Lesser Slave Watershed
2019 Water Monitoring Report

Prepared for: Lesser Slave Watershed Council

Prepared by: Palliser Environmental Services Ltd.

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Cover Photo: Upper South Heart River, view downstream, June 10, 2019 (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 third year (2019) 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 Seimens per centimetre (µS/cm) (Cole 1994). The `safe' irrigation guideline for electrical conductivity is ≤1000 µS/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). Total phosphorus concentration guidelines for rivers in Canada range from 0.025 to 0.050 mg/L, with Yukon and British Columbia having a 0.025 mg/L guideline and Manitoba and Saskatchewan a 0.050 mg/L guideline. Quebec, Nova Scotia, Northwest Territories, Newfoundland & Labrador, New Brunswick, and Ontario have a total phosphorus guideline of 0.030 mg/L (ECCC 2017). Until recently, Alberta had a total phosphorus guideline of 0.050 mg/L for the protection of aquatic life but in 2014 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 (NO_3-N), nitrite-nitrogen (NO_2-N), ammonia-nitrogen (NH_3-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 (Anderson et al. 1996, Robertson et al. 2006, Levesque and Dube 2007):

- 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.

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 ≤100 cfu/100 mL (geometric mean, 30-d interval) and ≤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 the middle of April through May, and monthly (July-October) at fifteen sites (Figure 1). Three sites were monitored to represent the upper, middle and lower reaches of the Driftpile River, Swan River, East Prairie River, West Prairie River (middle and lower sites only) and South Heart River. The Grouard Channel upstream of Lesser Slave Lake was also monitored at the same frequency. In 2019, the LSWC sampled on April 16/17, April 30/May 1, May 14/15, May 28/29, June 10/12, June 26/27, July 16/17, August 14/15, September 17/18, and October 16/17. Note that sampling in 2018 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

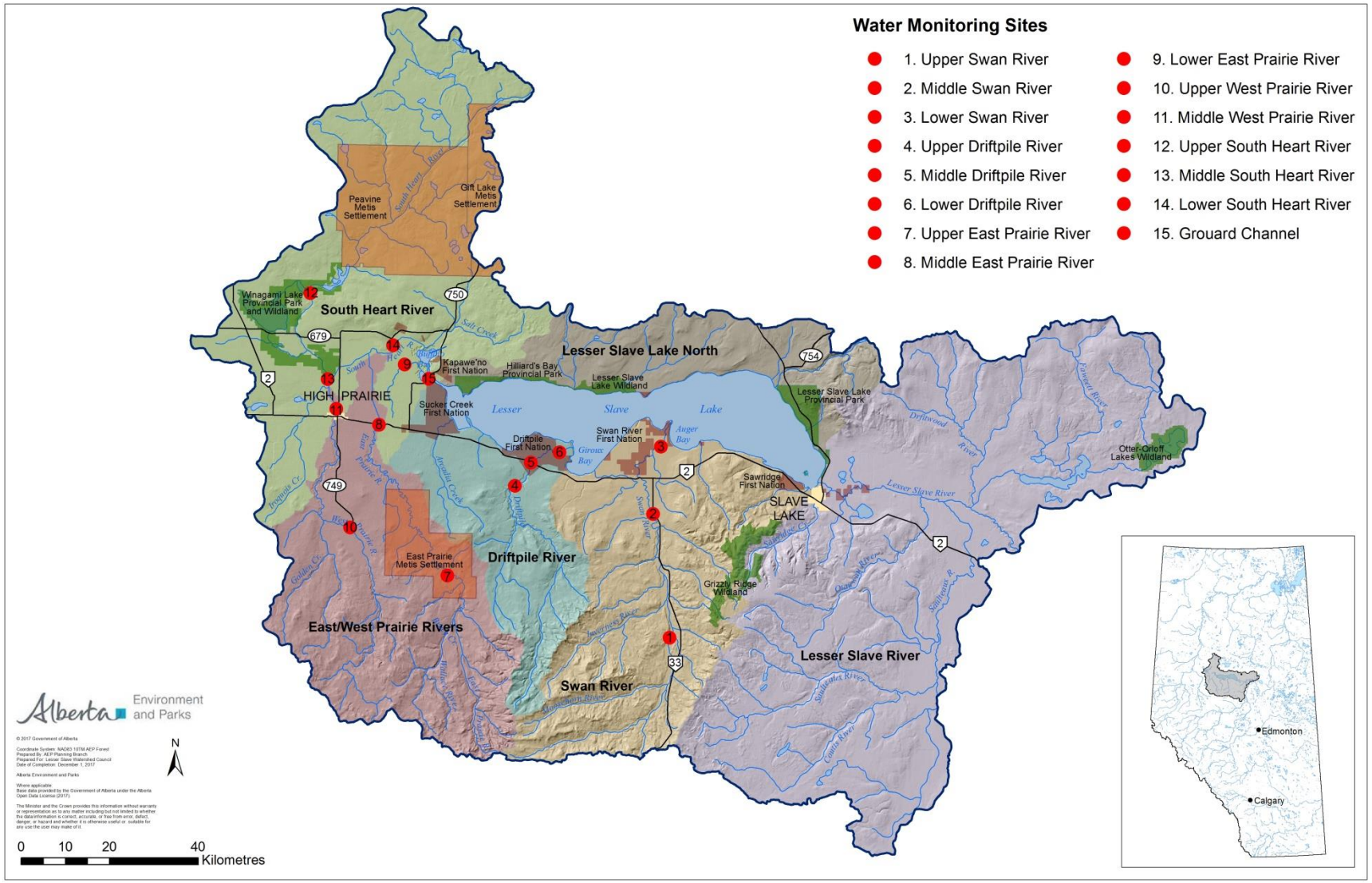

Figure 1. Water quality monitoring site locations in the Lesser Slave watershed, April-October, 2017 to 2019.

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**[1] accredited for criteria and standards established by the Association under their Certificate of Laboratory Proficiency.

Samples were analysed using **APHA**[2] approved methods for routine parameters (e.g., specific conductivity), nutrients (total phosphorus (TP), total dissolved phosphorus (TDP), nitrate+nitrite nitrogen (NO_3+NO_2-N), total kjeldahl nitrogen (TKN) and total nitrogen [TN; calculated]), total suspended solids (TSS) and fecal coliform bacteria (FCB).

Field measurements 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 April 17, May 15, June 12, July 17, August 15, September 18, and October 16 at the upper, middle and lower Swan River sites for metals analysis. Seven metals samples were collected at each site in 2018 and 2019, compared to 5 samples at each site in 2017. The Lower Swan River was not sampled on April 17 as the site was inaccessible.

3.2 Streamflow Data

Daily streamflow data for 2017, 2018 and 2019 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.).

Table 1. Streamflow gauging stations, Lesser Slave Lake watershed, and missing data (dates and days) for the period April-October, 2017 - 2019.

Site (Station Name)	2017	2018	2019
Driftpile River near Driftpile (07BH003)	None	Apr 1-29; May 1-7; Jun 12-20 (45 d)	Apr 1-30 (30 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)
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)
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)
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)
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)
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)

[1] **CALA** – Canadian Association for Laboratory Accreditation Inc.

[2] **APHA** – American Public Health Association

Streamflow data for the April to October monitoring period was isolated from the AEP data set. Streamflow data collection for the April to October period was substantially less comprehensive in 2018 compared to 2017, with most sites initiated in May in 2018, compared to January/February in 2017. In 2019, the number of missing data points improved at some sites compared to 2018, but the number of missing data points remains significant. A significant period of missing data each year limits the comparison of streamflow between years. All streamflow data should be considered interim, until the Water Survey of Canada validation is complete.

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 the sites Peavine, High Prairie AGDM, High Prairie Banana Belt, Slave Lake, Slave Lake RCS, House Mountain Lookout, Kinuso Auto, Salteaux, Swan Dive Auto and Flattop Lookout. Precipitation data was only available in August through October monitoring period for Gift Lake Auto, Salt Prairie 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.

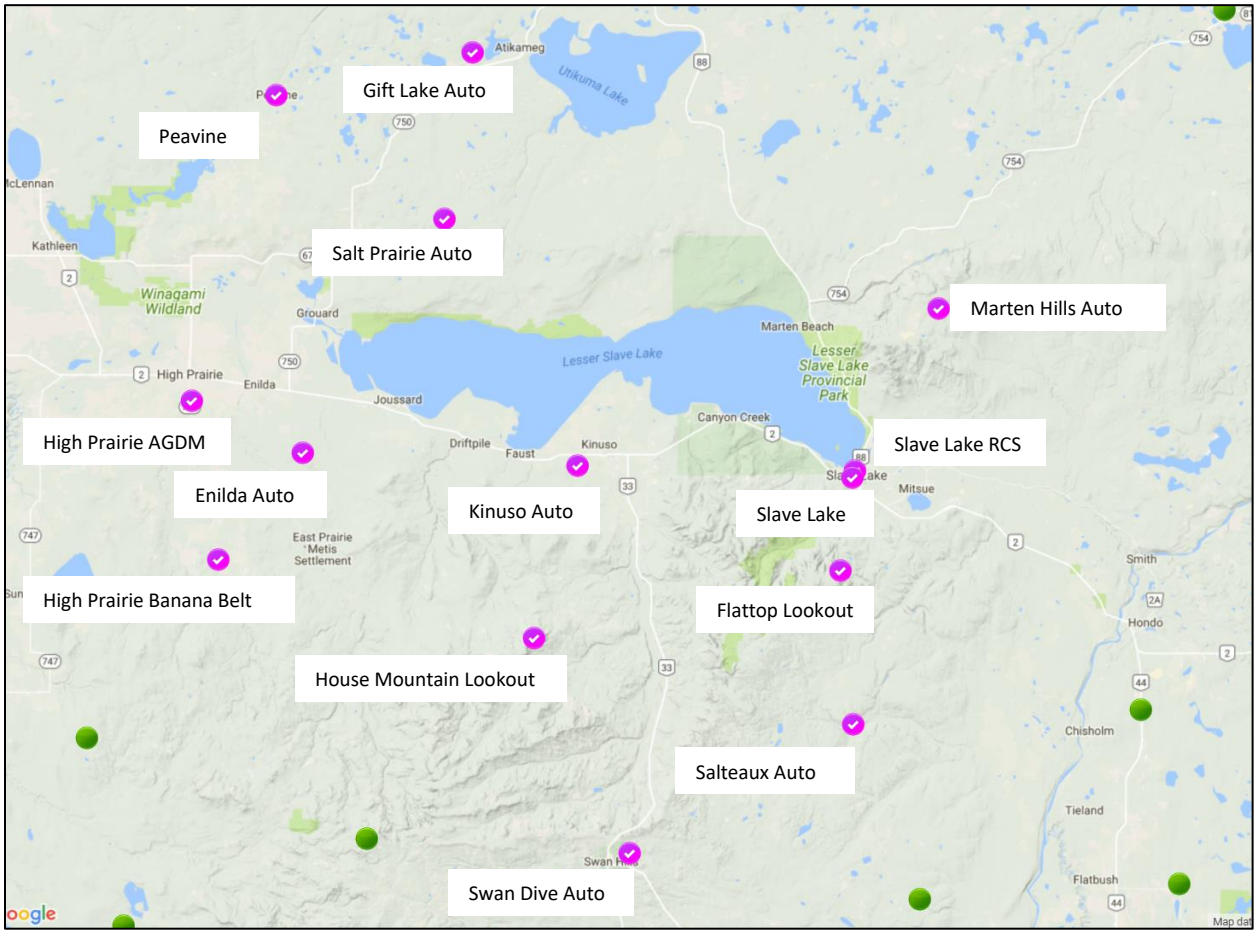

Figure 2. Weather stations in the Lesser Slave watershed.

3.4 Data Handling

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). Comparisons were also made to historic data as presented in the Lesser Slave Integrated Watershed Management Plan (IWMP) (PESL 2018) (Table 3).

3.5 Missing Data

In 2017, water quality data was missing at a few sites due to poor road conditions, and laboratory error (Table 2). In 2018, two samples were missed at two sites due to poor road conditions from flooding that prevented access to the site. In 2019, just one sample was missing at the Lower Swan River due to inaccessibility (Table 2).

Table 2. Missing water quality data, 2017 to 2019.

Site	Date	Measurement	Reason
Upper and Middle Swan River	May 24, 2017	EC, TP, TDP, NO_3-N, NO_3-N+NO_2-N, NO_2-N, TKN, TSS, TN, FC	The courier did not deliver one of the two coolers to the laboratory.
Lower East Prairie River	May 24, 2017	All	Road washed out, site inaccessible.
Middle Driftpile River	April 25, 2017	Total Dissolved Phosphorus	Laboratory reporting error. Value removed from analysis.
Lower Swan River	July 4, 2018	All including metals	Site inaccessible due to flooding.
Lower East Prairie River	June 18, 2018	All	Site inaccessible due to flooding.
Lower Swan River	April 17, 2019	All	Site inaccessible.

Lower Swan River site

In 2018, the missing data at Lower Swan River site on July 4 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 on the same date. Linear regression was used to estimate the TP and TSS concentration on July 4 at the Lower site (Appendix C-1).

In 2019, the missing data at the Lower Swan River site on April 17th probably resulted in an underestimation of the median and maximum total phosphorus, total suspended solids and metals concentrations. Total phosphorus and total metal concentrations is positively correlated with TSS. The Upper and Middle Swan River sites had high TSS concentrations (92 to 196 mg/L) on April 17th and the Lower site would also have had high TSS concentrations.

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[a]	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[a]	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
	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	**Where site-specific nutrient objectives do not exist:** 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	-	**Clear Flow Period**: 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).[c] **High Flow Period**: 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.[b]
	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	-	

[a]N ranges from 9 to 12; [b]TSS guideline is relevant to instream construction.

4.0 RESULTS

4.1 Precipitation

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 2019, generally, less precipitation was recorded at weather stations in the north (355.1 to 408.9 mm at Peavine, High Prairie AGDM, Kinuso Auto, Slave Lake RCS and Slave Lake) compared to weather stations in the south (416.2 to 579.2 mm at High Prairie Banana Belt, Flat Top Lookout, House Mountain Lookout and Swan Dive Auto). The two weather stations located in the eastern part of the watershed (Peavine and High Prairie AGDM) had amongst the lowest April to October precipitation (355.1 to 356.3 mm) of the 10 weather stations.

In 2019, five of the ten weather stations had less precipitation compared to 2018 and five had more precipitation than 2018 (Table 4). The higher elevation weather stations recorded considerably less precipitation in 2019 compared to 2018. Overall, precipitation in 2019 was similar to 2018 with 0.3% more precipitation in 2019 than 2018. Precipitation in 2019 was 16.1% less than 2017.

Table 4. Monthly total precipitation (mm) at Lesser Slave watershed, April-October, 2017 to 2019. 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	22.5	42.7	84.2	82.2	56.7	41.9	24.9	**355.1**
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	20.4	42.1	84.3	84.4	57.7	42.1	25.3	**356.3**
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	25.7	51.4	98	95.2	68.5	50	27.4	**416.2**
Kinuso Auto	2017	*47.0*[a]	47.2	67.2	91.4	26.1	61.6	30.9	371.4
	2018	*16.4*[a]	18.3	119.1	70.1	51.2	52.0	21.2	348.3
	2019	26.8	46.5	92.4	96.4	65.5	49.5	30.5	**407.6**
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	24.8	43.2	83.1	89.1	66.7	44.9	28.7	**380.5**
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	26.4	46.5	91.3	96.7	69	48.5	30.5	**408.9**
Salteaux Auto	2017	*119.0*[b]	59.1	113.6	134.9	24.3	67.4	32.7	551.0
	2018	*29.8*[b]	35.0	111.5	58.1	47.7	42.8	26.3	351.2
	2019	30.2	52.8	102.7	114.6	71.6	48.8	29.2	**449.9**
Flat Top 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	31.7	57.2	116	119.6	76.9	58	35.6	**495.0**
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	36.8	67.5	137	138.3	92.9	65.6	41.1	**579.2**
Swan Dive Auto	2017	*119.0*[b]	145.8	141.8	207.4	84.0	97.4	33.2	828.6
	2018	*29.8*[b]	39.2	167.2	153.6	92.0	60.4	37.4	579.6
	2019	31.6	63.4	119	138.2	87	50.1	29.2	**518.5**

[a] Estimated as average precipitation recorded at High Prairie AGDM and Slave Lake.

[b] Assumed to have similar precipitation as recorded at Flat Top Lookout.

4.2 Streamflow

Average daily streamflow data for 2017, 2018, and 2019 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), average daily streamflow for the April-October monitoring period was 9.7 m^3/s in 2017, 7.0 m^3/s in 2018 and 10.6 m^3/s in 2019. Peak discharge occurred on May 14 in 2017 when flow was 82.5 m^3/s during snowmelt, on July 4 in 2018 when the flow was 149 m^3/s during a rain event and in 2019 on July 26 (186 m^3/s) during a rain event (Figure 3). The second highest flow occurred on September 21 (69.5 m^3/s) in 2017, on May 8 in 2018 (29.0 m^3/s) and on June 21 in 2019 (66.0 m^3/s). Other significant flows (>30 m^3/s) occurred in response to rainfall events on May 25 (44.5 m^3/s), June 29 (40.2 m^3/s) and July 14 (31.8 m^3/s) in 2017; no other significant events were recorded in 2018. In 2019, other significant flows occurred on May 16 (30.2 m3/s) and June 26 (51.2 m^3/s). A period of low streamflows (<1 m^3/s) occurred from August 22 to September 10 at the Driftpile River in 2017. In 2018, low flows prevailed (about 2 m^3/s) from the beginning of August through October. In 2019, low flows prevailed for much of September and October, with an increase in flow from about 3 m^3/s to 16 m^3/s on October 26.

