7	3.43	2190	0.06	0.005	13.7	0.371	1.5
Lower Swan River	14-Oct-20	11:30	2760	0.088	6920	365	4	2320	0.09	0.005	13.5	0.8	1.5

**Notes:**

0.0183	Red fill indicates exceedance of chronic and acute Protection of Aquatic Life guidelines
	Red shading indicates exceedance of acute Protection of Aquatic Life guidelines
0.019	Red font indicates exceedance of chronic Protection of Aquatic Life guidelines
Total cadmium, total copper, total lead, total nickel, dissolved zinc and dissolved manganese PAL guidelines vary with hardness (see GoA 2018, CCME 2018 and CCME 2019 to determine appropriate PAL guidelines)	
Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L CaCO <sub>3</sub>	

**Appendix B-2: Dissolved Metals Data at Swan River Sites, May-October 2020.**

Site	Date	Time	DISSOLVED METALS									
			Mercury (µg/L)	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Calcium (mg/L)	Chromium (µg/L)	Copper (µg/L)
Upper Swan River	06-May-20	9:40	0.0068	86.4	0.13	0.6	34.6	5	0.0173	9.19	0.26	2.19
Middle Swan River	06-May-20	10:30	0.0079	90.4	0.14	6.2	36.6	5	0.0237	7.8	0.33	2.7
Lower Swan River	06-May-20	11:05	0.0057	88.9	0.14	0.58	35.3	5	0.0198	7.84	0.3	2.82
Upper Swan River	03-Jun-20	9:50	0.0025	52.6	0.17	0.76	48.7	20	0.0132	14.2	0.21	2.46
Middle Swan River	03-Jun-20	10:50	0.0051	58.5	0.17	0.78	51	17	0.0172	13	0.24	2.75
Lower Swan River	03-Jun-20	12:00	0.0025	47.4	0.17	0.77	58.2	14	0.0156	15.5	0.22	2.77
Upper Swan River	29-Jun-20	9:45	0.0025	37	0.19	0.82	54.6	5	0.0103	15.5	0.23	2.51
Middle Swan River	29-Jun-20	10:25	0.0025	39.3	0.2	0.94	58.6	11	0.0108	14.8	0.38	2.99
Upper Swan River	30-Jul-20	10:15	0.0025	24.6	0.19	1.07	56.5	5	0.0065	18.2	0.14	1.92
Middle Swan River	30-Jul-20	12:50	0.0025	35.3	0.19	1.21	57	12	0.0107	16.9	0.2	2.31
Lower Swan River	30-Jul-20	13:35	0.0025	30.5	0.2	1.26	68.8	14	0.0127	20.1	0.2	2.11
Upper Swan River	19-Aug-20	9:50	0.005	8.2	0.18	1.29	80.5	15	0.0106	29.3	0.37	1.02
Middle Swan River	19-Aug-20	10:25	0.0025	8.7	0.16	1.4	86.8	19	0.0158	30.5	0.37	1.16
Lower Swan River	19-Aug-20	11:10	0.0025	10.3	0.1	1.66	117	10	0.025	38.3	0.56	1.2
Upper Swan River	16-Sep-20	9:50	0.0025	4.1	0.19	1	69.1	5	0.0062	27.5	0.05	0.68
Middle Swan River	16-Sep-20	11:25	0.0025	3.6	0.14	1.03	76.9	16	0.0105	29.4	0.05	0.74
Lower Swan River	16-Sep-20	12:15	0.0025	3.3	0.14	0.96	104	15	0.0183	38.7	0.05	0.84
Upper Swan River	14-Oct-20	10:10	0.0025	5.4	0.1	0.88	72	19	0.0063	28.7	0.05	0.64
Replicate Sample: Upper Swan R.			0.0025	3	0.1	0.88	70.6	5	0.0066	29.3	0.05	0.64
Middle Swan River	14-Oct-20	10:50	0.0025	4.9	0.05	0.84	70.3	21	0.0068	26.8	0.1	0.74
Lower Swan River	14-Oct-20	11:30	0.0025	4.9	0.1	1	87.5	17	0.0144	33.9	0.05	0.7

**Notes:**

0.0183	Red fill indicates exceedance of chronic and acute Protection of Aquatic Life guidelines
	Red shading indicates exceedance of acute Protection of Aquatic Life guidelines
0.019	Red font indicates exceedance of chronic Protection of Aquatic Life guidelines
Total cadmium, total copper, total lead, total nickel, dissolved zinc and dissolved manganese PAL guidelines vary with hardness (see GoA 2018, CCME 2018 and CCME 2019 to determine appropriate PAL guidelines)	
Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L CaCO <sub>3</sub>	

**Appendix B-2: Dissolved Metals Data at Swan River Sites, May-October 2020.**

Site	Date	Time	DISSOLVED METALS										
			Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Potassium (µg/L)	Selenium (µg/L)	Silver (µg/L)	Sodium (mg/L)	Uranium (µg/L)	Zinc (µg/L)
Upper Swan River	06-May-20	9:40	252	0.137	1600	14.2	0.286	975	0.107	0.005	3.64	0.177	0.5
Middle Swan River	06-May-20	10:30	343	0.189	1540	28	3.91	1230	0.098	0.005	3.81	0.188	1.3
Lower Swan River	06-May-20	11:05	355	0.176	1570	19.9	4.54	1320	0.131	0.005	3.78	0.193	0.5
Upper Swan River	03-Jun-20	9:50	300	0.149	2510	31	3	1120	0.112	0.005	6.78	0.259	0.5
Middle Swan River	03-Jun-20	10:50	535	0.175	2550	49.6	4.17	1400	0.117	0.005	6.6	0.246	1.2
Lower Swan River	03-Jun-20	12:00	463	0.186	3110	40.3	4.37	1530	0.101	0.005	6.46	0.364	0.5
Upper Swan River	29-Jun-20	9:45	234	0.134	2980	2.13	2.95	1140	0.168	0.005	7.28	0.266	0.5
Middle Swan River	29-Jun-20	10:25	430	0.192	3090	2.27	5.21	1600	0.105	0.005	8.26	0.296	0.5
Upper Swan River	30-Jul-20	10:15	264	0.095	3200	2.86	2.77	1170	0.077	0.005	6.88	0.298	0.5
Middle Swan River	30-Jul-20	12:50	655	0.149	3120	3.12	4.07	1550	0.119	0.005	6.75	0.273	0.5
Lower Swan River	30-Jul-20	13:35	1010	0.15	3860	4.84	3.8	1590	0.114	0.005	6.95	0.358	0.5
Upper Swan River	19-Aug-20	9:50	877	0.069	4850	3.72	3.37	1900	0.097	0.005	12.6	0.375	0.5
Middle Swan River	19-Aug-20	10:25	1540	0.114	5420	27	4.25	2240	0.12	0.005	12.3	0.462	1.7
Lower Swan River	19-Aug-20	11:10	2040	0.15	7230	115	4.5	2400	0.14	0.005	11	0.102	6
Upper Swan River	16-Sep-20	9:50	976	0.025	4770	27.5	2.65	1550	0.144	0.005	12.1	0.381	0.5
Middle Swan River	16-Sep-20	11:25	1490	0.061	5670	55	3.39	1940	0.12	0.005	12.6	0.424	0.5
Lower Swan River	16-Sep-20	12:15	1500	0.025	7760	356	4.23	2220	0.139	0.005	11.6	1.11	0.5
Upper Swan River	14-Oct-20	10:10	977	0.025	4970	60.7	2.44	1660	0.057	0.005	12.9	0.458	3.4
Replicate Sample: Upper Swan R.			885	0.025	5320	56.8	2.43	1700	0.072	0.005	13.7	0.451	0.5
Middle Swan River	14-Oct-20	10:50	1440	0.025	5130	41.5	3.09	2180	0.066	0.005	13.1	0.378	0.5
Lower Swan River	14-Oct-20	11:30	1820	0.025	6720	284	3.66	2250	0.084	0.005	12.2	0.791	0.5

**Notes:**

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0.019	Red font indicates exceedance of chronic Protection of Aquatic Life guidelines
Total cadmium, total copper, total lead, total nickel, dissolved zinc and dissolved manganese PAL guidelines vary with hardness (see GoA 2018, CCME 2018 and CCME 2019 to determine appropriate PAL guidelines)	
Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L CaCO <sub>3</sub>	

**Appendix B-2: Miscellaneous Water Quality Data at Swan River Sites, May-October 2020.**

Site	Date	Time	MISCELLANEOUS PARAMETERS							Notes:
			Total Dissolved Solids	Chloride	Flouride	Hardness CaCO <sub>3</sub>	Sulfate SO <sub>4</sub>	Bicarbonate HCO <sub>3</sub>	Alkalinity CaCO <sub>3</sub>	
Upper Swan River	06-May-20	9:40	90	0.79	0.048	29.5	2.35	44.9	36.8	1) No sample was collected from the lower Swan River on June 29 due to poor road conditions preventing site accessibility. 2) A replicate sample was collected from the upper Swan River site on October 14 for QA/QC purposes to evaluate within-site variation and precision in the field and laboratory.
Middle Swan River	06-May-20	10:30	99	<0.50	0.045	25.8	2.37	39.8	32.6	
Lower Swan River	06-May-20	11:05	95	<0.50	0.046	26	2.53	35.5	29.1	
Upper Swan River	03-Jun-20	9:50	104	0.99	0.059	45.8	4.04	66.2	54.3	
Middle Swan River	03-Jun-20	10:50	109	0.75	0.061	43	3.72	60.6	49.7	
Lower Swan River	03-Jun-20	12:00	117	1.68	0.062	51.5	3.82	59.9	49.1	
Upper Swan River	29-Jun-20	9:45	128	0.68	0.058	51	4.15	71.7	58.8	
Middle Swan River	29-Jun-20	10:25	129	0.68	0.06	49.7	4.43	75.8	62.1	
Upper Swan River	30-Jul-20	10:15	124	0.66	0.054	58.6	4.68	85.4	70	
Middle Swan River	30-Jul-20	12:50	122	0.58	0.055	55	4.09	81	66.4	
Lower Swan River	30-Jul-20	13:35	150	1.04	0.058	66.1	4.67	91.3	74.8	
Upper Swan River	19-Aug-20	9:50	101	0.67	0.09	93.1	5.77	128	105	
Middle Swan River	19-Aug-20	10:25	119	1.58	0.097	98.5	4.89	134	110	
Lower Swan River	19-Aug-20	11:10	148	2.14	0.09	125	5.6	155	127	
Upper Swan River	16-Sep-20	9:50	147	0.76	0.087	88.3	8.3	139	114	
Middle Swan River	16-Sep-20	11:25	146	1.64	0.099	96.8	6.95	150	123	
Lower Swan River	16-Sep-20	12:15	187	2.366	0.095	129	7.63	181	149	
Upper Swan River	14-Oct-20	10:10	157	0.79	0.087	92.1	9.61	138	113	
Replicate Sample: Upper Swan R.			141	0.72	0.081	95.1	9.34	137	113	
Middle Swan River	14-Oct-20	10:50	125	1.22	0.091	88	7.57	137	112	
Lower Swan River	14-Oct-20	11:30	159	1.76	0.095	112	7.08	163	134	

**Provincial Protection of Aquatic Life (PAL) Guidelines for Metals (Total and Dissolved) and Other Parameters.**

Parameter	PAL Guideline		Parameter	PAL Guideline		Parameter	PAL Guideline	
	Chronic	Acute		Chronic	Acute		Chronic	Acute
Total Mercury	0.005	0.013	Total Selenium	2.0		Alkalinity	20	
Total Arsenic	5.0		Total Silver	0.25		Chloride	120	640
Total Boron	1,500	29,000	Total Uranium	15	33	Sulfate (SO <sub>4</sub> )	128 to 309	
Total Cadmium	0.05 to 0.28	0.52 to 4.2	Total Zinc	30		<b>Notes:</b> 1) All guidelines are ug/L. 2) All guidelines are provincial (GoA 2018) except dissolved zinc and dissolved manganese (federal: CCME 2018)		
Hexavalent Chromium	1.0		Dissolved Aluminum	50	100			
Total Copper	7	4.1 to 32.0	Dissolved Iron	300				
Total Lead	1.0 to 7.0		Dissolved Manganese	240 to 430	2005 to 12126			
Total Nickel	16 to 94	145 to 840	Dissolved Zinc	10 to 101	47 to 313			