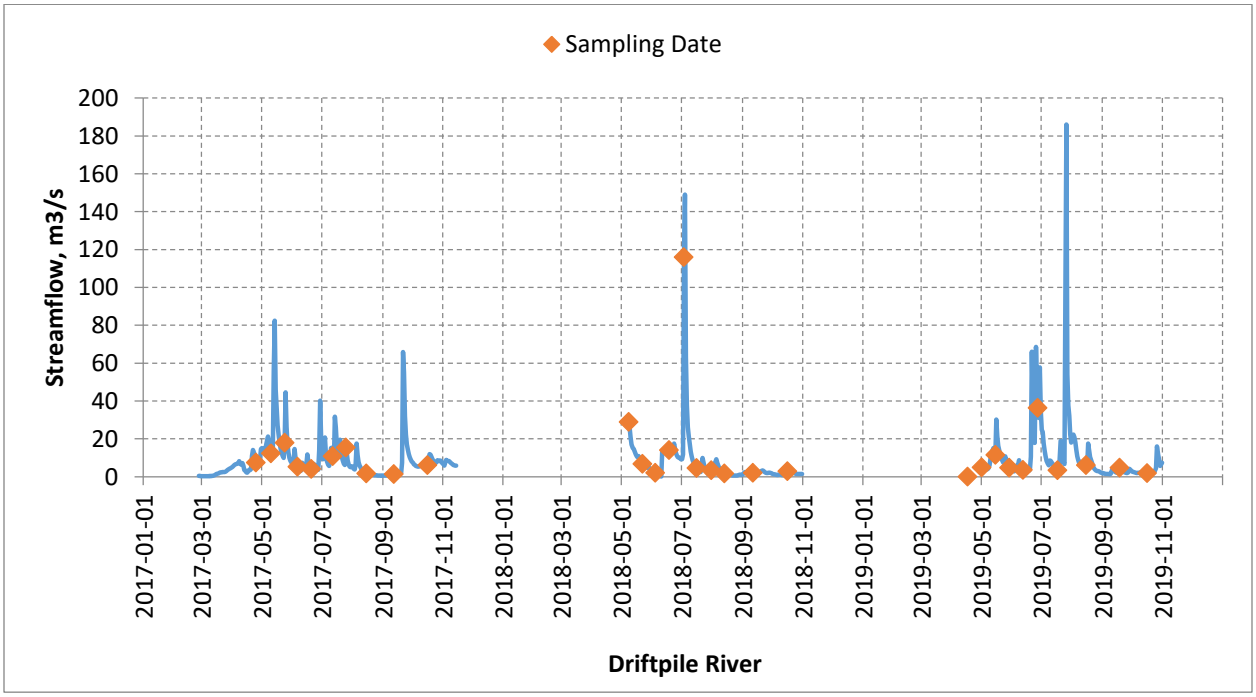

Figure 3. Average daily streamflow at Driftpile River, 2017-2019 (Near real-time flows (NRT) provided by AEP 2018, 2019, 2020).

At Swan River, average daily streamflow for the April-October monitoring period was 3.8 m^3/s in 2017, 1.47 m^3/s in 2018 and 3.2 m^3/s in 2019 at the Swan Hills site and 22.9 m^3/s (2017), 23.3 m^3/s (2018) and 37.9 m^3/s (2019) at the Kinuso site (Figure 4). Peak discharge occurred on May 13 in 2017 (29.7 m^3/s), on June 11 in 2018 (23.4 m^3/s) and on May 12 in 2019 (17.4 m^3/s) at Swan Hills. Note there were periods of missing data at the Swan Hills station periodically through 2018 and 2019. At Kinuso, peak discharge occurred on May 14 in 2017 (176.0 m^3/s), on June 13 in 2018 (498 m^3/s) and on July 26 in 2019 (507.0 m^3/s). Other significant flows at Kinuso (>80 m^3/s) occurred in response to rainfall events on May 7 (87.2 m^3/s), May 25 (109 m^3/s), June 29 (93.5 m^3/s) and July 25 (105.0 m^3/s) during 2017. In 2018, significant

flows greater than 80 m^3/s occurred on April 20 (106 m^3/s), May 1 (96.4 m^3/s) and July 4 (245 m^3/s). In 2019, significant flows greater than 80 m^3/s occurred on May 16 (83.6 m^3/s), June 29 (198 m^3/s) and July 28 (175 m^3/s). High flows recorded at Swan Hills generally trended with Kinuso, but streamflows were much smaller in comparison. In 2017, a period of prolonged low streamflow (<3 m^3/s) occurred from August 20 to September 19 at Swan River near Kinuso. In 2018, low flows prevailed from the middle of July through October. In 2019, low flows prevailed mainly through October, with flows increasing to 23.2 m^3/s on October 31 (the last reading of the year).

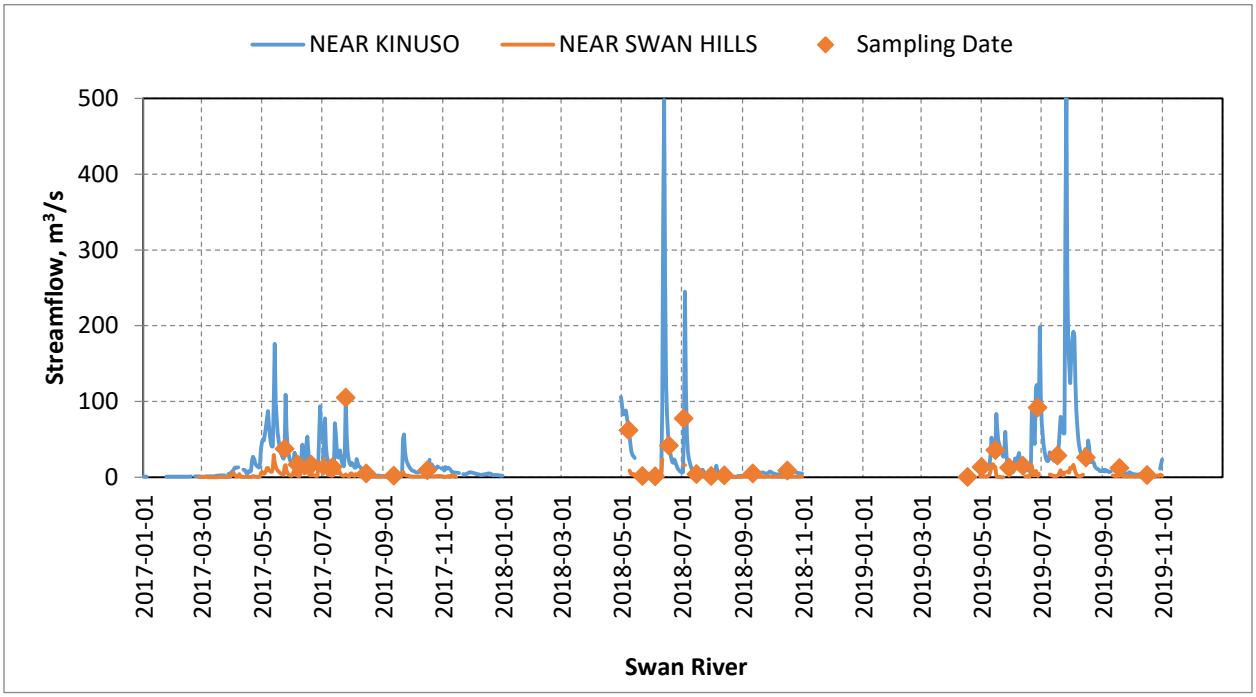

Figure 4. Average daily streamflow at Swan River, 2017-2019 (NRT-Flows provided by AEP, 2018, 2019, 2020).

At the East Prairie River (near Enilda), average daily streamflow for the April-October monitoring period was 12.8 m^3/s in 2017, 11.6 m^3/s in 2018 and 16.8 m^3/s in 2019. Peak discharge occurred on May 14 in 2017 (152.0 m^3/s), on July 4 in 2018 (234.0 m^3/s) and on July 26 in 2019 (155.0 m^3/s). Other significant flows (>40 m^3/s) were recorded on April 23 (41.6 m^3/s), May 25 (61.3 m^3/s) and September 22 (66.1 m^3/s) in 2017 and on June 15 (63.5 m^3/s) and July 22 (51.3 m^3/s) in 2018. In 2019, other significant flows (>40 m^3/s) were recorded on May 17 (47.2 m^3/s), June 22 (85.8 m^3/s), June 26 (136 m^3/s) and July 21 (42.4 m^3/s). In 2017, a period of prolonged low streamflow (<2 m^3/s) occurred from August 18 to September 19. In 2018, flows were similarly low from August through October. In 2019, extended periods of higher flows prevailed at the end of June and into July compared to the previous two years. Flows decreased to less than 4.0 m^3/s for a period of about two weeks in the middle of October.

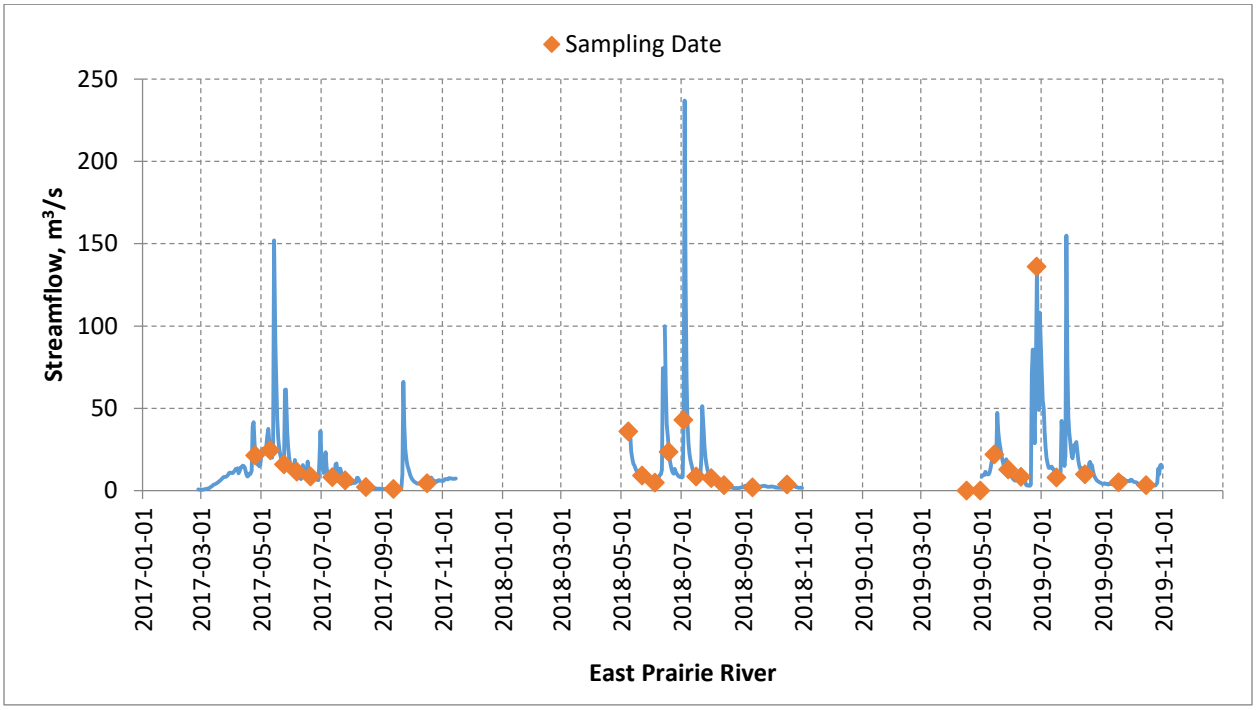

Figure 5. Average daily streamflow at East Prairie River, 2017-2019 (NRT-Flows provided by AEP, 2018, 2019, 2020).

At West Prairie River (near High Prairie), average daily streamflow for the April-October monitoring period was 10.7 m^3/s in 2017, 6.9 m^3/s in 2018 and 6.3 m^3/s in 2019. Peak discharge occurred on May 14 in 2017 (237.0 m^3/s), June 14 in 2018 (122 m^3/s) and June 29 (80.6 m^3/s) in 2019. Other significant flows (>30 m^3/s) were recorded on May 26 (38.6 m^3/s) and September 22 (35.3 m^3/s) in 2017, on June 12 (46.8 m^3/s), July 4 (55.4 $m^3/$) and July 22 (97.7 m^3/s) in 2018 and on July 3 (31.5 m^3/s) in 2019. In 2017, daily streamflows were relatively static for the period June 2 to September 21. In 2018, data was missing for much of August and into September. In 2019, flows were low (<3 m^3/s) from mid-August through October.

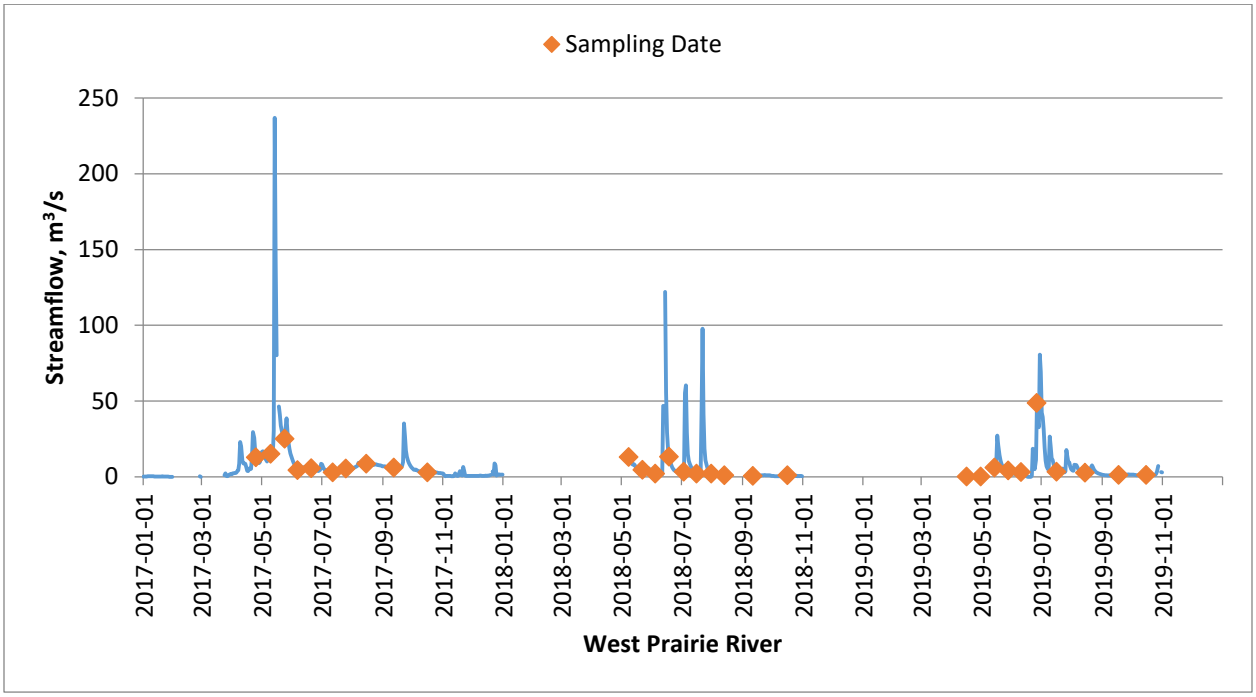

Figure 6. Average daily streamflow at West Prairie River, 2017-2019 (NRT-Flows provided by AEP, 2018, 2019, 2020).

At South Heart River, average daily streamflow for the April-October monitoring period was 1.0 m^3/s in 2017 and 6.4 m^3/s in 2018 and 3.4 m^3/s in 2019 at Peavine and 10.4 m^3/s in 2017, 16.5 m^3/s in 2018, and 11.7 m^3/s in 2019 at Big Prairie Settlement. Peak discharge occurred on May 16 (8.4 m^3/s) in 2017, on June 15 (28.5 m^3/s) in 2018, and on July 27 (30.0 m^3/s) at Peavine. At Big Prairie Settlement, peak discharge occurred on May 16 (57.8 m^3/s) in 2017, on June 18 (57.9 m^3/s) in 2018 and on July 2 (53.8 m^3/s) in 2019. Significant flows at Big Prairie Settlement (>30 m^3/s) occurred on May 4 (30.5 m^3/s) in 2017, and on May 8 (51.4 m^3/s), July 6 (53.7 m^3/s) and July 26 (46.1 m^3/s) in 2018. No significant flows (>30 m^3/s) were recorded at Big Prairie Settlement in 2019.

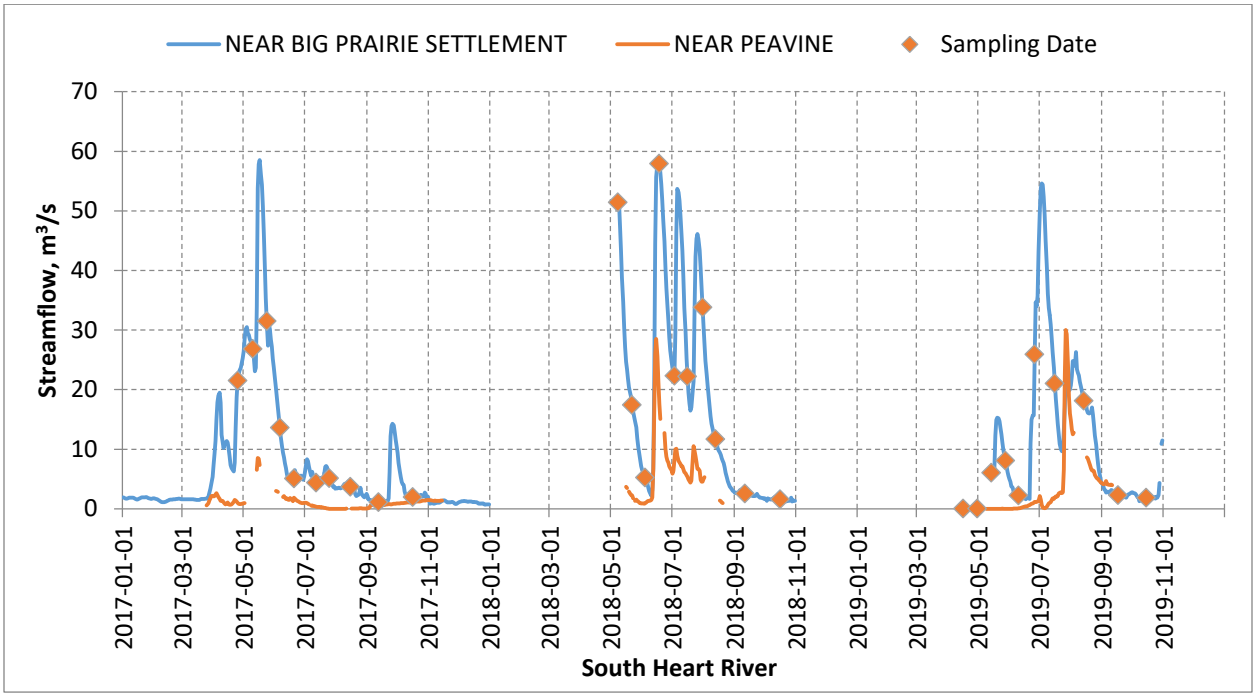

Figure 7. Average daily streamflow at South Heart River, 2017-2019 (NRT-Flows provided by AEP, 2018, 2019, 2020).