**Appendix B-3: Total Metals Data at West Prairie, East Prairie and Driftpile River Sites, May-October 2020.**

Site	Date	Time	TOTAL METALS										
			Mercury (µg/L)	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Calcium (mg/L)	Hexavalent Chromium (µg/L)	Chromium (µg/L)	Copper (µg/L)
Upper West Prairie River	05-May-20	9:00	0.0211	3790	2.7	3.89	122	13	0.198	11.2	0.25	5.5	12.4
Middle East Prairie River	05-May-20	13:40	0.0123	5670	0.36	6.05	202	14	0.250	17	0.25	8.22	19.6
Middle Driftpile River	06-May-20	12:35	0.0094	3020	0.22	2.7	95	10	0.103	11.3	0.25	5.5	8.03
Upper West Prairie River	02-Jun-20	9:00	0.0076	1160	0.2	1.71	71.6	28	0.0459	18	0.25	2.02	6.39
Middle East Prairie River	02-Jun-20	14:15	0.0025	2450	0.29	3.11	119	23	0.110	21.7	0.25	3.9	10.4
Middle Driftpile River	03-Jun-20	13:40	0.0025	856	0.21	1.47	66.9	12	0.0466	16	0.25	1.92	4.08
Upper West Prairie River	30-Jun-20	8:50	0.0062	4050	0.29	4.42	135	13	0.172	14.9	0.25	6.59	13.9
Middle East Prairie River	30-Jun-20	13:40	0.0074	5330	0.42	6.71	220	12	0.272	25.6	0.25	8.57	21.2
Middle Driftpile River	29-Jun-20	12:35	0.0025	5430	0.33	6.15	199	18	0.243	19	0.25	9.14	18.5
Replicate Sample: Middle Driftpile River			0.0025	5840	0.34	6.62	218	19	0.267	20.1	0.25	10.1	19.9
Upper West Prairie River	28-Jul-20	9:20	0.0061	219	0.2	1.4	72.7	13	0.0314	23.8	0.25	0.58	5.42
Middle East Prairie River	28-Jul-20	15:00	0.0059	888	0.29	2.43	84.5	11	0.0367	26.2	0.25	1.47	4.96
Middle Driftpile River	30-Jul-20	14:45	0.0055	832	0.27	2.42	85.7	5	0.0586	19.2	0.25	1.51	5.13
Upper West Prairie River	18-Aug-20	9:01	0.0056	114	0.18	1.73	105	21	0.0345	40.5	0.25	0.39	2.55
Middle East Prairie River	18-Aug-20	13:45	0.0025	118	0.22	2.38	105	14	0.0313	46.9	0.25	0.26	1.9
Middle Driftpile River	19-Aug-20	13:10	0.0025	87.1	0.17	2.16	118	38	0.0384	38.3	0.25	0.27	1.94
Upper West Prairie River	15-Sep-20	8:50	0.0025	41.9	0.13	1.23	118	30	0.0252	54.6	0.25	0.18	1.42
Middle East Prairie River	15-Sep-20	14:45	0.0025	46.3	0.25	1.34	99.1	18	0.0158	59.4	0.25	0.12	0.138
Middle Driftpile River	16-Sep-20	14:00	0.0025	30.7	0.13	1.55	106	19	0.0187	42.5	0.25	0.16	1.06
Upper West Prairie River	13-Oct-20	9:10	0.0025	28.2	0.1	0.92	106	26	0.0225	56.6	0.25	0.13	0.97
Middle East Prairie River	13-Oct-20	13:10	0.0025	56.3	0.11	1.24	97.5	13	0.0159	55.7	0.25	0.12	1.01
Middle Driftpile River	14-Oct-20	13:20	0.0025	45.3	0.11	1.32	98.3	18	0.0184	39.6	0.25	0.13	0.95

**Notes:**

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Total cadmium, total copper, total lead, total nickel, dissolved zinc and dissolved manganese PAL guidelines vary with hardness (see GoA 2018, CCME 2018 and CCME 2019 to determine appropriate PAL guidelines)	
Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L CaCO <sub>3</sub>	



**Appendix B-3: Total Metals Data at West Prairie, East Prairie and Driftpile River Sites, May-October 2020.**

Site	Date	Time	TOTAL METALS										
			Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Potassium (µg/L)	Selenium (µg/L)	Silver (µg/L)	Sodium (mg/L)	Uranium (µg/L)	Zinc (µg/L)
Upper West Prairie River	05-May-20	9:00	7800	5.72	3180	189	13.8	2210	0.299	0.057	3.71	0.972	37.9
Middle East Prairie River	05-May-20	13:40	11200	8.54	4780	334	21.3	3110	0.398	0.097	4.25	1.38	50.4
Middle Driftpile River	06-May-20	12:35	4940	3.03	2960	142	10.2	2140	0.234	0.033	3.6	0.6	21.4
Upper West Prairie River	02-Jun-20	9:00	2530	1.31	3710	47.9	7.82	1730	0.199	0.079	6.26	0.548	8.9
Middle East Prairie River	02-Jun-20	14:15	5370	3.55	4350	174	11.2	2490	0.249	0.092	6.2	0.736	19.1
Middle Driftpile River	03-Jun-20	13:40	2050	0.84	3490	72.6	6.04	1640	0.142	0.016	5.41	0.44	6.5
Upper West Prairie River	30-Jun-20	8:50	8110	6.59	4240	218	16.7	2170	0.315	0.055	6.28	1.13	36
Middle East Prairie River	30-Jun-20	13:40	11600	9.38	6810	392	22.3	3070	0.375	0.068	7.74	1.67	53.5
Middle Driftpile River	29-Jun-20	12:35	11900	7.14	5670	361	22.1	2750	0.459	0.069	5.38	1.16	47.4
Replicate Sample: Middle Driftpile River			12900	7.83	6080	383	23.6	2870	0.470	0.081	5.48	1.32	51.1
Upper West Prairie River	28-Jul-20	9:20	1300	0.778	4990	37.5	5.37	1240	0.178	0.005	8.51	0.624	5
Middle East Prairie River	28-Jul-20	15:00	2510	1.11	5200	53.7	5.4	1940	0.231	0.017	7.99	0.795	6.8
Middle Driftpile River	30-Jul-20	14:45	2720	1.26	3940	130	6.53	1790	0.171	0.019	6.26	0.475	7.8
Upper West Prairie River	18-Aug-20	9:01	1870	0.327	9560	67	5.52	2200	0.221	0.005	11	1.38	1.5
Middle East Prairie River	18-Aug-20	13:45	1570	0.333	9520	55.7	3.53	2360	0.184	0.005	12.1	2.4	1.5
Middle Driftpile River	19-Aug-20	13:10	2270	0.276	8360	171	4.93	2270	0.146	0.005	10	0.88	1.5
Upper West Prairie River	15-Sep-20	8:50	1730	0.135	12800	142	4.99	2360	0.138	0.005	12.9	1.75	1.5
Middle East Prairie River	15-Sep-20	14:45	923	0.264	10700	88.7	2.94	2280	0.131	0.005	12.5	2.45	1.5
Middle Driftpile River	16-Sep-20	14:00	2140	0.125	8640	175	3.89	2260	0.101	0.005	10.6	0.779	1.5
Upper West Prairie River	13-Oct-20	9:10	1540	0.025	13600	125	4.44	2690	0.154	0.005	16	1.63	1.5
Middle East Prairie River	13-Oct-20	13:10	1060	0.094	10900	89.5	2.89	2510	0.12	0.005	13.8	2.13	1.5
Middle Driftpile River	14-Oct-20	13:20	1990	0.102	7910	124	3.5	2490	0.066	0.005	12.6	0.742	1.5

**Notes:**

0.0183	Red fill indicates exceedance of chronic and acute Protection of Aquatic Life guidelines
	Red shading indicates exceedance of acute Protection of Aquatic Life guidelines
0.019	Red font indicates exceedance of chronic Protection of Aquatic Life guidelines
Total cadmium, total copper, total lead, total nickel, dissolved zinc and dissolved manganese PAL guidelines vary with hardness (see GoA 2018, CCME 2018 and CCME 2019 to determine appropriate PAL guidelines)	
Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L CaCO <sub>3</sub>	

**Appendix B-3: Dissolved Metals Data at West Prairie, East Prairie and Driftpile River Sites, May-October 2020.**

Site	Date	Time	DISSOLVED METALS									
			Mercury (µg/L)	Aluminum (µg/L)	Antimony (µg/L)	Arsenic (µg/L)	Barium (µg/L)	Boron (µg/L)	Cadmium (µg/L)	Calcium (mg/L)	Chromium (µg/L)	Copper (µg/L)
Upper West Prairie River	05-May-20	9:00	0.0068	137	0.13	0.65	32.6	5	0.0255	7.7	0.51	3.21
Middle East Prairie River	05-May-20	13:40	0.0079	36.5	0.19	0.68	41.1	5	0.0144	11.1	0.29	3.28
Middle Driftpile River	06-May-20	12:35	0.0057	90.1	0.13	6.9	37.4	5	0.0224	9.33	0.34	2.52
Upper West Prairie River	02-Jun-20	9:00	0.0025	70.6	0.18	0.77	48.7	16	0.022	16.9	0.39	2.7
Middle East Prairie River	02-Jun-20	14:15	0.0025	34.7	0.22	0.72	52.3	14	0.0156	19.2	0.26	3.21
Middle Driftpile River	03-Jun-20	13:40	0.0052	72.4	0.18	0.83	56.6	13	0.0248	15.9	0.29	2.75
Upper West Prairie River	30-Jun-20	8:50	0.0063	145	0.2	0.97	44.9	16	0.23	11.9	0.66	4.29
Middle East Prairie River	30-Jun-20	13:40	0.0025	36.1	0.27	0.99	62.8	13	0.0143	20.1	0.23	4.32
Middle Driftpile River	29-Jun-20	12:35	0.0054	70.7	0.21	0.94	60.2	12	0.0267	14	0.54	4.46
Replicate Sample: Middle Driftpile River			0.0065	73.3	0.22	0.95	60.3	12	0.0237	14.4	0.43	4.17
Upper West Prairie River	28-Jul-20	9:20	0.0025	53	1.9	1.03	65.2	13	0.0185	23.3	0.34	2.61
Middle East Prairie River	28-Jul-20	15:00	0.0025	21.4	0.26	1.3	66	5	0.0136	26.7	0.28	2.91
Middle Driftpile River	30-Jul-20	14:45	0.0025	35.7	0.24	1.43	62.6	5	0.0155	17.9	0.23	2.54
Upper West Prairie River	18-Aug-20	9:01	0.0025	27.9	0.19	1.4	109	26	0.0252	45.5	0.23	2.48
Middle East Prairie River	18-Aug-20	13:45	0.0025	4.4	0.23	1.46	102	18	0.0107	52.7	0.05	1.73
Middle Driftpile River	19-Aug-20	13:10	0.0025	14.6	0.2	1.8	118	34	0.0262	39.8	0.14	1.7
Upper West Prairie River	15-Sep-20	8:50	0.0025	22.6	0.12	0.97	109	28	0.0183	50.5	0.13	1.23
Middle East Prairie River	15-Sep-20	14:45	0.0025	10	0.16	0.9	93.9	16	0.0065	50.3	0.05	1.1
Middle Driftpile River	16-Sep-20	14:00	0.0025	3.5	0.15	0.96	96	20	0.0091	40.4	0.05	0.88
Upper West Prairie River	13-Oct-20	9:10	0.0025	2.5	0.1	0.59	99.1	25	0.0081	57.2	0.05	0.93
Middle East Prairie River	13-Oct-20	13:10	0.0025	1.6	0.12	0.63	89.3	12	0.0025	55.1	0.05	0.95
Middle Driftpile River	14-Oct-20	13:20	0.0025	4.1	0.1	0.91	93.9	19	0.01	39.3	0.05	0.69

**Notes:**

0.0183	Red fill indicates exceedance of chronic and acute Protection of Aquatic Life guidelines
	Red shading indicates exceedance of acute Protection of Aquatic Life guidelines
0.019	Red font indicates exceedance of chronic Protection of Aquatic Life guidelines
Total cadmium, total copper, total lead, total nickel, dissolved zinc and dissolved manganese PAL guidelines vary with hardness (see GoA 2018, CCME 2018 and CCME 2019 to determine appropriate PAL guidelines)	
Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L CaCO <sub>3</sub>	

**Appendix B-3: Dissolved Metals Data at West Prairie, East Prairie and Driftpile River Sites, May-October 2020.**

Site	Date	Time	DISSOLVED METALS										
			Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Potassium (µg/L)	Selenium (µg/L)	Silver (µg/L)	Sodium (mg/L)	Uranium (µg/L)	Zinc (µg/L)
Upper West Prairie River	05-May-20	9:00	371	0.188	1520	14.9	4.64	1350	0.161	0.005	3.53	0.264	1.7
Middle East Prairie River	05-May-20	13:40	252	0.164	1970	7.44	4.77	1760	0.154	0.005	3.99	0.231	0.5
Middle Driftpile River	06-May-20	12:35	375	0.197	1810	37.2	4.37	1380	0.127	0.005	3.38	0.252	2
Upper West Prairie River	02-Jun-20	9:00	399	0.141	3450	7.27	4.84	1470	0.27	0.005	6.47	0.416	1
Middle East Prairie River	02-Jun-20	14:15	294	0.151	3590	5.44	4.2	1930	0.226	0.005	6.76	0.332	0.5
Middle Driftpile River	03-Jun-20	13:40	583	0.188	3390	41.9	4.79	1570	0.131	0.005	5.56	0.376	1.1
Upper West Prairie River	30-Jun-20	8:50	441	0.29	2280	3.35	6.38	1090	0.229	0.005	5.74	3.73	1.9
Middle East Prairie River	30-Jun-20	13:40	314	0.25	3740	3.26	5.14	1670	0.188	0.005	7.2	0.408	0.5
Middle Driftpile River	29-Jun-20	12:35	485	0.283	3030	2.57	6.2	1570	0.221	0.005	5.26	0.336	1.3
Replicate Sample: Middle Driftpile River			478	0.276	2990	2.6	6.13	1550	0.243	0.005	5.36	0.324	1.3
Upper West Prairie River	28-Jul-20	9:20	656	0.143	4860	7.37	4.87	1220	0.214	0.005	7.86	5.19	3.3
Middle East Prairie River	28-Jul-20	15:00	405	0.135	4940	4.74	3.5	1750	0.186	0.005	7.86	0.693	0.5
Middle Driftpile River	30-Jul-20	14:45	704	0.198	3480	2.83	4.24	1580	0.129	0.005	5.92	0.346	0.5
Upper West Prairie River	18-Aug-20	9:01	1330	0.186	9550	27.3	5.44	2280	0.2	0.005	11.1	1.53	1.5
Middle East Prairie River	18-Aug-20	13:45	355	0.056	9580	7.49	3.31	2480	0.197	0.005	12.1	2.74	0.5
Middle Driftpile River	19-Aug-20	13:10	1600	0.15	7970	30	5.16	2450	0.141	0.005	10.3	0.9	1
Upper West Prairie River	15-Sep-20	8:50	1220	0.085	12600	41.9	4.66	2290	0.176	0.005	12.8	1.65	0.5
Middle East Prairie River	15-Sep-20	14:45	276	0.025	10900	45.7	2.82	2280	0.143	0.005	12.6	2.22	0.5
Middle Driftpile River	16-Sep-20	14:00	982	0.05	8500	101	3.59	2300	0.14	0.005	11.1	0.823	0.5
Upper West Prairie River	13-Oct-20	9:10	424	0.025	13500	95.9	4.21	2690	0.159	0.005	16.1	1.8	0.5
Middle East Prairie River	13-Oct-20	13:10	90	0.025	10800	37.6	2.66	2490	0.115	0.005	14.2	2.19	0.5
Middle Driftpile River	14-Oct-20	13:20	1170	0.05	7860	69.1	3.21	2440	0.116	0.005	11.4	0.73	0.5