4.3 Routine Parameters

4.3.1 Swan River

In 2019, the median water temperature ranged from 9.9°C at the Upper Swan River site to 13.5°C at the Lower Swan River site (Table 5). Maximum water temperatures ranged from 14.2°C at the Upper site to 19.7°C at the Lower site. Median and maximum water temperatures in 2019 were the lowest (coolest) of the three monitoring years at the Swan River.

Median pH ranged from 8.34 at the Lower Swan River site to 8.47 at the Upper Swan River site and met the provincial aquatic life guideline in 2019 (Table 6). Maximum pH values ranged from 8.66 at the Lower site to 9.44 at the Middle site. In 2019, 1 of 10 samples (pH: 9.44, September 18) from the Middle site did not meet the provincial guideline for the protection of aquatic life (≥6.5 to ≤9.0). Median and maximum pH values in 2019 were the highest of the three monitoring years at the Swan River.

In 2019, median dissolved oxygen concentrations ranged from 9.45 mg/L at the Lower Swan River site to 10.71 mg/L at the Upper Swan River site (Table 7). Minimum DO concentrations ranged from 8.13 mg/L at the Lower site to 9.16 mg/L at the Upper site. The medians and all samples complied with provincial guidelines for the protection of aquatic life: ≥6.5 mg/L (chronic) and ≥5.0 mg/L (acute) at the three Swan River sites. Median and maximum dissolved oxygen concentrations in 2019 were the highest of the three monitoring years at the Swan River.

Median specific conductivity values ranged from 121 µS/cm at the Middle Swan River site to 138 µS/cm at the Lower Swan River site in 2019 (Table 8). Maximum conductivity values ranged from 172 µS/cm at the Upper site to 215 µS/cm at the Lower site. In 2019, all samples met the provincial guideline for safe irrigation (≤1,000 µS/cm, GoA 2018) at the three Swan River sites.

Table 5. Median, minimum and maximum water temperature at Lesser Slave Lake tributaries, April-October, 2017 and 2018.

Site	2017				2018				2019			
	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
Middle Swan	10	12.8	1.4	17.4	10	14.9	3.9	20.6	10	11.30	2.80	16.90
Lower Swan	10	13.6	2.7	17.5	9	17.5	4.9	20.5	9	13.50	3.70	19.70
Upper Driftpile	10	14.9	4.2	18.1	10	16.1	5.6	22.1	10	12.30	2.30	20.30
Middle Driftpile	10	14.3	2.9	17.4	10	16.0	4.7	21.5	10	11.95	2.30	20.80
Lower Driftpile	10	15.1	3.6	16.7	10	15.6	4.7	20.4	10	12.00	3.00	20.80
Upper East Prairie	10	15.4	4.4	19.0	10	16.0	4.0	24.0	10	11.55	2.70	21.10
Middle East Prairie	10	17.2	4.0	21.8	10	16.1	4.1	23.6	10	12.60	3.60	21.50
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
Middle West Prairie	10	14.3	2.2	20.3	10	14.6	3.7	21.4	10	12.05	1.80	18.40
Upper South Heart	10	17.1	4.6	19.9	10	16.0	3.8	21.0	10	14.70	4.90	20.20
Middle South Heart	10	16.0	3.7	19.7	10	16.0	3.3	21.3	10	14.00	3.40	20.90
Lower South Heart	10	15.1	2.0	23.5	10	15.6	4.0	22.0	10	13.00	2.70	21.00
Grouard Channel	10	17.3	1.3	21.7	10	16.2	3.7	21.5	10	14.65	3.10	20.70

Table 6. Median, minimum and maximum pH at Lesser Slave Lake tributaries, April-October, 2017 and 2018.

Site	2017				2018				2019			
	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
Middle Swan	10	8.14	7.88	11.56	10	7.95	7.44	8.94	10	8.35	7.59	9.44
Lower Swan	10	7.96	7.68	8.23	9	7.85	7.29	8.33	9	8.34	7.64	8.66
Upper Driftpile	10	8.09	7.51	8.79	10	8.07	7.26	8.48	10	8.44	7.47	8.76
Middle Driftpile	9	8.15	7.70	9.67	10	8.03	7.27	8.31	10	8.22	7.38	8.93
Lower Driftpile	10	8.00	7.70	8.82	10	7.65	7.12	8.04	10	8.26	7.36	8.69
Upper East Prairie	10	8.18	7.64	8.74	10	8.15	7.67	8.50	10	8.60	7.64	9.43
Middle East Prairie	10	7.98	7.71	8.18	10	8.12	7.66	8.74	10	8.42	7.58	9.07
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
Middle West Prairie	10	7.87	7.59	8.04	10	7.99	7.62	8.36	10	8.45	6.94	8.92
Upper South Heart	10	8.11	7.50	8.57	10	8.00	7.69	8.12	10	8.72	7.39	9.65
Middle South Heart	10	8.01	7.79	8.22	10	8.06	7.87	8.27	10	8.55	7.83	9.46
Lower South Heart	10	7.85	7.50	8.95	10	7.83	7.38	8.56	10	8.32	7.91	10.00
Grouard Channel	10	7.76	7.56	9.25	10	7.71	7.11	8.13	10	8.24	7.27	8.99

Table 7. Median, minimum and maximum dissolved oxygen at Lesser Slave Lake tributaries, April-October, 2017 and 2018. Red values indicate a guideline exceedance.

Site	2017				2018				2019			
	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
Middle Swan	10	9.70	8.72	11.20	10	9.45	7.38	11.73	10	10.33	8.75	12.18
Lower Swan	10	8.90	8.51	11.60	9	8.49	7.08	11.56	9	9.45	8.13	11.52
Upper Driftpile	10	9.35	8.70	11.90	10	9.45	7.74	12.13	10	10.28	8.36	12.56
Middle Driftpile	10	10.01	8.80	11.60	10	9.25	7.50	11.70	10	10.18	8.19	12.38
Lower Driftpile	10	8.90	8.10	11.40	10	8.73	6.88	11.52	10	9.77	7.83	11.74
Upper East Prairie	10	10.54	8.70	11.36	10	9.48	7.30	11.74	10	10.49	8.30	12.66
Middle East Prairie	10	9.83	8.20	11.69	10	8.98	7.20	11.94	10	9.78	8.08	12.32
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
Middle West Prairie	10	10.20	8.40	11.00	10	9.12	7.46	11.62	10	9.85	8.37	12.37
Upper South Heart	10	9.98	8.90	11.29	10	9.39	7.80	11.58	10	10.24	8.58	12.12
Middle South Heart	10	9.05	8.00	10.56	10	8.39	6.87	11.55	10	8.79	7.20	12.51
Lower South Heart	10	8.34	7.34	10.01	10	7.44	4.05	11.38	10	8.26	5.31	12.25
Grouard Channel	10	8.69	7.00	10.61	10	6.93	3.88	11.20	10	8.15	5.96	11.57

Table 8. Median, minimum and maximum conductivity at Lesser Slave Lake tributaries, April-October, 2017 and 2018.

Site	2017				2018				2019			
	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
Middle Swan	9	119	64	226	10	168	65	212	10	121	80	174
Lower Swan	9	111	65	268	9	186	66	256	9	138	92	215
Upper Driftpile	8	114	65	245	10	169	58	217	10	134	71	195
Middle Driftpile	10	113	69	269	10	183	63	249	10	143	66	211
Lower Driftpile	9	120	63	297	10	194	64	300	10	148	68	229
Upper East Prairie	9	197	114	313	10	271	89	339	10	188	89	263
Middle East Prairie	10	186	93	362	10	250	93	378	10	191	104	297
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
Middle West Prairie	10	188	88	457	10	243	90	490	10	184	90	332
Upper South Heart	10	336	294	419	10	266	253	422	10	345	281	432
Middle South Heart	10	359	300	407	10	327	252	422	10	353	298	501
Lower South Heart	10	232	126	337	10	274	136	388	10	271	169	386
Grouard Channel	10	217	146	289	10	276	152	367	10	237	167	351

4.3.2 Driftpile River

In 2019, median water temperature ranged from 11.95°C at the Middle Driftpile River site to 12.30°C at the Upper Driftpile River site (Table 5). Maximum water temperatures ranged from 20.8°C at the Middle and Upper sites to 20.30°C at the Upper site. Median and maximum water temperatures in 2019 were the lowest (coolest) of the three monitoring years at the Driftpile River.

In 2019, median pH ranged from 8.22 at the Middle Driftpile River site to 8.44 at the Upper Driftpile River site (Table 6) and met the provincial guideline for the protection of aquatic life (PAL) (≥6.5 to ≤9.0). Maximum pH values ranged from 8.69 at the Lower site to 8.93 at the Middle site. All pH samples in

2019 met the provincial PAL guideline at the Upper, Middle and Lower Driftpile River sites. Median and maximum pH values in 2019 were the highest of the three monitoring years at the Driftpile River.

In 2019, median dissolved oxygen concentrations ranged from 9.77 mg/L at the Lower Driftpile River site to 10.28 mg/L at the Upper Driftpile River site (Table 7). Minimum DO concentrations ranged from 7.83 mg/L at the Lower site to 8.36 mg/L at the Upper site. In 2019, the medians and all samples complied with provincial guidelines for the protection of aquatic life: ≥6.5 mg/L (chronic) and ≥5.0 mg/L (acute). Median and maximum dissolved oxygen concentrations in 2019 were the highest of the three monitoring years at the Driftpile River.

In 2019, median specific conductivity values ranged from 134 µS/cm at the Upper Driftpile River site to 148 µS/cm at the Lower Driftpile River site (Table 8). Maximum conductivity values ranged from 195 µS/cm at the Upper site to 229 µS/cm at the Lower site. All samples met the provincial guideline for safe irrigation (<1,000 µS/cm) (GoA 2018) in 2019.

4.3.3 East Prairie River

In 2019, median water temperature ranged from 11.55°C at the Upper East Prairie River site to 13.55°C at the Lower East Prairie River site (Table 5). Maximum water temperatures ranged from 20.1°C at the Lower site to 21.5°C at the Middle site. Median and maximum water temperatures in 2019 were the lowest (coolest) of the three monitoring years at the East Prairie River.

In 2019, median pH ranged from 8.08 at the Lower East Prairie River site to 8.60 at the Upper East Prairie River site and met the provincial guideline for the protection of aquatic life (PAL) (≥6.5 to ≤9.0) (Table 6). Maximum pH values ranged from 9.07 at the Middle site to 9.51 at the Lower site. In 2019, 2 of 10 samples (pH: 9.01 and 9.44) from Upper East Prairie River, 1 of 10 samples (pH: 9.07) from Middle East Prairie River and 2 of 10 samples (pH: 9.08 and 9.51) from Lower East Prairie River did not meet the provincial guideline for the protection of aquatic life. Median and maximum pH values in 2019 were the highest of the three monitoring years at the East Prairie River.

In 2019, median dissolved oxygen concentrations ranged from 9.24 mg/L at the Lower East Prairie site to 10.49 mg/L at the Upper East Prairie River site (Table 7). Minimum DO concentrations ranged from 6.02 mg/L at the Lower site to 8.30 mg/L at the Upper site. The medians and all samples complied with provincial guidelines for the protection of aquatic life: ≥6.5 mg/L (chronic) and ≥5.0 mg/L (acute) with the exception of two samples (6.10 and 6.02 mg/L) on June 26 and July 16 at the Lower East Prairie River that exceeded the chronic guideline.

Median specific conductivity values ranged from 188 µS/cm at the Upper East Prairie River site to 197 µS/cm at the Lower East Prairie River site (Table 8). Maximum conductivity values ranged from 263 µS/cm at the Upper site to 305 µS/cm at the Lower site. In 2019, all samples met the provincial guideline for safe irrigation (<1,000 µS/cm) (GoA 2018).

4.3.4 West Prairie River

In 2019, the median water temperature was 10.65°C at the Upper West Prairie River site and 12.05°C at the Middle West Prairie River site (Table 5). Maximum water temperature was 16.70°C at the Upper site and 18.40°C at the Middle site. Median and maximum water temperatures in 2019 were the lowest (coolest) of the three monitoring years at the West Prairie River.

In 2019, median pH was 8.42 at the Upper West Prairie River site and 8.45 at the Middle West Prairie River site, and met the provincial guideline for the protection of aquatic life (PAL) (≥6.5 to ≤9.0) (Table 6). The maximum pH was 9.15 at the Upper site and 8.92 at the Middle site. In 2019, all pH samples from West Prairie River met the provincial guideline for the protection of aquatic life (≥6.5 to ≤9.0) with the exception of Upper West Prairie River on October 15 (pH: 9.15). Median and maximum pH values in 2019 were the highest of the three monitoring years at the West Prairie River.

In 2019, the median dissolved oxygen concentration was 9.65 mg/L at the Upper West Prairie site and 9.85 mg/L at the Middle West Prairie River site (Table 7). The minimum DO concentration was 8.26 mg/L at the Upper site and 8.37 mg/L at the Middle site. The medians and all samples complied with provincial guidelines for the protection of aquatic life: ≥6.5 mg/L (chronic) and ≥5.0 mg/L (acute).

The median specific conductivity value was 144 µS/cm at the Upper West Prairie River site and 184 µS/cm at the Middle West Prairie River site (Table 8) in 2019. The maximum conductivity value was 229 µS/cm at the Upper site and 332 µS/cm at the Middle site. In 2019, all samples met the provincial guideline for safe irrigation (<1,000 µS/cm) (GoA 2018).

4.3.5 South Heart River and Grouard Channel

Median water temperature ranged from 13.00°C at the Lower South Heart River site to 14.70°C at the Upper South Heart River site in 2019 (Table 5). Maximum water temperatures ranged from 20.2°C at the Upper site to 21.0°C at the Lower site. Median and maximum water temperatures in 2019 were the lowest (coolest) of the three monitoring years at the South Heart River.

In 2019, median pH ranged from 8.32 at the Lower South Heart River site to 8.72 at the Upper South Heart River site, and met the provincial guideline for the protection of aquatic life (PAL) (≥6.5 to ≤9.0) at all sites (Table 6). Maximum pH values ranged from 9.46 at the Middle site to 10.00 at the Lower site. In 2019, 2 of 10 samples did not meet the provincial guideline for the protection of aquatic life (≥6.5 to ≤9.0) at each of the Upper (pH: 9.02 and 9.65), Middle (pH: 9.22 and 9.46) and Lower (pH: 9.49 and 10.00) sites. Median and maximum pH values in 2019 were the highest of the three monitoring years at the South Heart River.

Median dissolved oxygen concentrations ranged from 8.26 mg/L at the Lower South Heart site to 10.24 mg/L at the Upper South Heart River site (Table 7) in 2019. Minimum DO concentrations ranged from 5.31 mg/L at the Lower site to 8.58 mg/L at the Upper site. The medians and all individual samples complied with provincial guidelines for the protection of aquatic life: ≥6.5 mg/L (chronic) and ≥5.0 mg/L (acute) with the exception of two samples on June 26 and July 16 (5.99 mg/L and 5.31 mg/L, respectively) at the Lower South Heart River that exceeded the chronic guideline.

In 2019, median specific conductivity values ranged from 271 µS/cm at the Lower South Heart River site to 353 µS/cm at the Middle South Heart River site (Table 8). Maximum conductivity values ranged from 386 µS/cm at the Lower site to 501 µS/cm at the Middle site. All conductivity samples met the provincial guideline for safe irrigation (≤1,000 µS/cm) (GoA 2018).

At the Grouard Channel, the median water temperature was 14.65°C, minimum water temperature was 3.10°C and maximum was 20.70°C in 2019 (Table 5). Median and maximum water temperatures in 2019 were the lowest (coolest) of the three monitoring years at the Grouard Channel. The median pH was 8.24, minimum pH was 7.27 and the maximum pH was 8.99 (Table 6). Median and maximum pH values

in 2019 were the highest of the three monitoring years at the Grouard Channel. The median dissolved oxygen concentration was 8.15 mg/L, the minimum dissolved oxygen concentration was 5.96 mg/L and maximum was 11.57 mg/L (Table 7) in 2019. The median dissolved oxygen concentration met the provincial guideline for the protection of aquatic life (≥6.5 to ≤9.0); however, samples on July 16 and August 14 (5.96 mg/L and 6.35 mg/L, respectively) at the Grouard Channel exceeded the chronic guideline. The median conductivity was 237 µS/cm, minimum conductivity was 167 µS/cm and maximum conductivity was 351 µS/cm (Table 8). 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 2019, the median total phosphorus (TP) concentration ranged from 0.026 mg/L at the Upper Swan River site to 0.044 mg/L at the Lower Swan River site (Table 9). Maximum TP concentration ranged from 0.091 mg/L at the Upper site to 0.172 mg/L at the Lower site. Total dissolved phosphorus was often less than the detection limit of the analytical equipment (0.020 mg/L) at the three sites. The median total dissolved phosphorus was 0.010 mg/L at all three sites and the maximum TDP increased from the Upper to Lower site and ranged from 0.024 to 0.028 mg/L (maximum) (Table 10).

Table 9. Median, minimum and maximum total phosphorus concentrations at Lesser Slave Lake tributaries, April to October 2017, 2018 and 2019. Cells shaded green include derived values (Appendix C-1).