**Notes:**

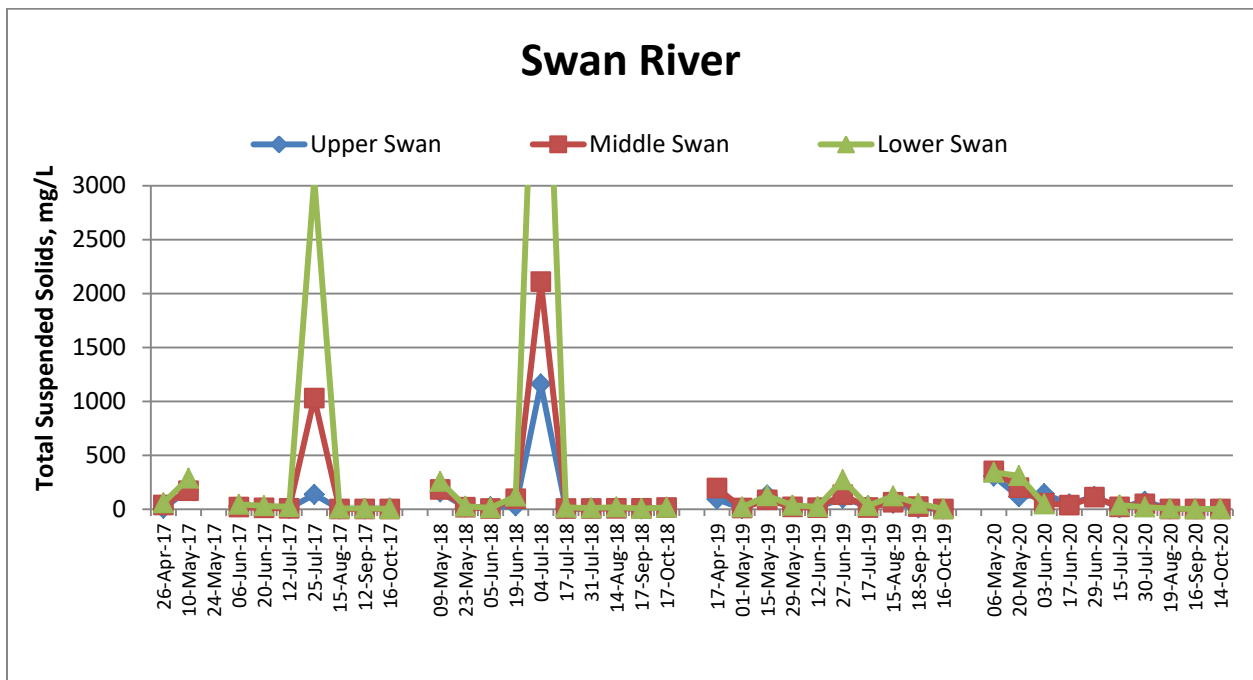
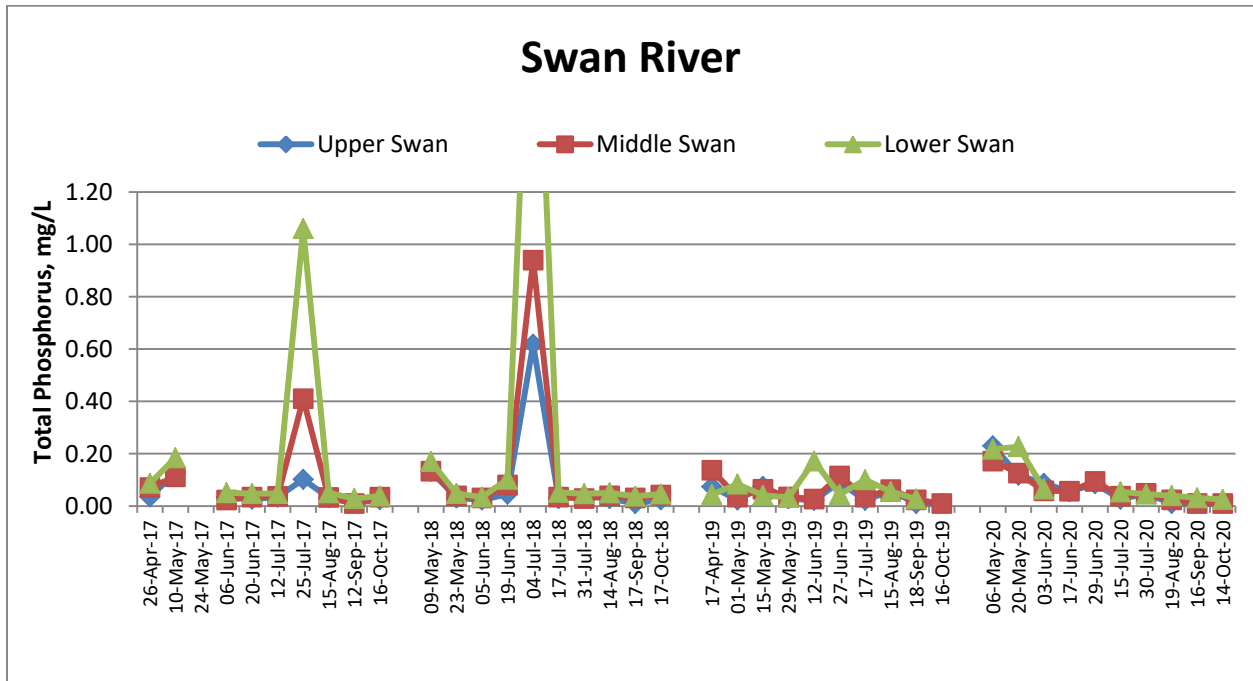
0.0183	Red fill indicates exceedance of chronic and acute Protection of Aquatic Life guidelines
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Total cadmium, total copper, total lead, total nickel, dissolved zinc and dissolved manganese PAL guidelines vary with hardness (see GoA 2018, CCME 2018 and CCME 2019 to determine appropriate PAL guidelines)	
Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L CaCO <sub>3</sub>	