Site	2017				2018				2019			
	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
Middle Swan	9	0.034	0.010	0.410	10	0.039	0.029	0.940	10	0.035	0.010	0.137
Lower Swan	9	0.050	0.029	1.060	10 (9)	0.048	0.034	2.38 (0.170)	9	0.044	0.027	0.172
Upper Driftpile	8	0.039	0.010	0.148	10	0.047	0.028	0.970	10	0.039	0.026	0.160
Middle Driftpile	10	0.053	0.020	0.118	10	0.051	0.030	1.290	10	0.040	0.027	0.217
Lower Driftpile	9	0.045	0.024	0.108	10	0.046	0.031	1.280	10	0.043	0.030	0.305
Upper East Prairie	9	0.025	0.010	0.110	10	0.029	0.010	1.590	10	0.035	0.010	0.304
Middle East Prairie	10	0.086	0.010	0.241	10	0.076	0.032	0.480	10	0.090	0.043	0.983
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
Middle West Prairie	10	0.055	0.030	0.362	10	0.065	0.024	0.333	10	0.061	0.023	1.050
Upper South Heart	10	0.092	0.064	0.239	10	0.097	0.019	0.137	10	0.078	0.035	0.114
Middle South Heart	10	0.094	0.072	0.193	10	0.144	0.043	0.282	10	0.074	0.056	0.195
Lower South Heart	10	0.153	0.109	0.602	10	0.138	0.089	0.229	10	0.118	0.080	0.218
Grouard Channel	10	0.118	0.039	0.248	10	0.107	0.046	0.341	10	0.104	0.069	0.199

At the Middle Swan River site, the median TP concentration from 2017 to 2019 (0.034 to 0.039 mg/L) was lower compared to the historic[3] 1991-92 median (0.048 mg/L, Table 3). The maximum TP concentration in 2017 (0.410 mg/L) and 2018 (0.940 mg/L) at the Middle Swan River site was

[3] For the Swan River, samples were collected at Hwy 2 near Kinuso (AB07BJ0010) in 1991-92, corresponding to the Middle site in 2017 and 2018. In 2012-13, samples were collected near the confluence with Lesser Slave Lake (AB07BHJ0020), corresponding to the Lower site in 2017 and 2018.

higher compared to 2019 (0.137 mg/L) and the historic 1991-92 maximum TP (0.173 mg/L). At the Lower Swan River site, median TP concentration from 2017 to 2019 (0.044 to 0.050 mg/L) was lower than the historic 2012-13 median (0.060 mg/L, Table 3). The maximum TP concentration at the Lower Swan River site in 2017 (1.060 mg/L), 2018 (2.38 mg/L) and 2019 (0.172 mg/L) was 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).

Table 10. Median, minimum and maximum total dissolved phosphorus concentrations at Lesser Slave Lake tributaries, April to October 2017, 2018 and 2019.

Site	2017				2018				2019			
	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
Middle Swan	9	0.010	0.010	0.026	10	0.016	0.010	0.030	10	0.010	0.010	0.027
Lower Swan	9	0.010	0.010	0.028	9	0.023	0.010	0.035	10	0.010	0.010	0.028
Upper Driftpile	8	0.010	0.010	0.080	10	0.025	0.010	0.032	10	0.010	0.010	0.030
Middle Driftpile	9	0.010	0.010	0.028	10	0.025	0.010	0.035	10	0.010	0.010	0.029
Lower Driftpile	9	0.010	0.010	0.041	10	0.025	0.010	0.033	10	0.016	0.010	0.026
Upper East Prairie	9	0.010	0.010	0.021	10	0.010	0.010	0.238	10	0.010	0.010	0.025
Middle East Prairie	10	0.010	0.010	0.067	10	0.024	0.010	0.054	10	0.016	0.010	0.264
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
Middle West Prairie	10	0.022	0.010	0.132	10	0.028	0.010	0.066	10	0.022	0.010	0.039
Upper South Heart	10	0.051	0.010	0.165	10	0.069	0.010	0.187	10	0.040	0.010	0.075
Middle South Heart	10	0.034	0.010	0.165	10	0.052	0.010	0.082	10	0.037	0.010	0.147
Lower South Heart	10	0.023	0.010	0.169	10	0.050	0.010	0.088	10	0.038	0.021	0.052
Grouard Channel	10	0.010	0.010	0.120	10	0.051	0.010	0.279	10	0.036	0.010	0.059

4.4.2 Driftpile River

In 2019, the median TP concentration ranged from 0.039 mg/L at the Upper Driftpile River site to 0.043 mg/L at the Lower Driftpile River site (Table 9). Maximum TP concentrations ranged from 0.160 mg/L at the Upper site to 0.305 mg/L at the Lower Driftpile site. Maximum TP concentrations occurred on June 27 at the three Driftpile River sites concurrent with higher discharge (51 m^3/s) and the highest total suspended solids (TSS range: 220 to 551 mg/L). There was a strong, positive linear relationship between total phosphorus and total suspended solids at the Driftpile River (Pearson's correlation: r=0.97). In 2019, total phosphorus tended to increase from upstream to downstream, similar to 2017 and 2018.

The median total dissolved phosphorus was 0.010 mg/L at the Upper and Middle Driftpile River sites and 0.016 mg/L at the Lower Driftpile River site (Table 10). The maximum total dissolved phosphorus was similar at all Driftpile River sites (0.026 to 0.030 mg/L). The maximum total dissolved phosphorus occurred on April 17 at the Upper and Middle sites and May 1 at the Lower Driftpile River site.

At the Middle Driftpile River site, the median TP concentration from 2017 to 2019 (0.040 to 0.053 mg/L) was similar to the historical 1991-92 median (0.040 mg/L, Table 3). The maximum TP concentrations from 2018 (1.290 mg/L) and 2019 (0.217 mg/L) at the Middle Driftpile River was substantially higher than the historical 1991-92 maximum (0.129 mg/L) but the 2017 maximum TP (0.118 mg/L) was similar to the historic maximum TP from 1991-92.

The median TP concentration at the Lower Driftpile River site from 2017 to 2019 (0.043 to 0.046 mg/L) was similar to the historical[4] 2012-13 median (0.051 mg/L, Table 3). The maximum TP concentration in 2017 (0.108 mg/L) and 2019 (0.305 mg/L) was substantially lower than the historical maximum 2012-13 (0.873 mg/L); however, the maximum TP in 2018 (1.280 mg/L) was substantially higher than the 2017, 2019 and 2012-13 TP maximum.

4.4.3 East Prairie River

In 2019, the median TP concentration ranged from 0.035 mg/L at the Upper East Prairie River site to 0.125 mg/L at the Lower East Prairie River site (Table 9). Maximum TP concentrations ranged from 0.304 mg/L at the Upper site to 0.983 mg/L at the Middle East Prairie site. Maximum TP concentrations occurred on June 26/27 at the three sites. Total dissolved phosphorus (TDP) was often less than the detection limit of the analytical equipment (0.020 mg/L) at the three East Prairie River sites. The median total dissolved phosphorus ranged from 0.010 mg/L at the Upper and Lower sites to 0.016 mg/L at the Middle site. The maximum TDP ranged from 0.025 at the Upper site to 0.264 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=0.97).

The median TP concentration at the Middle East Prairie River from 2017 to 2019 (0.076 to 0.090 mg/L) was similar compared to the historic median[5] (2012-13: 0.076 mg/L, Table 3). The maximum TP concentration at the Middle East Prairie River site from 2017 to 2019 (0.241 to 0.983 mg/L) was lower compared to the historical 2012-13 maximum (1.120 mg/L).

4.4.4 West Prairie River

The median TP concentration was 0.022 mg/L at the Upper West Prairie River site and 0.061 mg/L at the Middle West Prairie River site (Table 9) in 2019. The maximum TP concentration was 0.761 mg/L at the Upper site and 1.050 mg/L at the Middle West Prairie site. Maximum TP concentrations occurred on June 26 at both sites. The median total dissolved phosphorus concentration was 0.022 mg/L at both sites and the maximum TDP concentration was 0.033 mg/L at the Upper site and 0.039 mg/L at the Middle West Prairie site. Maximum TDP concentration occurred on August 14 at both sites. There was a strong, positive linear relationship between total phosphorus and total suspended solids at the West Prairie River (Pearson's correlation: r=0.91).

The median TP concentration at the Middle West Prairie River site from 2017 to 2019 (0.055 to 0.065 mg/L) was similar compared to the historic[6] 2012-13 median (0.053 mg/L, Table 3). The maximum TP from 2017 (0.362 mg/L) and 2018 (0.333 mg/L) was lower than the historic maximum TP concentration from 2012-13 (1.150 mg/L) at the Middle West Prairie River site; however, the 2019 TP maximum (1.050 mg/L) was similar to the historic maximum TP.

[4] For the Driftpile River, samples were collected at Hwy 2 (AB07BH0010) in 1991-92, corresponding to the Middle site in 2017. In 2012-13, samples were collected near the confluence with Lesser Slave Lake (AB07BH0020), corresponding to the Lower site in 2017 and 2018.

[5] For the East Prairie River, samples were collected at Hwy 2 (AB07BF0285) in 2012-13.

[6] 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 2019.

4.4.5 South Heart River and Grouard Channel

In 2019 at the South Heart River, the median TP concentration ranged from 0.074 mg/L at the Middle South Heart site to 0.118 mg/L at the Lower site (Table 9). Maximum TP concentrations ranged from 0.114 mg/L at the Upper site to 0.218 mg/L at the Lower South Heart River site. Maximum TP concentrations occurred on September 17 at the Upper site, April 16 at the Middle site and on June 26 at the Lower site. The median total dissolved phosphorus concentration ranged from 0.037 mg/L at the Middle South Heart River site to 0.040 mg/L at the Upper South Heart River site. Maximum TDP concentrations ranged from 0.052 mg/L at the Lower site to 0.175 mg/L at the Upper site. Maximum TDP concentrations occurred on July 16 at the Upper site, August 14 at the Middle site and May 28 at the Lower site. There was a moderate, positive linear relationship between total phosphorus and total suspended solids at the South Heart River (Pearson's correlation: r=0.51).

The median TP concentration at the Lower South Heart River site from 2017 to 2019 (0.118 to 0.153 mg/L) was similar to the historical[7] medians from 1991-92 and 2012-13 (0.094 and 0.143 mg/L, Table 3). The maximum TP concentration at the Lower South Heart River site from 2017 to 2019 (0.218 to 0.602 mg/L) was within the range of the 1991-92 and 2012-13 medians (0.190 to 0.838 mg/L) (Table 3 and 9).

At the Grouard Channel site, the median TP concentration was 0.104 mg/L and ranged from 0.069 mg/L to 0.199 mg/L (Table 5). The median, minimum and maximum TP concentrations at the Grouard Channel in 2019 were similar to the Lower South Heart River site. The maximum TP concentration occurred on June 26. The median TDP at Grouard Channel in 2019 was 0.036 mg/L (range: 0.010 to 0.059 mg/L) and was lower than 2018 (median: 0.051, range: 0.010 to 0.279 mg/L) (Table 10). The maximum TDP concentration occurred on August 14 at the Grouard Channel.

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 results presented in the following section focus 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) concentration ranged from 0.415 mg/L at the Upper Swan River site to 0.550 mg/L at the Middle Swan River site (Table 13). The maximum TN concentrations ranged from 0.900 mg/L at the Upper site to 1.150 mg/L at the Middle site. Maximum TN concentrations occurred on June 27 at the three Swan River sites.

At the Lower Swan River site, the median TN concentration in 2017 (0.400 mg/L) and 2018 (0.410 mg/L) was lower than the historic 2012-13 median (0.518 mg/L, Table 3); however, the 2019 TN median (0.500 mg/L) was similar to the historic 2012-13 median. At the Lower Swan River site, the maximum TN concentration in 2018 (0.790 mg/L) and 2019 (1.140 mg/L) was lower than the historic 2012-13 maximum (2.110 mg/L, Table 3); however, the 2017 TN maximum (3.430 mg/L) was greater than the historic 2012-13 maximum.

[7] 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 2019.

At the Middle Swan River site, the median TN concentrations in 2017 (0.270 mg/L) and 2018 (0.395 mg/L) was lower than the historic 1991-92 median (0.431 mg/L, Table 3); however, the 2019 median TN (0.550 mg/L) was higher than the historic 1991-92 median. The maximum TN concentration from 2017 to 2019 (1.150 to 1.570 mg/L) was higher than the 1991-92 maximum TN (0.832 mg/L).

4.5.2 Driftpile River

The median TN concentration ranged from 0.500 mg/L at the Middle Driftpile River site to 0.575 mg/L at the Upper Driftpile River site in 2019 (Table 13). Maximum TN concentrations ranged from 1.420 mg/L at the Upper site to 1.710 mg/L at the Middle Driftpile site. Maximum TN concentrations occurred on June 27 at the Upper and Middle sites and April 17 at the Lower site.

The median TN concentration at Lower Driftpile River site from 2017 to 2019 (0.450 to 0.545 mg/L) was similar compared to the historic[8] 2012-13 median (0.546 mg/L, Table 3). Maximum TN concentrations from 2017 to 2019 (1.120 to 1.460 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 concentration in 2017 (0.455 mg/L) and 2019 (0.500 mg/L) was similar to the historic 1991-92 median (0.482 mg/L, Table 3); however, the 2018 TN (0.685 mg/L) was higher than the 2017, 2019 and 1991-92 TN median. The maximum TN concentration in 2017 (1.030 mg/L) and 2018 (1.130 mg/L) was similar compared to the historic 1991-92 maximum TN (0.976 mg/L); however, the 2019 maximum TN (1.710 mg/L) was higher than the 2017, 2018 and historic maximum TN.

Table 11. Median, minimum and maximum nitrate+nitrite nitrogen concentrations at the Lesser Slave Lake tributaries, April to October 2017, 2018 and 2019.

Site	2017				2018				2019			
	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
Middle Swan	9	0.011	0.011	0.044	10	0.011	0.003	0.040	10	0.011	0.011	0.067
Lower Swan	9	0.011	0.011	0.045	9	0.011	0.003	0.041	9	0.011	0.011	0.028
Upper Driftpile	8	0.011	0.010	0.025	10	0.011	0.011	0.049	10	0.011	0.011	0.054
Middle Driftpile	10	0.011	0.011	0.027	10	0.011	0.011	0.031	10	0.011	0.011	0.049
Lower Driftpile	9	0.011	0.011	0.198	10	0.011	0.011	0.025	10	0.011	0.011	0.062
Upper East Prairie	9	0.011	0.011	0.057	10	0.011	0.011	0.080	10	0.011	0.011	0.062
Middle East Prairie	10	0.011	0.011	0.075	10	0.011	0.011	0.075	10	0.011	0.011	0.340
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
Middle West Prairie	10	0.011	0.011	0.040	10	0.011	0.011	0.035	10	0.011	0.011	0.062
Upper South Heart	10	0.011	0.011	0.111	10	0.022	0.011	0.081	10	0.011	0.010	0.084
Middle South Heart	10	0.011	0.010	0.239	10	0.032	0.011	0.146	10	0.011	0.010	0.124
Lower South Heart	10	0.023	0.011	0.095	10	0.011	0.011	0.239	10	0.011	0.011	0.025
Grouard Channel	10	0.011	0.011	0.067	10	0.011	0.011	0.054	10	0.011	0.010	0.027

[8] For the Driftpile River, samples were collected at Hwy 2 (AB07BH0010) in 1991-92, corresponding to the Middle site in 2017 and 2018. In 2012-13, samples were collected near the confluence with Lesser Slave Lake (AB07BH0020), corresponding to the Lower site in 2017 and 2018.

Table 12. Median, minimum and maximum total Kjeldahl nitrogen concentrations at the Lesser Slave Lake tributaries, April to October 2017, 2018 and 2019.

Site	2017				2018				2019			
	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
Middle Swan	9	0.270	0.100	1.570	10	0.395	0.100	1.370	10	0.550	0.260	1.150
Lower Swan	9	0.400	0.100	3.430	9	0.410	0.100	0.780	9	0.500	0.400	1.140
Upper Driftpile	8	0.370	0.100	0.990	10	0.610	0.300	2.980	10	0.575	0.100	1.420
Middle Driftpile	10	0.455	0.100	1.030	10	0.675	0.220	1.100	10	0.500	0.100	1.710
Lower Driftpile	9	0.450	0.100	1.120	10	0.520	0.240	1.290	10	0.545	0.100	1.400
Upper East Prairie	9	0.100	0.100	0.830	10	0.390	0.100	1.010	10	0.425	0.100	1.100
Middle East Prairie	10	0.485	0.100	1.700	10	0.555	0.280	1.090	10	0.565	0.100	3.250
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
Middle West Prairie	10	0.805	0.560	1.890	10	0.725	0.360	1.520	10	0.655	0.300	1.860
Upper South Heart	10	1.425	0.670	2.240	10	1.150	0.890	1.620	10	1.330	0.640	2.040
Middle South Heart	10	1.295	0.720	2.070	10	1.295	0.910	1.900	10	1.155	0.370	2.030
Lower South Heart	10	1.240	0.910	3.650	10	1.205	0.960	1.570	10	1.055	0.700	5.750
Grouard Channel	10	0.860	0.340	2.420	10	1.040	0.560	1.520	10	0.870	0.100	1.820

Table 13. Median, minimum and maximum total nitrogen concentrations at the Lesser Slave Lake tributaries, April to October 2017, 2018 and 2019.

Site	2017				2018				2019			
	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
Middle Swan	9	0.270	0.100	1.570	10	0.395	0.100	1.370	10	0.550	0.260	1.150
Lower Swan	9	0.400	0.100	3.430	9	0.410	0.100	0.790	9	0.500	0.400	1.140
Upper Driftpile	8	0.370	0.100	0.990	10	0.610	0.300	2.980	10	0.575	0.100	1.420
Middle Driftpile	10	0.455	0.100	1.030	10	0.685	0.220	1.130	10	0.500	0.100	1.710
Lower Driftpile	9	0.450	0.100	1.120	10	0.520	0.240	1.290	10	0.545	0.100	1.460
Upper East Prairie	9	0.100	0.100	0.830	10	0.390	0.100	1.010	10	0.425	0.100	1.100
Middle East Prairie	10	0.485	0.100	1.730	10	0.555	0.280	1.160	10	0.565	0.100	3.290
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
Middle West Prairie	10	0.805	0.560	1.930	10	0.725	0.360	1.550	10	0.655	0.300	1.920
Upper South Heart	10	1.425	0.780	2.350	10	1.165	0.920	1.700	10	1.370	0.660	2.040
Middle South Heart	10	1.295	0.720	2.310	10	1.305	1.030	2.050	10	1.155	0.370	2.150
Lower South Heart	10	1.260	0.910	3.700	10	1.220	0.980	1.630	10	1.055	0.700	5.770
Grouard Channel	10	0.860	0.340	2.420	10	1.070	0.560	1.520	10	0.870	0.100	1.820

4.5.3 East Prairie River

In 2019, the median TN concentration ranged from 0.425 mg/L at the Upper East Prairie River site to 0.765 mg/L at the Lower East Prairie River site (Table 13). Maximum TN concentrations ranged from 1.100 mg/L at the Upper site to 3.290 mg/L at the Middle East Prairie River site. Maximum TN concentrations occurred on June 26/27 at the Upper and Middle sites and July 16 at the Lower site.