**Appendix B-3: Misc. Water Quality Data at West Prairie, East Prairie and Driftpile River Sites, May-Oct 2020.**

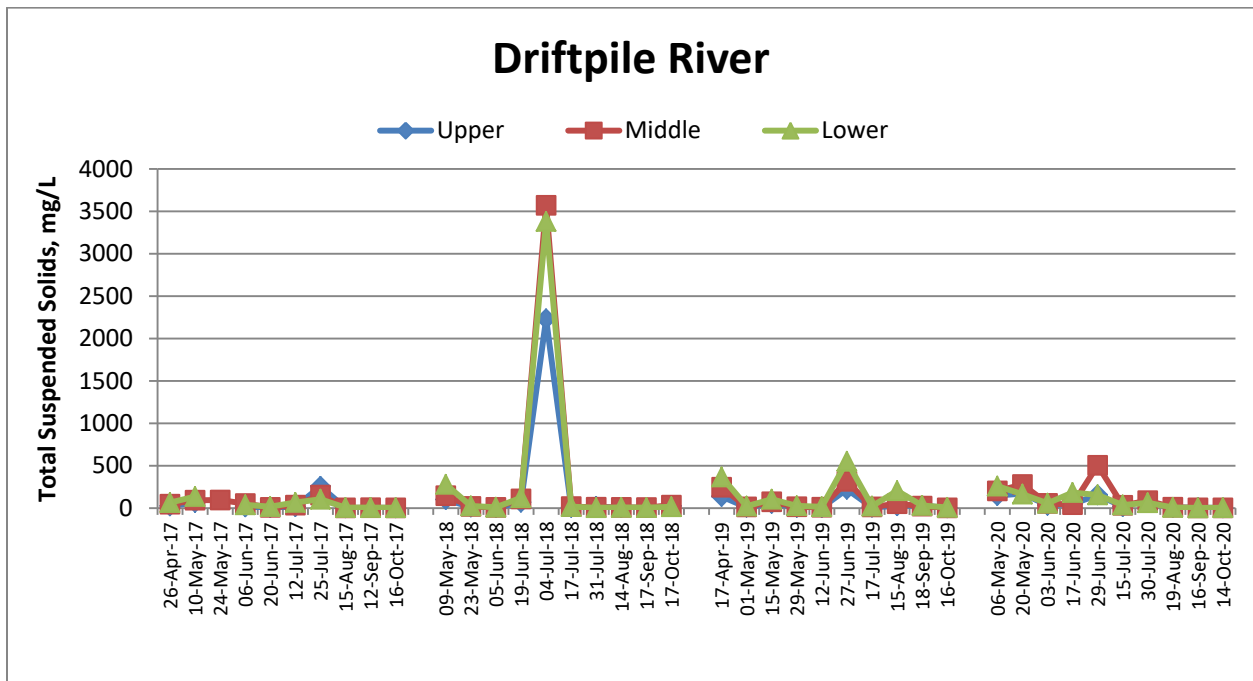
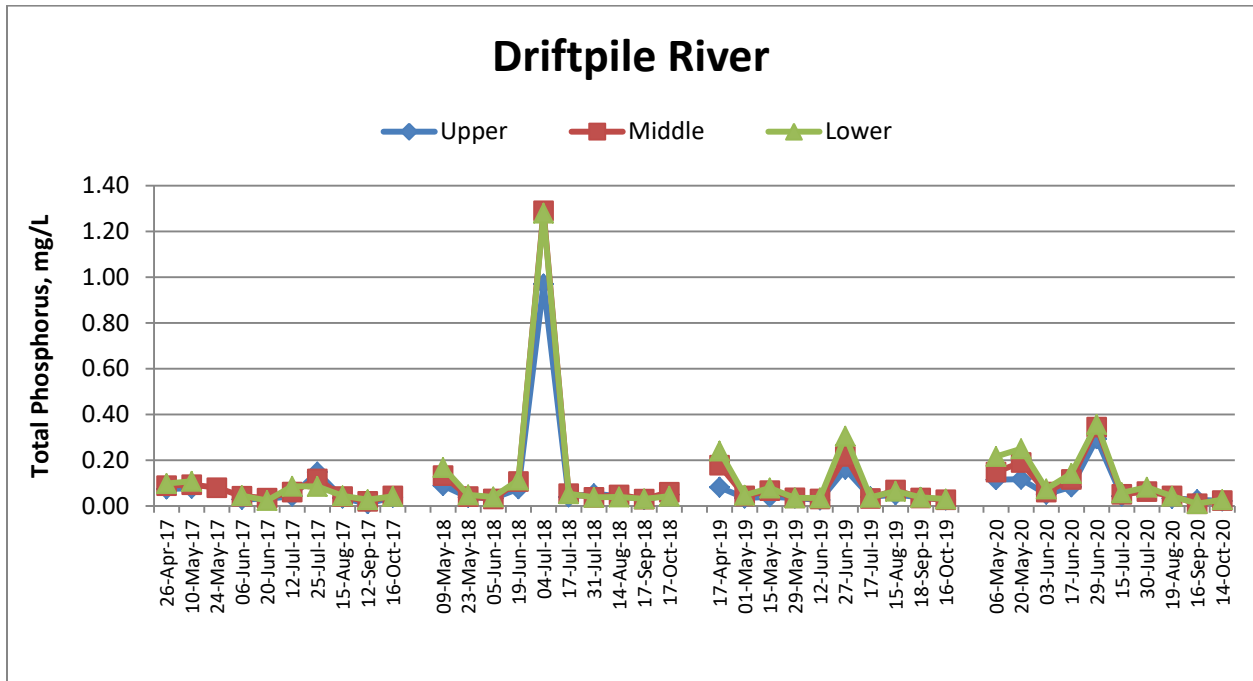
Site	Date	Time	MISCELLANEOUS PARAMETERS							Notes:	
			Total Dissolved Solids	Chloride	Flouride	Hardness CaCO <sub>3</sub>	Sulfate SO <sub>4</sub>	Bicarbonate HCO <sub>3</sub>	Alkalinity CaCO <sub>3</sub>		
Upper West Prairie River	05-May-20	9:00		<0.50	0.045	25.5	2.93	32.6	26.7	1) A replicate sample was collected from the middle Driftpile River site on June 29 for QA/QC purposes to evaluate within-site variation and precision in the field and laboratory.	
Middle East Prairie River	05-May-20	13:40		<0.50	0.054	35.8	4.43	46.1	37.8		
Middle Driftpile River	06-May-20	12:35	102	<0.50	0.041	30.8	3.56	42.8	35.1		
Upper West Prairie River	02-Jun-20	9:00	153	<0.50	0.077	56.4	8.5	67.5	55.3		
Middle East Prairie River	02-Jun-20	14:15	155	0.63	0.092	62.7	9.66	81	66.4		
Middle Driftpile River	03-Jun-20	13:40	109	0.74	0.057	53.7	6.55	59.8	49		
Upper West Prairie River	30-Jun-20	8:50	152	<0.50	0.046	39.1	3.38	45.4	37.2		
Middle East Prairie River	30-Jun-20	13:40	236	<0.50	0.067	65.6	6.9	87.2	71.5		
Middle Driftpile River	29-Jun-20	12:35	179	<0.50	0.053	47.4	4.5	59.7	48.9		
Replicate Sample: Middle Driftpile River			170	<0.50	0.053	48.3	4.53	58.1	47.6		
Upper West Prairie River	28-Jul-20	9:20	162	<0.50	0.055	78.2	7.07	97.4	79.8		
Middle East Prairie River	28-Jul-20	15:00	143	0.55	0.069	87	7.27	97.4	79.8		
Middle Driftpile River	30-Jul-20	14:45	170	<0.5	0.055	59	5.13	136	69		
Upper West Prairie River	18-Aug-20	9:01	228	0.77	0.076	153	13.1	183	150		
Middle East Prairie River	18-Aug-20	13:45	206	1.44	0.111	171	13.6	210	172		
Middle Driftpile River	19-Aug-20	13:10	169	0.51	0.095	132	11.2	164	134		
Upper West Prairie River	15-Sep-20	8:50	256	1.39	0.099	178	20	237	194		
Middle East Prairie River	15-Sep-20	14:45	274	1.62	0.109	170	17.2	407	190		
Middle Driftpile River	16-Sep-20	14:00	210	0.72	0.101	136	13.3	184	151		
Upper West Prairie River	13-Oct-20	9:10	239	1.11	0.111	198	20.9	250	205		
Middle East Prairie River	13-Oct-20	13:10	229	1.57	0.112	182	15.9	245	201		
Middle Driftpile River	14-Oct-20	13:20	164	<0.50	0.098	130	12.5	185	151		
			Provincial Protection of Aquatic Life (PAL) Guidelines for Metals (Total and Dissolved) and Other Parameters.								
			Parameter	PAL Guideline		Parameter	PAL Guideline		Parameter	PAL Guideline	
				Chronic	Acute		Chronic	Acute		Chronic	Acute
			Total Mercury	0.005	0.013	Total Selenium	2.0		Alkalinity	20	
			Total Arsenic	5.0		Total Silver	0.25		Chloride	120	640
			Total Boron	1,500	29,000	Total Uranium	15	33	Sulfate (SO <sub>4</sub> )	128 to 309	
			Total Cadmium	0.05 to 0.28	0.52 to 4.2	Total Zinc	30		Notes: 1) All guidelines are ug/L. 2) All guidelines are provincial (GoA 2018) except dissolved zinc and dissolved manganese (federal: CCME 2018)		
			Hexavalent Chromium	1.0		Dissolved Aluminum	50	100			
			Total Copper	7	4.1 to 32.0	Dissolved Iron	300				
			Total Lead	1.0 to 7.0		Dissolved Manganese	240 to 430	2005 to 12126			
			Total Nickel	16 to 94	145 to 840	Dissolved Zinc	10 to 101	47 to 313			