The median TN concentration at Middle East Prairie from 2017 to 2019 (0.485 to 0.565 mg/L) was similar to the historic median[9] (2012-13: 0.565 mg/L, Table 3). The maximum TN concentration from 2017 and 2018 (1.730 and 1.160 mg/L) was lower compared to the historic 2012-13 median (2.972 mg/L); however, the 2019 TN maximum (3.290 mg/L) was similar to the historic 2012-13 median.

4.5.4 West Prairie River

In 2019, the median TN concentration was 0.755 mg/L at the Upper West Prairie River site and 0.655 mg/L at the Middle West Prairie River site (Table 13). The maximum TN concentration was 1.600 mg/L at the Upper site and 1.920 mg/L at the Middle West Prairie site. Maximum TN concentrations occurred on June 26 at the Middle and Upper sites.

The median TN concentration at Middle West Prairie River from 2017 to 2019 (0.655 to 0.805 mg/L) was lower compared to the historic[10] 2012-13 median (0.859 mg/L, Table 3). The maximum TN concentration from 2017 to 2019 (1.550 to 1.930 mg/L) was substantially lower compared to the historical 2012-13 median (3.786 mg/L).

4.4.5 South Heart River and Grouard Channel

At the South Heart River in 2019, the median TN concentration ranged from 1.055 mg/L at the Lower South Heart River site to 1.370 mg/L at the Upper South Heart River site (Table 13). Maximum TN concentrations ranged from 2.040 mg/L at the Upper site to 5.770 mg/L at the Lower site. Maximum TN concentrations occurred on August 14 at the Middle site and on July 16 at the Upper and Lower sites.

Compared to historic data[11], the median TN concentration at the Lower South Heart River site from 2017 to 2019 (1.055 to 1.220 mg/L) was similar compared 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 2019 (1.630 to 5.770 mg/L) was higher compared to 1991-92 (1.955 mg/L) and 2012-13 (2.762 mg/L) (Table 3).

At Grouard Channel in 2019, the median TN concentration was 0.870 mg/L, and ranged from 0.100 to 1.820 mg/L. Median and maximum TN concentrations were lower at the Grouard Channel compared to the Lower South Heart River site. The maximum TN concentration occurred on April 30.

4.6 Total Suspended Solids (TSS)

4.6.1 Swan River

In 2019 the median total suspended solids (TSS) concentration ranged from 22 mg/L at the Middle Swan River site to 36 mg/L at the Lower Swan River site (Table 14). Maximum TSS concentrations ranged from 130 mg/L at the Upper site to 271 mg/L at the Lower site in 2019 and were considerably lower compared to 2018 maximum TSS concentrations (Table 14). A sample was not obtained at Lower Swan

[9] For the East Prairie River, samples were collected at Hwy 2 (AB07BF0285) in 2012-13.

[10] 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 in 2017 and 2018.

[11] 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 2019.

River on April 17 due to site accessibility. Therefore, the maximum TSS at the Lower Swan River site may have been higher. Maximum TSS concentrations occurred on May 15 at the Upper site, April 17 at the Middle site and June 27 at the Lower site.

At the Middle Swan River site, the median TSS concentration from 2017 to 2019 (11 to 22 mg/l) was similar to the historic 1991-92 median (21 mg/L, Table 3). The maximum TSS concentration from 2017 to 2019 (196 to 2110 mg/L) was substantially higher than the 1991-92 TSS maximum (187 mg/L).

Table 14. Median, minimum and maximum total suspended solids concentrations (mg/L) at the Lesser Slave Lake tributaries, April to October 2017, 2018 and 2019. Cells shaded green include derived values (Appendix C-1).

Site	2017				2018				2019			
	N	Median	Min	Max	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	8	2	183	10	19	2	1160	10	29	2	130
Middle Swan	9	12	2	1030	10	11	5	2110	10	22	2	196
Lower Swan	9	31	3	3060	10 (9)	16	7	6200 (257)	9	36	4	271
Upper Driftpile	8	15	2	254	10	14	3	2230	10	18	2	220
Middle Driftpile	10	39	2	153	10	18	6	3570	10	19	2	315
Lower Driftpile	9	37	5	136	10	16	4	3380	10	28	7	551
Upper East Prairie	9	15	2	168	10	9	4	3200	10	35	2	737
Middle East Prairie	10	83	2	445	10	37	5	576	10	85	7	1410
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	1650
Middle West Prairie	10	18	2	451	10	17	6	440	10	38	4	1280
Upper South Heart	10	3	2	16	10	5	4	12	10	5	2	9
Middle South Heart	10	15	7	75	10	72	8	125	10	13	6	79
Lower South Heart	10	75	26	818	10	30	21	144	10	39	12	450
Grouard Channel	10	25	5	270	10	15	4	143	10	21	6	230

4.6.2 Driftpile River

In 2019, the median TSS concentration ranged from 18 mg/L at the Upper Driftpile River site to 28 mg/L at the Lower Driftpile River site (Table 14). In 2019, maximum TSS concentrations ranged from 220 mg/L at the Upper site to 551 mg/L at the Lower site and were considerably lower compared to 2018 maximum TSS concentrations (Table 14). Maximum TSS concentrations occurred on June 27 at the three Driftpile River sites.

At the Middle Driftpile River site, the median TSS concentration from 2017 to 2019 (18 to 39 mg/L) was higher compared to the 1991-92 median (14 mg/L, Table 3). The maximum TSS concentration at the Middle Driftpile River site from 2017 to 2019 (153 to 3570 mg/L) was higher than 1991-92 maximum (128 mg/L).

4.6.3 East Prairie River

The median TSS concentration ranged from 35 mg/L at the Upper East Prairie River site to 98 mg/L at the Lower East Prairie River site in 2019 (Table 14). Maximum TSS concentrations ranged from 737 mg/L at the Upper site to 1410 mg/L at the Middle site. Maximum TSS concentrations occurred on June 26/27 at the three Eat Prairie River sites.

Compared to historic data[12], minimum TSS concentrations from 2017 to 2019 (2 to 7 mg/L) were lower compared to 2012-13 (12 mg/L, Table 3). Maximum TSS concentrations from 2017 to 2019 (445 to 1410 mg/L) were higher compared to historical 2012-13 data (1150 mg/L).

4.6.4 West Prairie River

In 2019, the median TSS concentration was 33 mg/L at the Upper West Prairie River site and 38 mg/L at the Middle West Prairie River site (Table 14). The maximum TSS concentration was 1650 mg/L at the Upper site and 1280 mg/L at the Middle site. The maximum TSS concentrations occurred on June 26 at both the Upper and Middle sites.

The minimum TSS concentrations at Middle West Prairie River from 2017 to 2019 (2 to 6 mg/L) was similar compared to the historic[13] 2012-13 minimum (6 mg/L, Table 3). The maximum TSS concentration from 2017 to 2019 (440 to 1280 mg/L) was similar compared to 2012-13 maximum TSS (1170 mg/L).

4.6.5 South Heart River and Grouard Channel

At the South Heart River, the median TSS concentration ranged from 5 mg/L at the Upper South Heart River site to 39 mg/L at the Lower South Heart River site (Table 14). The maximum TSS concentration ranged from 9 mg/L at the Upper site to 450 mg/L at the Lower site. In 2019, the maximum TSS concentrations occurred on May 14 at the Upper site, April 16 at the Middle site and July 16 at the Lower site.

Compared to historic data[14], the median TSS concentration at the Lower South Heart River site from 2017 to 2019 (30 to 75 mg/L) was higher compared to the 1991-92 median (10 mg/L). Maximum TSS concentration from 2017 to 2109 (144 to 818 mg/L) was higher compared to 1991-92 (132 mg/L) (Table 3 and 14).

At Grouard Channel in 2019, the median TSS concentration was 21 mg/L, and ranged from 6 to 230 mg/L (Table 14). The maximum TSS concentration occurred on June 26 at the Grouard Channel. The TSS median and range in 2019 was higher than 2018 but quite similar to 2017 (Table 14).

4.7 Fecal Coliform Bacteria (FCB)

4.7.1 Swan River

The median fecal coliform bacteria (FCB) count ranged from 11 cfu/100 mL at the Upper Swan River site to 42 cfu/100 mL at the Lower Swan River site (Table 15). Maximum FCB counts ranged from 64 cfu/100 mL at the Middle and Lower sites to 73 cfu/100 mL at the Upper site. Maximum FCB concentrations occurred on May 29 at the Upper site, July 17 at the Middle site and August 15 at the Lower site. No sample was obtained from the Lower site on April 17 due to site accessibility.

[12] For the East Prairie River, samples were collected at Hwy 2 (AB07BF0285) in 2012-13.

[13] 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 in 2017 and 2018.

[14] 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 2019.

Compared to historic data, the median FCB count at the Middle Swan River site from 2017 to 2019 (31 to 46 cfu/100 mL) was slightly lower compared to the 1991-92 median (60 cfu/100 mL) (Table 3). Maximum FCB counts from 2017 to 2019 (64 to 620 cfu/100 mL) were higher compared to 1991-92 (200 cfu/100 mL) (Table 3 and 15).

Table 15. Median, minimum and maximum fecal coliform bacteria counts (cfu/100 mL) at Lesser Slave Lake tributaries, April to October 2017, 2018 and 2019.

Site	2017				2018				2019			
	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
Middle Swan	9	46	5	250	10	31	9	620	10	32	1	64
Lower Swan	9	110	5	870	9	20	7	65	9	42	8	64
Upper Driftpile	8	20	8	160	10	12	1	2400	10	9	1	72
Middle Driftpile	10	20	3	200	10	16	1	220	10	10	1	52
Lower Driftpile	9	71	3	210	10	15	1	1100	10	15	1	90
Upper East Prairie	9	11	1	44	10	30	1	520	10	22	1	50
Middle East Prairie	10	45	5	200	10	43	7	110	10	38	17	210
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
Middle West Prairie	10	145	20	330	10	98	11	330	10	66	17	810
Upper South Heart	10	5	1	10	10	1	1	4	10	2	1	10
Middle South Heart	10	64	5	200	10	30	1	330	10	14	1	41
Lower South Heart	10	67	10	1400	10	17	2	360	10	44	10	580
Grouard Channel	10	20	5	48	10	3	1	54	10	11	1	100

4.7.2 Driftpile River

The median fecal coliform count ranged from 9 cfu/100 mL at the Upper Driftpile River site to 15 cfu/100 mL at the Lower Driftpile River site in 2019 (Table 15). Maximum FCB counts ranged from 52 cfu/100 mL at the Middle site to 90 cfu/100 mL at the Lower site. Maximum FCB concentrations occurred on June 27 at all Driftpile River sites.

Compared to historic data, the median FCB count at the Middle Driftpile River site from 2017 to 2019 (16 to 52 cfu/100 mL) was higher compared to the 1991-92 median (15 cfu/100 mL, Table 3). Maximum FCB counts from 2017 to 2019 (52 to 220 cfu/100 mL) were similar to 1991-92 (200 cfu/100 mL) (Table 3 and 15).

4.7.3 East Prairie River

In 2019, the median fecal coliform count ranged from 22 cfu/100 mL at the Upper East Prairie River site to 73 cfu/100 mL at the Lower East Prairie River site (Table 15). Maximum FCB counts ranged from 50 cfu/100 mL at the Upper site to 460 cfu/100 mL at the Lower site. Maximum FCB concentrations occurred on April 16 at the Upper site, June 10 at the Middle site and June 26 at the Lower site. Two of 10 samples (160 to 210 cfu/100 mL) at the Middle site exceeded the irrigation guideline (≤100 cfu/100 mL) and four of 10 samples (130 to 460 cfu/100 mL) exceeded the irrigation guideline at the Lower site.

4.7.4 West Prairie River

In 2019, the median fecal coliform count was 68 cfu/100 mL at the Upper West Prairie River site and 66 cfu/100 mL at the Middle West Prairie River site (Table 15). The maximum FCB count was 256 cfu/100 mL at the Upper site and 810 cfu/100 mL at the Middle site. Maximum FCB counts occurred on May 28 at the Upper site and June 26 at the Middle West Prairie River site. Three of 10 samples (200 to 256 cfu/100 mL) at the Upper site exceeded the irrigation guideline (≤100 cfu/100 mL) and two of 10 samples (160 and 810 cfu/100 mL) exceeded the irrigation guideline at the Middle site.

4.7.5 South Heart River and Grouard Channel

In 2019 at the South Heart River, the median fecal coliform count ranged from 2 cfu/100 mL at the Upper South Heart River site to 44 cfu/100 mL at the Lower South Heart River site (Table 15). The maximum FCB count ranged from 10 cfu/100 mL at the Upper site to 580 cfu/100 mL at the Lower site. The maximum FCB concentrations occurred on June 26 at the Upper and Lower sites and June 10 at the Middle site. Three of 10 samples (190 to 580 cfu/100 mL) at the Lower site exceeded the irrigation guideline (≤100 cfu/100 mL).

Compared to historic data, the median FCB count at the Lower South Heart River site in 2019 (44 cfu/100 mL) was higher compared to the 1991-92 median (20 cfu/100 mL, Table 3) and within the range of the 2017 and 2018 FCB counts (17 and 67 cfu/100 mL). Maximum FCB counts from 2017 to 2019 (360 to 1400 cfu/100 mL) were higher compared to 1991-92 maximum counts (264 cfu/100 mL) (Table 3 and 15).

In 2019 at the Grouard Channel, the median fecal coliform count was 11 cfu/100 mL, and ranged from 1 to 100 cfu/100 mL (Table 15). The maximum FCB concentration occurred on June 26 at the Grouard Channel. No fecal coliform bacteria samples at the Grouard Channel exceeded the irrigation guideline (≤100 cfu/100 mL).

4.8 Microbial Source Tracking

In 2019, the LSWC worked with Big Lakes County to better understand the sources of fecal coliform bacteria using bacterioides DNA marker analysis in the West Prairie River. Several observations were made regarding the sources of fecal coliform bacteria during the water quality monitoring program.

Methods (Sample Analysis)

The study took place during the open water season in 2019, from April through October. The sampling program was designed to be exploratory to help direct additional monitoring activity. The first year was also used to expand the DNA marker database to include beaver.

Water samples were shipped to the University of Alberta's School of Public Health where they were filtered, preserved and frozen prior to analysis. DNA extraction and Enterococcus enumeration was performed as per USEPA Method 1611. Microbial source tracking markers were detected and quantified from the same DNA extracts using quantitative PCR.

Enterococcus

Enterococcus is a gram–positive, oval or round bacterium that normally resides in the gastrointestinal tract of nearly all vertebrates, frequently belonging to the genus Streptococcus. There are also some environmental strains of Enterococcus. Enterococcus are expressed as CCE/100 mL.

Bacteroides

The human colon has the largest population of bacteria in the body (in excess of 10^{11} organisms per gram of wet weight), and the majority of these organisms are anaerobes; of these, ~25% are species of *Bacteroides* (in Wexler 2007). *Bacteroides* species are anaerobic, bile-resistant, non-spore-forming, gram-negative rods. Bacteroides are a genus of Gram-negative, obligate anaerobic bacteria. Bacteroides are expressed as gene copy number (CN)/100 mL.

Results

The results from the West Prairie River microbial source tracking scoping study are summarized in Table 16. No human bacteroides genetic markers (HF183) were detected in samples collected at West Prairie River.

Table 16. Summary of microbial source tracking results at the Upper and Middle West Prairie River sites, 2019.

Date, 2019	West Prairie River Site	Enterococcus	Human	Ruminant	Cow	Birds		Beaver
		Entero1	HF183	Rum2Bac	CowM3	LeeSG	CGO1	Beapol
		CCE/100mL	Copies/ 100 mL	Copies/ 100 mL	Copies/ 100 mL	Copies/ 100 mL	Copies/ 100 mL	Copies/ 100 mL
16-Apr	Upper	1693	ND	ND	ND	ND	ND	ND
	Middle	3167	ND	ND	ND	ND	ND	DNQ
14-May	Upper	765	ND	1206	ND	ND	ND	DNQ
	Middle	706	ND	ND	ND	ND	DNQ	DNQ
10-Jun	Upper	638	ND	4260	ND	ND	ND	DNQ
	Middle	887	ND	2076	ND	ND	DNQ	DNQ
16-Jul	Upper	330	ND	2274	ND	ND	ND	DNQ
	Middle	456	ND	DNQ	ND	ND	ND	DNQ
14-Aug	Upper	222	ND	4056	ND	ND	DNQ	DNQ
	Middle	617	ND	DNQ	ND	ND	ND	DNQ
17-Sep	Upper	911	ND	10422	ND	ND	ND	DNQ
	Middle	462	ND	ND	ND	ND	5100	DNQ
15-Oct	Upper	911	ND	32664	4740	ND	ND	DNQ
	Middle	2143	ND	ND	ND	ND	4716	DNQ

ND = Not detected
DNQ = detected, not quantifiable
CCE = Cell calibrator equivalents

In 2019, ruminant markers were detected in 9 of 14 samples (or in 64% of samples) at the West Prairie River. The ruminant marker was found in all of the monthly samples collected at the Upper West Prairie site (from May through October), and in samples collected in June, July and August at the Middle West Prairie site (although the July and August detections were not quantifiable). The cattle marker was found in only 1 of 14 samples (or in 7% of samples), at the Upper West Prairie site in October. Based on research experience, these ruminant detections are likely cattle as the ruminant marker is much more sensitive than the cattle marker (G. Banting, pers. comm). However, additional follow-up testing could be undertaken to increase the confidence in the result. Additional follow-up testing would require collecting cattle fecal samples from the area and testing them with both the ruminant and cattle markers. However, it cannot be guaranteed there is no guarantee that the cattle in the region carry the specific cattle marker that is present in the School of Public Health marker database. However, the cattle will undoubtedly carry the ruminant marker.

The Canada Goose marker was also prominent, found in 5 of 14 samples (or in 36% of samples). Four of the five samples having the goose marker were collected at the Middle West Prairie site. Canada Geese are commonly found in Alberta's rivers and lakes. Surprisingly, there were no Gull markers detected.

The Beaver marker was detected at low levels in almost all of the samples. This result should be interpreted cautiously as it was the first time running the beaver marker at the laboratory. There was no validation data yet in terms of the specificity of the marker (e.g., does it cross react with the feces of other animals?).

Comparison with Proposed Recreational Water Quality Criteria for Alberta

The overall water quality bacteriologically (based on *Enterococcus*) was good, though the samples seemed to have relatively high turbidity. Compared to the proposed recreational water quality criteria for Alberta (< 1280 CCE Enterococcus/ 100mL), 13 of 16 samples (81%) met the guideline (Graham Banting, Research Associate, School of Public Health, pers. comm.). Samples that did not meet the guideline were those collected on April 16 at the Upper and Middle sites, and the sample collected on October 15 at the Middle site.

Overall, the results suggest that livestock (cows), aquatic birds (Canada Geese), and possibly beaver are the major influences of fecal coliform bacteria at West Prairie River.

4.9 Metals (Swan River)

Appendix B-2 provides the raw data for metals analysis at the Swan 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).

Samples for metals analysis were collected at the upper, middle and lower sites of the Swan River in 2019. Results showed that 5 metals exceeded the provincial guideline for the protection of aquatic life (PAL) at the upper site, 6 metals exceeded guidelines at the middle site, and 5 metals exceeded guidelines at the lower site (Figure 8). In 2019, four metals exceeding guidelines that were common to all sites were total mercury, total lead, dissolved aluminum and dissolved iron and these were the metals that most often exceeded guidelines.

In addition to the four metals that exceeded the provincial PAL guideline at all three Swan River sites, total cadmium and total copper exceeded PAL guidelines at one or two Swan River sites. 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.

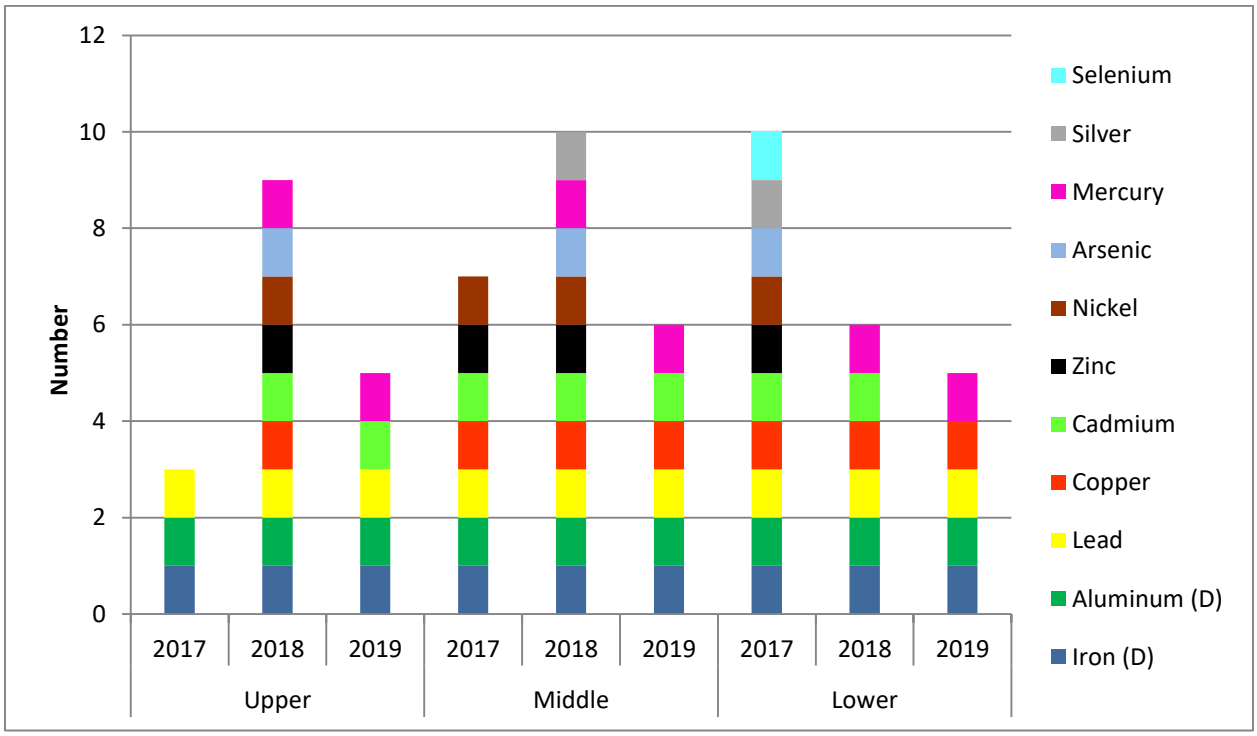

Figure 8. Number of metals detected that exceeded the provincial PAL guideline at the upper, middle and lower Swan River sites, June to September 2017 (samples: N=5), May to October 2018 (samples: N=7) and April to October (samples: N=7).

Total Cadmium

In 2019, total cadmium concentrations at the Swan River sites ranged from 0.0122 to 0.114 µg/L with a median of 0.0364 µg/L. Two of 20 samples (10%) exceeded the chronic total cadmium guideline in 2019 at the Swan River sites. The samples exceeded the chronic total cadmium guideline by a factor of 1.1 to 1.9 times. None of the samples had total cadmium concentrations below the detection limit of the analytical equipment. 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); average concentrations range from 0.2 to 0.3 mg/L (CCME 2014). Typical background dissolved cadmium concentrations in freshwaters of the United States ranged from 0.002 to 0.08 mg/L (Mebane 2010).

Total cadmium at the Swan River 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[15] (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 2019 was 3.76 µg/L (range: 1.48 to 7.41 µg/L). Three of 20 samples (15%) exceeded the acute total copper guideline in 2019 at the Swan River sites. The samples exceeded the acute total copper guideline by a factor of 1.0 to 1.5 times. None of the 20 samples had total copper concentrations below the detection limit of the analytical equipment. Two exceedances occurred at the lower Swan River site on May 15 and August 15 and one exceedance occurred at the middle Swan River site on April 17. Total copper at the Swan River 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). Elevated total copper concentrations at the Swan River corresponded with higher total suspended solids (TSS) ranging from 122 to 196 mg/L. At 11 interprovincial border 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 2019 was 0.866 µg/L (range: 0.143 to 2.43 µg/L). Eight of 20 samples (40%) exceeded the chronic total lead guideline in 2019 at the Swan River sites. Total lead exceedances occurred on April 17, May 15 and August 15 concurrent with the highest suspended solids concentrations. The samples exceeded the chronic total lead guideline by a factor of 1.2 to 2.4 times.

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.

[15] 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.

Total Mercury

Total mercury at the Swan River sites in 2019 ranged from 0.0025 to 0.0149 µg/L with a median of 0.0040 µg/L. Ten of 20 samples (50%) exceeded the chronic or acute total mercury guideline in 2019 at the Swan River sites. Eight samples exceeded the chronic total mercury PAL guideline by a factor of 1.1 to 3.0 times on all sample dates except July 17. Two samples exceeded the acute PAL guideline by a factor of 1.1 times on June 12 and August 15. Ten of the 20 samples (50%) had total mercury concentrations below the detection limit of the analytical equipment.

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).

Dissolved Aluminum

At the Swan River sites in 2019, dissolved aluminum ranged from 19.3 to 145 µg/L with a median of 50.7 µg/L. Eleven of 20 samples (55%) exceeded chronic or acute dissolved aluminum guideline in 2019 at the Swan River sites. Nine samples exceeded the chronic guideline by a factor of 1.0 to 1.4 times on all sample dates except October 16. Two samples exceeded the acute guideline by a factor of 1.1 to 1.5 on April 17. 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 2018 ranged between 7.1 to 8.2 and 26 to 105 mg/L, respectively.

Dissolved Iron

At the Swan River sites in 2019, dissolved iron ranged from 223 to 1680 µg/L with a median of 549 µg/L. Eighteen of 20 samples (90%) exceeded the chronic dissolved iron guideline in 2019 at the Swan River sites. Dissolved iron exceeded the chronic PAL guideline (300 µg/L) at all sites on all sample dates. Iron ranged from 223 to 777 µg/L at the Upper site, from 332 to 1520 µg/L at the Middle site and from 296 to 1680 µg/L at the Lower site. 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, FeS2) 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).

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 2019) 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.

An increasing trend in total metal concentrations and decreasing trend in dissolved metal concentrations from upstream to downstream was noted for the Swan River by Hutchinson et al. (2015). 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 third 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 2019. 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 3 monitoring results. Table 16 compares the 2017 to 2019 water quality to historic water quality at each of the five main tributaries.

Weather and Streamflow

- Overall, as measured by the 10 weather stations in the watershed, April to October precipitation in 2019 was similar to 2018 with 0.3% more precipitation in 2019.
- Average flow and peak flows increased in 2019 compared to 2018 at the Driftpile and Swan rivers. Peak flows occurred in late-July at the Driftpile and Swan rivers.
- Average flows increased but peak flows decreased at East Prairie and West Prairie rivers in 2019 compared to 2018. At East Prairie River, peak flows occurred in early- and late-July and at West Prairie River peak flows occurred in early July. There were fewer peak flow events at South Heart River in 2019 compared to 2018. At South Heart River, peak flows occurred in early-July at the Big Prairie Settlement site and late-July at the Peavine site.

Swan River

- All dissolved oxygen and conductivity samples met guidelines and 1 of 10 pH samples at the Middle site did not meet the guideline.
- Total phosphorus concentrations were highest at the Lower Swan River site and tended to increase from upstream to downstream.
- A strong correlation was observed between total phosphorus and total suspended solids (r=0.96).
- Maximum fecal coliform counts were lower at the Swan River in 2019 compared to 2017 and 2018; however, median counts were similar to 2018 and lower than 2017.
- There was a three-year trend for degrading (increasing concentrations or counts) median total nitrogen, minimum fecal coliform bacteria and maximum dissolved oxygen[16] (Table 16).
- There was a three-year trend for improving (decreasing concentrations or counts) median total phosphorus, maximum nitrate-nitrite and maximum fecal coliform bacteria (Table 16)

Metals

- At Swan River, there were 5 sampling events and 15 samples for metals in 2017, compared to 7 sampling events and 20 samples for metals in each of 2018 and 2019.
- In 2019, no sample was obtained at the Lower Swan River site on April 17th due to site inaccessibility; however, there were several metals exceedances at the Upper and Middle sites on April 17th. The overall number of metals exceeded and number of exceedances per metal may be under represented at the Lower Swan River site.
- Overall, the number of metals that exceeded guidelines decreased in 2019 compared to 2017 and 2018. In 2017 and 2018, ten metals exceeded guidelines and in 2019 six metals exceeded guidelines.
- From 2017 to 2019, the metals most often exceeding guidelines were dissolved iron, dissolved aluminum, total cadmium, total copper, total lead and total mercury.
- Total mercury did not exceed the PAL guideline in 2017. In 2018 it exceeded the guideline 10 times; with 5 chronic and 5 acute guideline exceedances. In 2019 total mercury exceeded the guideline 10 times; with 8 chronic and 2 acute guideline exceedances.
- Total selenium exceeded the PAL guideline once in 2017, but did not exceed the guideline in 2018 or 2019.

Driftpile River

- Routine parameters (dissolved oxygen, pH and conductivity) met guidelines in 2019.
- Median and maximum total phosphorus concentrations were lowest at the Upper site, and highest at the Lower site in 2019.
- Median and maximum total suspended solids concentration was lowest at the Upper site and highest at the Lower site in 2019.
- A strong correlation was observed between total phosphorus and total suspended solids (r=0.97) in 2019.
- Median fecal coliform bacteria counts at the Driftpile River site were similar from 2017 to 2019. Maximum fecal coliform bacteria counts were lower at the Driftpile River in 2019 compared to 2017 and 2018.
- There was a three-year trend for degrading (increasing temperate or concentrations) maximum water temperature and maximum total nitrogen (Table 16).

[16] Note: a degrading dissolved oxygen concentration indicates a decreasing (lower) concentration

- There was a three-year trend for improving (decreasing concentrations) median and maximum dissolved oxygen[17] and maximum dissolved phosphorus (Table 16).

East Prairie River

- All conductivity samples met the irrigation guideline. Two dissolved oxygen samples did not meet the chronic dissolved oxygen guideline at the Lower East Prairie River site in 2019.
- Median and maximum pH values were the highest of the three monitoring years in 2019 at East Prairie River and 5 of 30 pH samples did not meet the guideline.
- Median total phosphorus concentrations increased in the downstream direction in 2019 at East Prairie River; however, the maximum TP concentration (0.983 mg/l) occurred at the Middle site. Median TP concentrations in 2019 were higher than median concentrations in 2017 and 2018.
- Median TSS concentrations increased in the downstream direction in 2019 at East Prairie River; however, the maximum TSS concentration (1410 mg/l) occurred at the Middle site. Median TSS concentrations in 2019 were higher than median concentrations in 2017 and 2018.
- A strong correlation was observed between total phosphorus and total suspended solids (r=0.97) in 2019.
- Median and maximum fecal coliform bacteria counts increased in the downstream direction in 2019 at East Prairie River. Two of 10 samples at the Middle site and 4 of 10 samples at the Lower site exceeded the irrigation guideline for fecal coliform bacteria.
- There was a three-year trend for degrading (increasing concentrations or counts) minimum and maximum total suspended solids and minimum fecal coliform bacteria (Table 16).
- There was a three-year trend for improving (decreasing temperatures and counts) median water temperature, median fecal coliform bacteria and maximum dissolved oxygen (Table 16).

West Prairie River

- All dissolved oxygen and conductivity samples met guidelines in 2019. All pH samples met guideline with the exception of a sample at Upper West Prairie River.
- Median and maximum total phosphorus concentrations were higher at the Middle site compared to the Upper site. The maximum total phosphorus concentrations occurred on June 26th concurrent with the highest discharge and total suspended solids concentration.
- The median (33 to 38 mg/L) and maximum (1280 to 1650 mg/L) TSS at the Upper and Middle West Prairie River sites in 2019 was the highest of the three years (2017 to 2019). In 2019 the maximum TSS occurred on June 26th at both sites concurrent with peak flows.
- A strong correlation was observed between total phosphorus and total suspended solids (r=0.91) in 2019.
- The maximum fecal coliform bacteria count was highest at the Middle West Prairie River site (810 cfu/100 mL) in 2019, and the median count was highest at the Upper site (68 cfu/100 mL). Three of 10 samples (200 to 256 cfu/100 mL) at the Upper site and two of 10 samples (160 and 810 cfu/100 mL) at the Middle site exceeded the irrigation guideline.
- There was a three-year trend for improving (decreasing concentrations and counts) maximum dissolved oxygen, minimum total phosphorus, median and minimum total nitrogen and median fecal coliform bacteria (Table 16).

[17] Note: an improving dissolved oxygen concentration indicates an increasing (higher) concentration

Table 16. Comparison of 2017-2019 water quality results at middle or lower sites with corresponding historic data, Lesser Slave Lake tributaries. Cells shaded green include derived values from linear regression (Appendix C-1).

Indicator	Statistic	Driftpile					Trend	Swan					Trend
		1991-92	2012-13	2017[c]	2018[c]	2019[c]		1991-92	2012-13	2017[c]	2018[c]	2019	
		N=11	N=12	N=10	N=10	N=10		N=11	N=11	N=10	N=10 (9)	N=10	
Temperature, °C	Median	16.2	13.9	15.1	15.6	12.0	-	15.6	14.5	13.6	17.5	13.5	-
	Min	0.7	1.6	3.6	4.7	3.0	-	0.8	2.5	2.7	4.9	3.7	-
	Max	21.7	23.1	16.7	20.4	20.8	↑	20.0	22.6	17.5	20.5	19.7	-
Dissolved Oxygen, mg/L	Median	9.00	9.72	8.90	8.73	9.77	↓	8.60	9.60	8.90	8.49	9.45	-
	Min	8.00	7.54	8.10	6.88	7.83	-	8.16	7.80	8.51	7.08	8.13	-
	Max	13.18	15.32	11.40	11.52	11.74	↓	12.89	12.18	11.60	11.56	11.52	↑
Total Phosphorus, mg/L	Median	0.040	0.051	0.045[d]	0.046	0.043	-	0.048	0.060	0.050[d]	0.048	0.044	↓
	Min	0.022	0.020	0.024	0.031	0.030	-	0.026	0.031	0.029	0.034	0.027	-
	Max	0.129	0.873	0.108	1.280	0.305	-	0.173	0.084	1.060	2.380 (0.170)	0.172	-
Total Dissolved Phosphorus, mg/L	Median	0.016	0.012	0.010[d]	0.025	0.016	-	0.015	0.012	0.010[d]	0.023	0.010	-
	Min	0.007	0.005	0.010	0.010	0.010	-	0.010	0.009	0.010	0.010	0.010	-
	Max	0.021	0.025	0.041	0.033	0.026	↓	0.016	0.023	0.028	0.035	0.028	-
Total Nitrogen, mg/L	Median	0.482	0.546	0.450[d]	0.520	0.545	-	0.431	0.518	0.400[d]	0.410	0.500	↑
	Min	0.281	0.262	0.100	0.240	0.100	-	0.275	0.201	0.100	0.100	0.400	-
	Max	0.976	7.878	1.120	1.290	1.460	↑	0.832	2.110	3.430	0.790	1.140	-
Nitrate+Nitrite Nitrogen, mg/L	Median	0.003	0.006	0.011[d]	0.011	0.011	-	0.002	0.012	0.011[d]	0.011	0.011	-
	Min	0.001	0.003	0.011	0.011	0.011	-	0.001	0.003	0.011	0.003	0.011	-
	Max	0.026	0.148	0.198	0.025	0.062	-	0.032	0.093	0.045	0.041	0.028	↓
Total Suspended Solids, mg/L	Median	14	-	37[a]	16	28	-	21	-	31[a]	16	36	-
	Min	2	-	5	4	7	-	4	-	3	7	4	-
	Max	128	-	136	3380	551	-	187	-	3060	6200 (257)	271	-
Fecal Coliform Bacteria, cfu/100 mL	Median	15	-	71[a]	15	15	-	60	-	110[a]	20	42	-
	Min	2	-	3	1	1	-	20	-	5	7	8	↑
	Max	200	-	210	1100	90	-	200	-	870	65	64	↓

[a]Lower site, comparable to 1991-92 and 2012-13 historic data.