## APPENDIX C. WATER QUALITY GRAPHS FOR SELECT PARAMETERS, 2017-2020.

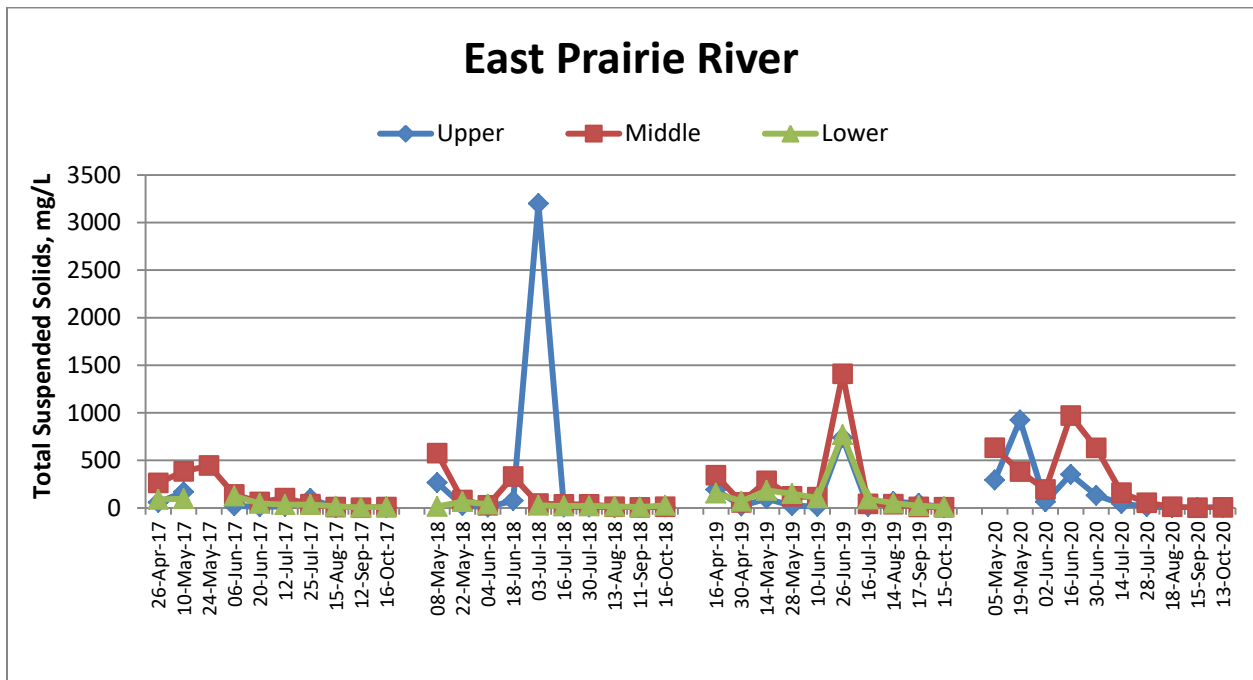
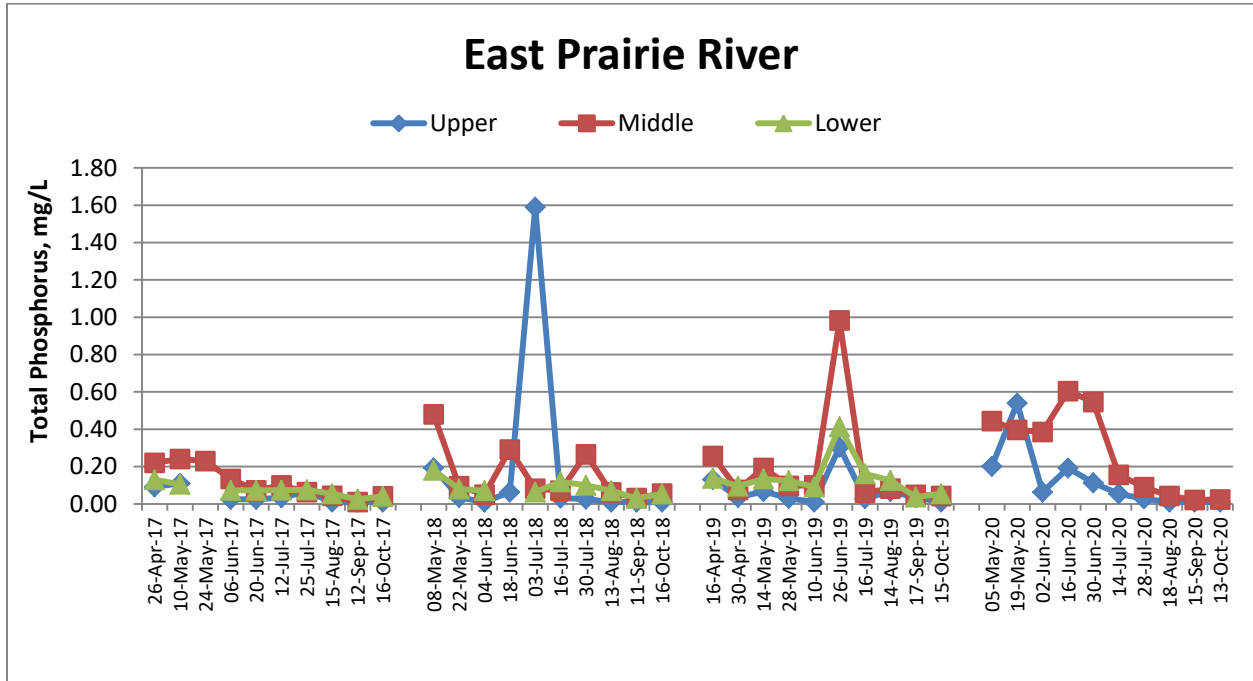
### C-1. Swan River