[b]Middle site, comparable to 2012-13 historic data.

[c]Lower site, comparable to 2012-13 historic data.

[d]N=9

Indicator	Statistic	South Heart						West Prairie					East Prairie				
		1991-92	2012-13	2017[a]	2018[a]	2019[b]	Trend	2012-13	2017[b]	2018[b]	2019[b]	Trend	2012-13	2017[b]	2018[b]	2019[b]	Trend
		N=9	N=12	N=10	N=10	N=10		N=12	N=10	N=10	N=10		N=12	N=10	N=10	N=10	
Temperature, °C	Median	16.5	12.7	15.1	15.6	14.0	↓	12.8	14.3	14.6	12.1	-	13.4	17.2	16.1	12.6	↓
	Min	12.0	0.9	2.0	4.0	3.4	-	3.3	2.2	3.7	1.8	-	1.3	4	4.1	3.6	-
	Max	21.5	21.3	23.5	22.0	20.9	↓	21.7	20.3	21.4	18.4	-	22.6	21.8	23.6	21.5	-
Dissolved Oxygen, mg/L	Median	-	8.36	8.34	7.44	8.79	-	9.95	10.20	9.12	9.85	-	9.62	9.83	8.98	9.78	-
	Min	-	6.05	7.34	4.05	7.20	-	8.23	8.40	7.46	8.37	-	7.94	8.20	7.20	8.08	-
	Max	-	15.87	10.01	11.38	12.51	↓	13.85	11.00	11.62	12.37	↓	16.04	11.69	11.94	12.32	↓
Total Phosphorus, mg/L	Median	0.094	0.143	0.153[d]	0.138	0.074	↓	0.053	0.055	0.065	0.061	-	0.076	0.086	0.076	0.090	-
	Min	0.050	0.079	0.109	0.089	0.056	↓	0.028	0.030	0.024	0.023	↓	0.028	0.010	0.032	0.043	-
	Max	0.190	0.838	0.602	0.229	0.195	↓	1.150	0.362	0.333	1.050	-	1.120	0.241	0.480	0.983	-
Total Dissolved Phosphorus, mg/L	Median	0.027	0.024	0.023	0.050	0.037	-	0.018	0.022	0.028	0.022	-	0.013	0.010	0.024	0.016	-
	Min	0.015	0.012	0.010	0.010	0.010	-	0.006	0.010	0.010	0.010	-	0.004	0.010	0.010	0.010	-
	Max	0.058	0.064	0.162	0.088	0.147	-	0.033	0.132	0.066	0.390	-	0.032	0.067	0.054	0.264	-
Total Nitrogen, mg/L	Median	1.197	1.187	1.260	1.220	1.155	↓	0.859	0.805	0.725	0.655	↓	0.565	0.485	0.555	0.565	-
	Min	1.052	0.724	0.910	0.980	0.370	-	0.411	0.560	0.360	0.300	↓	0.249	0.100	0.280	0.100	-
	Max	1.955	2.762	3.700	1.630	2.150	-	3.786	1.930	1.550	1.920	-	2.972	1.730	1.160	3.290	-
Nitrate+Nitrite Nitrogen, mg/L	Median	0.039	0.032	0.023	0.011	0.011	-	0.009	0.011	0.011	0.011	-	0.009	0.011	0.011	0.011	-
	Min	0.002	0.003	0.011	0.011	0.010	-	0.003	0.011	0.011	0.011	-	0.003	0.011	0.011	0.011	-
	Max	0.083	0.072	0.095	0.239	0.124	-	0.086	0.040	0.035	0.062	-	0.152	0.075	0.075	0.340	-
Total Suspended Solids, mg/L	Median	10	-	75	30	13	↓	-	18	17	38	-	-	83	37	85	-
	Min	5	-	26	21	6	↓	6	2	6	4	-	12	2	5	7	↑
	Max	132	-	818	144	79	↓	1170	451	440	1280	-	1150	445	576	1410	↑
Fecal Coliform Bacteria, cfu/100 mL	Median	20	-	67	17	14	↓	-	145	98	66	↓	-	45	43	38	↓
	Min	4	-	10	2	1	↓	-	20	11	17	-	-	5	7	17	↑
	Max	264	-	1400	360	41	↓	-	330	330	810	-	-	200	110	210	-

[a]Lower site, comparable to 1991-92 and 2012-13 historic data.

[b]Middle site, comparable to 2012-13 historic data.

[c]Lower site, comparable to 2012-13 historic data.

[d]N=9

Note: ↑ Degrading trend (increasing concentration with exception of dissolved oxygen where an increase in concentration represents an improving trend); ↓ Improving trend (decreasing concentration with the exception of dissolved oxygen where a decrease in concentration represents a degrading trend); – No trend

South Heart River and Grouard Channel

- At the Lower South Heart River, dissolved oxygen generally met guidelines, with the exception of two dissolved oxygen samples on June 26 and July 16 (5.99 mg/L and 5.31 mg/L, respectively) that exceeded the chronic guideline. In 2019, 2 of 10 pH samples did not meet the provincial guideline for the protection of aquatic life ($\geq$6.5 to $\leq$9.0) at each of the Upper, Middle and Lower sites.
- All pH and conductivity samples at the Grouard Channel met guidelines in 2019; however, dissolved oxygen samples on July 16 and August 14 (5.96 mg/L and 6.35 mg/L, respectively) exceeded the chronic guideline.
- Maximum total phosphorus concentration generally increased from the Upper South Heart River site to the Lower site. Median and maximum total phosphorus concentrations in 2019 were generally the lowest of the three monitoring years (2017 to 2019).
- Total suspended solids concentrations increased in the downstream direction at the South Heart River in 2019. In 2019, the maximum TSS concentrations occurred on May 14 at the Upper site, April 16 at the Middle site and July 16 at the Lower site.
- Total phosphorus and total suspended solids were moderately correlated at the South Heart River (r=0.51) in 2019.
- Maximum fecal coliform bacteria counts increased from upstream to downstream at the South Heart River in 2019. The median and maximum count was highest at the Lower site. Three of 10 samples (190 to 580 cfu/100 mL) at the Lower site exceeded the irrigation guideline (≤100 cfu/100 mL) in 2019. All fecal coliform bacteria samples at the Grouard Channel met irrigation guidelines in 2019. There was a three-year trend for improving (decreasing concentrations and counts) maximum dissolved oxygen, minimum total phosphorus, median and minimum total nitrogen and median fecal coliform bacteria (Table 16).
- At the South Heart River there was a three-year trend for improving (decreasing temperature, concentrations and counts) median and maximum water temperature, maximum dissolved oxygen, median, minimum and maximum total phosphorus, median total nitrogen, median, minimum and maximum total suspended solids and median, minimum and maximum fecal coliform bacteria (Table 16).

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 2019 should be undertaken for at least the next two years.
- Care should be taken to minimize missing data points in order to identify trends between sites on the same river, and between the main tributaries to Lesser Slave Lake. Sample collection should continue at regular frequency and intervals according to a pre-determined schedule.
- Streamflow data should be collected regularly, and care should be taken to maintain gauging stations when the system fails by undertaking regular inspection and maintenance.
- Further investigation of the sources of fecal coliform bacteria at West Prairie River could be undertaken to better differentiate between the more general ruminant marker and specific cattle marker present in the watershed.

Laboratory Analysis

- The laboratory should take care to ensure that all detection limits of the analytical equipment are less than associated water quality guidelines so that exceedences may be determined (e.g., total boron). The LSWC should confirm detection limits with the laboratory at the beginning of the monitoring season.

Communication of Results

- Disseminate the results of the monitoring among partners.

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APPENDIX A. WATER MONITORING SAMPLE LOCATIONS, 2017-2019.

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. RAW DATA, 2019.

B-1. Routine Monitoring 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 mg/L	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/ 100mL
Upper West Prairie	16-Apr-19	09:00:00	7.15		71	12.50	94.7	0.8	0.222	0.027	0.025	0.025	0.005	1.060	223	1.090	80
Mid West Prairie	16-Apr-19	09:30:00	7.75		90	12.37	95.4	1.8	0.464	0.024	0.049	0.049	0.005	1.560	114	1.610	20
Mid South Heart	16-Apr-19	10:00:00	7.94		353	11.66	95.5	4.0	0.195	0.039	0.010	0.010	0.005	1.680	79	1.680	1
Upper South Heart	16-Apr-19	10:35:00	7.39		352	12.12	101.7	4.9	0.105	0.034	0.010	0.010	0.005	1.630	9	1.630	1
Lower South Heart	16-Apr-19	11:10:00	8.34		191	10.25	81.5	2.9	0.106	0.030	0.025	0.025	0.005	1.330	47	1.350	10
Lower East Prairie	16-Apr-19	12:20:00	7.49		113	10.55	86.7	4.0	0.137	0.010	0.068	0.068	0.005	0.280	155	0.350	30
Badger Crk – dup. Lower East Prairie		`			113				0.116	0.021	0.066	0.066	0.005	0.880	178	0.950	10
Grouard Channel	16-Apr-19	11:55:00	7.83		185	10.60	84.7	3.1	0.112	0.033	0.021	0.010	0.005	0.100	33	0.100	1
Upper East Prairie	16-Apr-19	14:00:00	7.64		89	12.66	100.7	2.7	0.131	0.025	0.062	0.062	0.005	1.030	191	1.090	50
Mid East Prairie	16-Apr-19	13:10:00	7.68		104	11.77	97.2	4.3	0.257	0.021	0.097	0.097	0.005	1.040	344	1.140	30
Upper Swan	17-Apr-19	09:50:00	7.65	138	111	12.59	98.4	1.6	0.074	0.020	0.010	0.003	0.005	0.320	92	0.320	1
Mid Swan	17-Apr-19	10:25:00	7.59	119	80	12.18	69.8	2.8	0.137	0.026	0.067	0.067	0.005	0.900	196	0.960	1
Lower Swan	17-Apr-19	No Sample															
Lower Driftpile	17-Apr-19	12:15:00	7.36		68	11.74	93.8	3.0	0.240	0.024	0.062	0.062	0.005	1.400	366	1.460	1
Mid Driftpile	17-Apr-19	12:40:00	7.38		66	12.38	97.3	2.3	0.178	0.029	0.049	0.049	0.005	1.540	245	1.590	1
Upper Driftpile	17-Apr-19	13:00:00	7.47		71	12.56	98.4	2.3	0.082	0.030	0.053	0.054	0.005	0.820	135	0.870	1
Upper West Prairie	30-Apr-19	9:25	7.82		107	11.50	93.5	3.9	0.059	0.028	0.010	0.011	0.005	0.650	32	0.650	44
Mid West Prairie	30-Apr-19	10:00	6.94		123	11.74	96.2	4.7	0.060	0.027	0.010	0.011	0.005	0.560	57	0.560	50
Mid South Heart	30-Apr-19	10:20	7.83		353	10.80	91.1	5.3	0.126	0.044	0.010	0.011	0.005	1.500	21	1.500	6
Upper South Heart	30-Apr-19	10:50	7.65		338	11.83	102.3	6.6	0.079	0.046	0.010	0.011	0.005	1.340	8	1.340	1
Lower South Heart	30-Apr-19	11:20	7.91		181	10.75	88.8	5.0	0.104	0.038	0.010	0.011	0.005	0.970	47	0.970	12
Lower East Prairie	30-Apr-19	12:10	7.53		140	10.70	87.7	4.6	0.095	0.027	0.010	0.011	0.005	0.850	69	0.850	4
Grouard Channel	30-Apr-19	11:50	7.27		189	10.94	89.8	4.7	0.166	0.037	0.010	0.011	0.005	1.820	140	1.820	6
Upper East Prairie	30-Apr-19	13:10	8.15		147	11.81	97.1	4.4	0.035	0.024	0.010	0.011	0.005	0.450	21	0.450	12
Mid East Prairie	30-Apr-19	12:35	7.58		140	11.49	96.6	5.6	0.075	0.027	0.010	0.011	0.005	0.950	57	0.950	20

Site	Date	Time	pH	TDS mg/L	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/ 100mL
Upper Swan	01-May-19	10:00	8.13		137	12.58	99.1	2.1	0.023	0.010	0.010	0.011	0.005	0.360	5	0.360	1
Mid Swan	01-May-19	10:35	8.12		115	12.16	97.2	3.2	0.034	0.023	0.010	0.011	0.005	0.380	10	0.380	4
Lower Swan	01-May-19	11:05	7.64		119	11.52	96.1	4.9	0.044	0.025	0.010	0.011	0.005	0.500	19	0.500	8
Lower Driftpile	01-May-19	12:20	7.72		116	11.34	95.4	5.2	0.047	0.026	0.010	0.011	0.005	0.450	23	0.450	6
Mid Driftpile	01-May-19	12:40	8.16		117	11.92	98.6	4.6	0.044	0.027	0.010	0.011	0.005	0.580	13	0.580	12
Upper Driftpile	01-May-19	13:00	7.74		112	12.19	99.0	4.0	0.034	0.026	0.010	0.011	0.005	0.840	9	0.840	18
Upper West Prairie	14-May-19	9:00	8.24		135	9.51	94.2	10.4	0.058	0.021	0.010	0.011	0.005	0.610	45	0.610	71
Mid West Prairie	14-May-19	9:35	7.94		173	9.90	97.7	11.8	0.066	0.021	0.010	0.011	0.005	0.550	48	0.550	17
Mid South Heart	14-May-19	10:00	8.34		501	8.71	87.0	12.3	0.090	0.032	0.010	0.011	0.005	1.090	17	1.090	3
Upper South Heart	14-May-19	10:40	8.48		432	10.15	101.4	12.1	0.076	0.035	0.010	0.011	0.005	1.070	9	1.070	1
Lower South Heart	14-May-19	11:20	8.11		277	8.41	82.6	11.6	0.117	0.039	0.010	0.011	0.005	0.880	41	0.880	67
Lower East Prairie	14-May-19	11:40	7.89		165	8.97	87.8	11.5	0.134	0.010	0.010	0.011	0.005	0.600	184	0.600	16
Grouard Channel	14-May-19	12:05	8.00		232	8.29	84.5	13.5	0.105	0.026	0.010	0.011	0.005	0.570	105	0.570	29
Upper East Prairie	14-May-19	13:30	8.12		147	10.47	99.7	9.9	0.067	0.010	0.010	0.011	0.005	0.290	97	0.290	7
Mid East Prairie	14-May-19	12:45	8.45		155	9.77	96.5	11.8	0.193	0.010	0.010	0.011	0.005	0.460	284	0.460	17
Upper Swan	15-May-19	9:50	8.26	130	102	11.13	98.0	6.2	0.075	0.010	0.010	0.011	0.005	0.330	130	0.330	1
Mid Swan	15-May-19	10:25	8.16	94	102	10.71	97.8	8.3	0.064	0.010	0.021	0.011	0.005	0.410	87	0.430	1
Lower Swan	15-May-19	11:10	8.25	94	100	10.46	96.6	9.0	0.084	0.010	0.028	0.028	0.005	0.460	123	0.480	25
Lower Driftpile	15-May-19	12:40	8.34		99	10.30	96.5	9.5	0.078	0.010	0.010	0.011	0.005	0.540	103	0.540	1
Mid Driftpile	15-May-19	13:10	8.20		104	10.45	98.2	9.6	0.067	0.010	0.010	0.011	0.005	0.470	73	0.470	1
Badger Crk – Dup. Mid Driftpile									0.075	0.010	0.010	0.011	0.005	0.400	81	0.400	14
Upper Driftpile	15-May-19	13:40	8.46		100	10.71	99.6	9.2	0.040	0.010	0.010	0.011	0.005	0.520	55	0.520	1
Upper West Prairie	28-May-19	9:00	8.11		153	8.75	93.5	14.0	0.045	0.010	0.010	0.011	0.005	0.790	31	0.790	256
Mid West Prairie	28-May-19	9:35	8.33		195	8.91	97.7	16.0	0.051	0.010	0.010	0.011	0.005	0.990	29	0.990	64
Mid South Heart	28-May-19	10:05	8.47		446	7.93	87.8	16.7	0.063	0.032	0.010	0.011	0.005	1.220	10	1.220	13
Upper South Heart	28-May-19	10:40	8.64		397	9.68	107.6	16.8	0.035	0.021	0.010	0.011	0.005	1.100	3	1.100	1
Lower South Heart	28-May-19	11:15	8.29		281	8.00	91.5	18.4	0.125	0.052	0.010	0.011	0.005	1.070	19	1.070	15
Lower East Prairie	28-May-19	12:20	7.79		196	7.80	88.2	17.4	0.124	0.010	0.010	0.011	0.005	1.040	149	1.040	96
Grouard Channel	28-May-19	11:45	8.22		294	8.00	89.8	18.1	0.088	0.037	0.010	0.011	0.005	1.330	15	1.330	1
Upper East Prairie	28-May-19	13:40	8.39		208	8.86	101.2	18.0	0.030	0.010	0.010	0.011	0.005	0.530	23	0.530	9