## C-2. Driftpile River

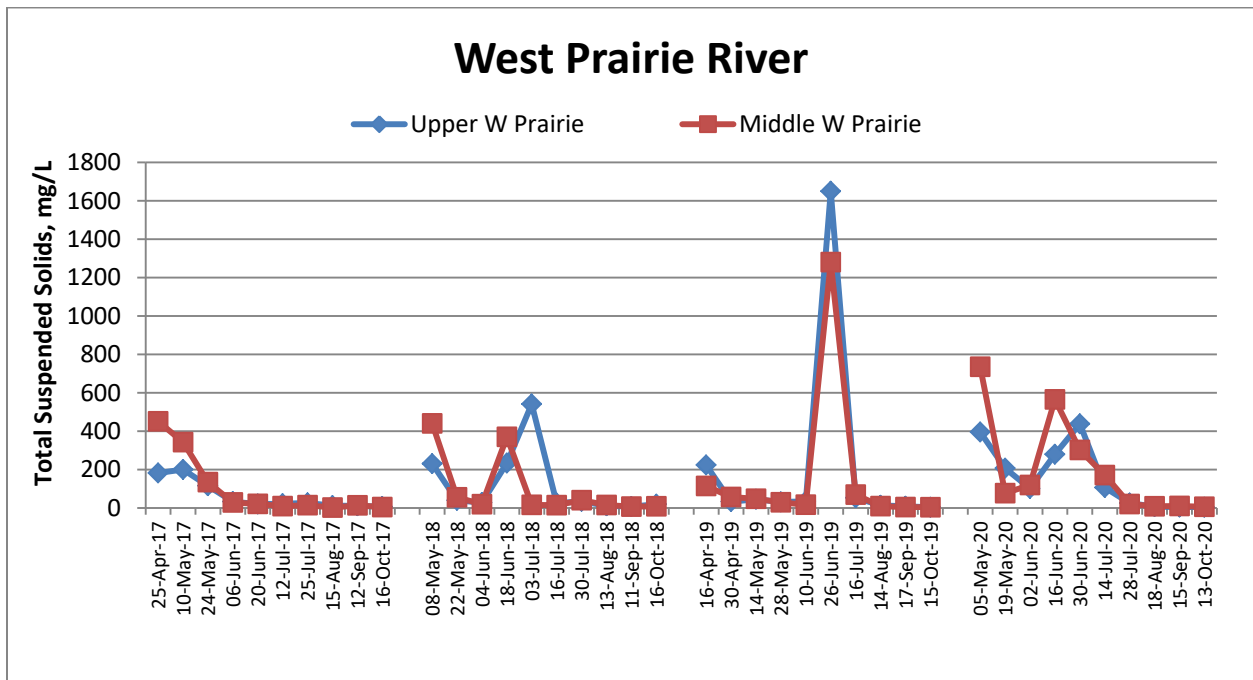
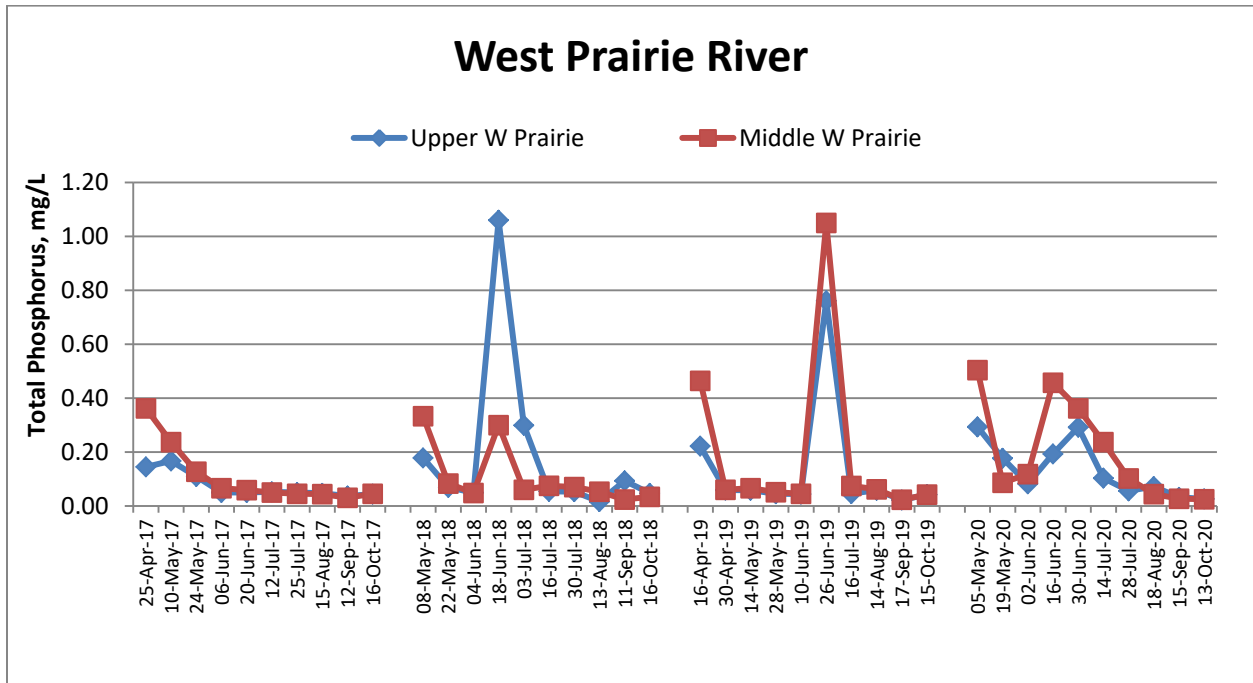


### C-3. East Prairie River





#### C-4. West Prairie River



### C-5. South Heart River and Grouard Channel