Site	Date	Time	pH	TDS mg/L	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/ 100mL
Mid East Prairie	28-May-19	12:55	8.14		189	8.54	99.5	19.3	0.097	0.010	0.010	0.011	0.005	0.630	121	0.630	40
Upper Swan	29-May-19	9:25	8.13		137	9.79	101.1	12.7	0.028	0.010	0.010	0.011	0.005	0.630	29	0.630	73
Mid Swan	29-May-19	10:15	8.14		142	8.75	96.7	16.5	0.035	0.010	0.010	0.011	0.005	0.590	21	0.590	36
Lower Swan	29-May-19	11:00	7.94		139	8.41	95.2	17.3	0.041	0.010	0.010	0.011	0.005	0.400	36	0.400	42
Lower Driftpile	29-May-19	12:15	7.96		145	8.11	94.2	18.7	0.035	0.010	0.010	0.011	0.005	0.550	26	0.550	10
Mid Driftpile	29-May-19	12:45	8.10		141	8.48	99.3	19.3	0.036	0.010	0.010	0.011	0.005	0.640	16	0.640	6
Upper Driftpile	29-May-19	13:15	8.24		136	8.77	102.5	18.8	0.034	0.010	0.010	0.011	0.005	0.620	8	0.620	6
Upper West Prairie	10-Jun-19	9:00	8.46		167	9.59	98.4	13.2	0.044	0.010	0.010	0.011	0.005	0.600	35	0.600	200
Mid West Prairie	10-Jun-19	9:35	8.65		301	9.93	103.7	14.5	0.045	0.010	0.010	0.011	0.005	0.300	16	0.300	160
Mid South Heart	10-Jun-19	10:00	8.52		407	8.86	95.2	15.7	0.075	0.042	0.010	0.011	0.005	0.980	12	0.980	41
Upper South Heart	10-Jun-19	10:40	8.73		398	10.39	112.8	16.4	0.061	0.044	0.022	0.011	0.005	1.180	2	1.210	3
Lower South Heart	10-Jun-19	11:10	8.99		386	7.84	81.8	14.4	0.135	0.037	0.010	0.011	0.005	1.000	37	1.000	210
Lower East Prairie	10-Jun-19	12:15	8.42		244	9.50	101.0	15.2	0.091	0.010	0.010	0.011	0.005	0.100	104	0.100	220
Grouard Channel	10-Jun-19	11:45	8.58		351	9.34	100.7	15.7	0.101	0.035	0.010	0.011	0.005	0.300	23	0.300	32
Upper East Prairie	10-Jun-19	13:35	8.54		210	10.50	102.3	13.3	0.010	0.010	0.010	0.011	0.005	0.100	16	0.100	48
Mid East Prairie	10-Jun-19	12:45	8.56		226	9.79	104.8	15.4	0.099	0.010	0.010	0.011	0.005	0.100	112	0.100	210
Upper Swan	12-Jun-19	9:40	8.55	116	159	10.14	106.2	13.8	0.022	0.010	0.010	0.011	0.005	0.470	17	0.470	12
Mid Swan	12-Jun-19	10:25	8.44	113	148	9.43	103.4	16.5	0.027	0.010	0.010	0.011	0.005	0.510	13	0.510	34
Lower Swan	12-Jun-19	11:15	8.18	121	151	9.19	103.0	17.7	0.033	0.010	0.010	0.011	0.005	0.440	22	0.440	50
Bager Crk – Dup. Lower Swan				120					0.036	0.010	0.010	0.011	0.005	0.430	21	0.430	1
Lower Driftpile	12-Jun-19	12:20	8.17		150	8.74	101.1	18.9	0.035	0.021	0.010	0.011	0.005	0.100	16	0.100	44
Mid Driftpile	12-Jun-19	12:50	8.24		144	9.10	106.4	19.3	0.031	0.010	0.010	0.011	0.005	0.100	9	0.100	10
Upper Driftpile	12-Jun-19	13:20	8.41		137	9.34	109.9	19.7	0.026	0.010	0.010	0.011	0.005	0.100	6	0.100	20
Upper West Prairie	26-Jun-19	8:55	8.38		84	9.76	97.6	10.9	0.761	0.022	0.010	0.011	0.005	1.600	1650	1.600	210
Mid West Prairie	26-Jun-19	9:30	8.62		133	8.91	89.0	12.3	1.050	0.023	0.062	0.062	0.005	1.860	1280	1.920	810
Mid South Heart	26-Jun-19	10:00	8.57		390	8.39	93.0	17.1	0.064	0.038	0.010	0.011	0.005	0.370	12	0.370	20
Upper South Heart	26-Jun-19	10:35	8.88		385	10.33	116.8	17.8	0.051	0.041	0.024	0.024	0.005	0.640	2	0.660	10
Lower South Heart	26-Jun-19	11:15	8.01		199	5.99	64.1	15.1	0.218	0.021	0.010	0.011	0.005	0.700	258	0.700	580
Lower East Prairie	26-Jun-19	12:20	8.01		166	6.10	63.7	14.4	0.413	0.010	0.021	0.011	0.005	1.250	769	1.270	460
Grouard Channel	26-Jun-19	11:45	8.18		215	7.04	77.6	16.8	0.199	0.010	0.027	0.027	0.005	0.670	230	0.690	100

Site	Date	Time	pH	TDS mg/L	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/ 100mL
Upper East Prairie	26-Jun-19	13:35	8.91		105	10.86	103.4	9.8	0.304	0.010	0.010	0.011	0.005	1.100	737	1.100	50
Mid East Prairie	27-Jun-19	8:45	8.21		112	9.32	93.6	11.2	0.983	0.264	0.340	0.340	0.005	3.250	1410	3.290	160
Upper Swan	27-Jun-19	10:10	8.51		106	10.78	105.6	10.7	0.091	0.023	0.010	0.011	0.005	0.900	101	0.900	20
Mid Swan	27-Jun-19	10:40	8.26		91	10.48	104.3	12.0	0.115	0.027	0.010	0.011	0.005	1.150	134	1.150	44
Lower Swan	27-Jun-19	11:20	8.34		92	9.45	98.1	13.5	0.172	0.028	0.010	0.011	0.005	1.140	271	1.140	48
Lower Driftpile	27-Jun-19	12:50	7.97		76	9.87	98.5	12.5	0.305	0.024	0.010	0.011	0.005	1.340	551	1.340	90
Mid Driftpile	27-Jun-19	13:20	7.93		78	10.44	104.3	12.4	0.217	0.028	0.010	0.011	0.005	1.710	315	1.710	52
Upper Driftpile	27-Jun-19	13:40	8.02		76	10.49	106.0	13.0	0.160	0.022	0.010	0.011	0.005	1.420	220	1.420	72
Upper West Prairie	16-Jul-19	9:10	8.53		130	8.26	91.8	16.7	0.046	0.010	0.010	0.011	0.005	0.720	52	0.720	16
Mid West Prairie	16-Jul-19	9:50	8.57		142	8.37	95.2	18.4	0.074	0.010	0.010	0.011	0.005	0.660	69	0.660	24
Mid South Heart	16-Jul-19	10:10	8.83		342	7.20	85.8	20.9	0.056	0.010	0.010	0.011	0.005	0.640	13	0.640	22
Upper South Heart	16-Jul-19	10:45	9.65		300	8.91	105.4	20.2	0.040	0.010	0.010	0.011	0.005	2.040	4	2.040	8
Lower South Heart	16-Jul-19	11:20	8.16		169	5.31	63.8	21.0	0.125	0.043	0.022	0.022	0.005	5.750	450	5.770	14
Badger Crk – Dup. Lower South Heart									0.157	0.050	0.022	0.011	0.005	0.840	30	0.860	20
Lower East Prairie	16-Jul-19	12:25	8.14		202	6.02	71.7	20.1	0.161	0.054	0.010	0.011	0.005	1.730	92	1.730	50
Grouard Channel	16-Jul-19	12:00	8.26		167	5.96	71.4	20.7	0.115	0.038	0.010	0.011	0.005	1.190	19	1.190	1
Upper East Prairie	16-Jul-19	13:40	8.66		220	8.30	101.0	21.1	0.029	0.010	0.010	0.011	0.005	0.100	15	0.100	20
Mid East Prairie	16-Jul-19	13:00	8.74		193	8.08	98.3	21.5	0.061	0.010	0.010	0.011	0.005	0.240	42	0.240	36
Upper Swan	17-Jul-19	10:00	8.88		142	9.16	98.9	14.2	0.022	0.010	0.010	0.011	0.005	0.100	30	0.100	30
Mid Swan	17-Jul-19	10:35	8.81	132	127	8.75	97.8	16.9	0.034	0.023	0.010	0.011	0.005	0.260	15	0.260	64
Lower Swan	17-Jul-19	11:15	8.55	138	138	8.13	95.0	19.7	0.044	0.021	0.010	0.011	0.005	0.420	31	0.420	62
Lower Driftpile	17-Jul-19	12:40	8.58		156	7.83	94.7	20.8	0.038	0.010	0.010	0.011	0.005	0.260	22	0.260	34
Badger Crk – Dup. Lower Driftpile									0.037	0.010	0.010	0.011	0.005	0.370	19	0.370	18
Mid Driftpile	17-Jul-19	13:05	8.64		153	8.19	99.3	20.8	0.033	0.010	0.010	0.011	0.005	0.330	13	0.330	24
Upper Driftpile	17-Jul-19	13:30	8.76		147	8.36	100.3	20.3	0.040	0.010	0.010	0.011	0.005	0.560	9	0.560	10
Upper West Prairie	14-Aug-19	9:00	8.67		190	8.68	93.2	15.0	0.058	0.033	0.010	0.011	0.005	1.060	13	1.060	41
Mid West Prairie	14-Aug-19	9:30	8.32		259	8.75	90.4	16.4	0.062	0.039	0.010	0.011	0.005	1.270	9	1.270	68
Mid South Heart	14-Aug-19	10:00	8.80		298	7.53	84.7	18.0	0.137	0.147	0.109	0.124	0.015	2.030	47	2.150	17
Upper South Heart	14-Aug-19	10:35	8.79		295	8.58	97.0	17.9	0.109	0.075	0.038	0.038	0.005	1.640	2	1.680	4
Lower South Heart	14-Aug-19	11:15	8.66		264	8.10	92.4	18.7	0.080	0.042	0.010	0.011	0.005	1.600	12	1.600	71

Site	Date	Time	pH	TDS mg/L	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/ 100mL
Lower East Prairie	14-Aug-19	12:15	8.24		199	6.81	76.5	17.0	0.126	0.037	0.010	0.011	0.005	1.120	51	1.120	150
Grouard Channel	14-Aug-19	11:45	8.42		242	6.35	72.1	18.3	0.103	0.059	0.010	0.011	0.005	1.430	7	1.430	15
Upper East Prairie	14-Aug-19	13:10	8.75		168	8.85	99.9	17.4	0.067	0.010	0.010	0.011	0.005	0.910	68	0.910	35
Mid East Prairie	14-Aug-19	12:50	8.38		216	8.50	98.5	19.3	0.082	0.029	0.010	0.011	0.005	0.850	39	0.850	72
Upper Swan	15-Aug-19	10:10	8.42	120	110	9.39	99.3	14.2	0.058	0.024	0.010	0.011	0.005	0.710	55	0.710	12
Mid Swan	15-Aug-19	10:55	8.59	121	102	9.01	98.2	15.9	0.063	0.010	0.010	0.011	0.005	0.610	65	0.610	30
Lower Swan	15-Aug-19	11:40	8.37	120	99	8.44	90.2	16.2	0.100	0.010	0.010	0.011	0.005	0.670	122	0.670	64
Lower Driftpile	15-Aug-19	13:25	8.35		161	8.02	91.5	17.9	0.064	0.026	0.010	0.011	0.005	0.670	204	0.670	34
Mid Driftpile	15-Aug-19	13:50	8.93		148	8.48	96.2	17.8	0.070	0.010	0.010	0.011	0.005	0.480	51	0.480	10
Badger Crk – Dup. Mid Driftpile									0.062	0.024	0.010	0.011	0.005	0.660	72	0.660	10
Upper Driftpile	15-Aug-19	14:15	8.64		132	8.67	98.9	17.7	0.049	0.010	0.010	0.011	0.005	0.590	27	0.590	8
Upper West Prairie	17-Sep-19	9:10	8.70		229	9.70	93.1	10.0	0.022	0.010	0.010	0.011	0.005	0.500	9	0.500	65
Mid West Prairie	17-Sep-19	9:50	8.82		332	9.79	96.0	11.2	0.023	0.010	0.010	0.011	0.005	0.650	4	0.650	100
Mid South Heart	17-Sep-19	10:15	9.46		310	9.79	96.8	11.7	0.072	0.028	0.050	0.050	0.005	1.030	12	1.080	15
Upper South Heart	17-Sep-19	11:00	8.71		284	9.61	98.6	13.0	0.114	0.055	0.074	0.084	0.011	1.320	5	1.400	1
Lower South Heart	17-Sep-19	11:40	10.00		331	9.97	95.3	10.3	0.118	0.024	0.010	0.011	0.005	1.040	36	1.040	190
Lower East Prairie	17-Sep-19	12:50	9.51		276	9.53	96.5	12.7	0.037	0.010	0.010	0.011	0.005	0.680	22	0.680	130
Grouard Channel	17-Sep-19	12:20	8.84		295	7.52	77.4	13.6	0.069	0.021	0.010	0.011	0.005	0.880	7	0.880	27
Upper East Prairie	17-Sep-19	14:00	9.43		214	9.71	100.0	13.2	0.034	0.010	0.010	0.011	0.005	0.390	46	0.390	23
Mid East Prairie	17-Sep-19	14:40	9.00		285	9.87	105.0	13.4	0.049	0.010	0.010	0.011	0.005	0.490	10	0.490	57
Upper Swan	18-Sep-19	10:00	8.70	126	135	10.63	99.4	9.1	0.010	0.010	0.010	0.011	0.005	0.680	11	0.680	9
Mid Swan	18-Sep-19	10:45	9.44	147	130	10.18	97.7	10.6	0.024	0.010	0.010	0.011	0.005	0.630	24	0.630	19
Lower Swan	18-Sep-19	11:30	8.66	143	141	9.80	95.0	11.2	0.055	0.010	0.010	0.011	0.005	0.640	54	0.640	31
Lower Driftpile	18-Sep-19	12:30	8.69		184	9.66	94.5	11.5	0.038	0.010	0.010	0.011	0.005	0.590	31	0.590	19
Mid Driftpile	18-Sep-19	13:00	8.70		176	9.92	97.7	11.5	0.035	0.010	0.010	0.011	0.005	0.520	23	0.520	25
Upper Driftpile	18-Sep-19	13:25	8.68		154	10.07	99.2	11.6	0.038	0.010	0.010	0.011	0.005	0.560	30	0.560	28
Upper West Prairie	15-Oct-19	9:00	9.15		216	11.94	93.3	2.6	0.042	0.032	0.010	0.011	0.005	0.970	3	0.970	19
Mid West Prairie	15-Oct-19	9:35	8.92		307	12.05	95.9	3.0	0.042	0.030	0.010	0.011	0.005	0.650	4	0.650	69
Mid South Heart	15-Oct-19	10:00	9.22		306	12.51	99.6	3.4	0.058	0.036	0.010	0.011	0.005	1.340	6	1.340	7
Upper South Heart	15-Oct-19	10:30	9.02		281	11.56	97.2	5.1	0.090	0.039	0.010	0.011	0.005	1.630	7	1.630	4

Site	Date	Time	pH	TDS mg/L	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/ 100mL
Lower South Heart	15-Oct-19	11:10	9.49		320	12.25	96.0	2.7	0.085	0.035	0.010	0.011	0.005	1.290	24	1.290	20
Lower East Prairie	15-Oct-19	11:25	9.08		305	12.11	96.4	3.3	0.054	0.038	0.010	0.011	0.005	0.590	12	0.590	15
Grouard Channel	15-Oct-19	11:50	8.99		292	11.57	93.0	3.4	0.069	0.039	0.010	0.011	0.005	0.860	6	0.860	3
Upper East Prairie	15-Oct-19	12:45	9.01		263	12.19	98.0	3.1	0.010	0.010	0.010	0.011	0.005	0.400	1.5.0	0.400	1
Mid East Prairie	15-Oct-19	13:25	9.07		297	12.32	99.3	3.6	0.043	0.027	0.010	0.011	0.005	0.500	7	0.500	28
Upper Swan	16-Oct-19	10:00	8.97	126	172	12.18	97.1	2.2	0.010	0.010	0.010	0.011	0.005	0.290	1.5.0	0.290	4
Mid Swan	16-Oct-19	10:45	8.82	122	174	11.91	96.0	3.4	0.010	0.010	0.010	0.011	0.005	0.330	1.5.0	0.330	49
Lower Swan	16-Oct-19	11:30	8.56	158	215	11.29	92.2	3.7	0.027	0.010	0.010	0.011	0.005	0.530	4	0.530	20
Lower Driftpile	16-Oct-19	13:00	8.68		229	11.52	93.5	4.0	0.030	0.010	0.010	0.011	0.005	0.450	7	0.450	5
Mid Driftpile	16-Oct-19	13:25	8.67		211	11.92	97.9	4.0	0.027	0.021	0.010	0.011	0.005	0.390	1.5.0	0.390	1
Upper Driftpile	16-Oct-19	13:45	8.57		195	12.13	100.3	4.2	0.026	0.022	0.010	0.011	0.005	0.550	1.5.0	0.550	1

*Cells shaded yellow indicate a reversal of values in original spreadsheet.

B-2. Swan River Metals Monitoring Data

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**		NO_2-N NO_3-N	**0.02 to 0.04** **3.0**	**0.06 to 0.12** **124**
Total Boron	**1,500**	**29,000**	Total Uranium	**15**	**33**	Chloride	**120**	**640**
Total Cadmium	**0.06 to 0.17**	**0.62 to 2.2**	Total Zinc	**30**		Sulfate (SO_4)	**218 to 309**	
Hexavalent Chromium	**1.0**		Dissolved Aluminum	**50**	**100**	pH (units)	**≥6.5 to ≤9.0**	
Total Copper	**7**	**4.9 to 17.0**	Dissolved Iron	**300**		All guidelines are mg/L except pH		
Total Lead	**1.0 to 3.4**		Dissolved Manganese	**270 to 470**	**2394 to 6890**	All guidelines are provincial (GoA 2018) except dissolved zinc (federal: CCME 2018)		
Total Nickel	**19 to 54**	**170 to 490**	Dissolved Zinc	**12 to 23**	**43 to 136**			

Appendix B-2: Total Metals Data at Swan River Sites, April to October 2019.

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)	Iron (µg/L)
Upper Swan River	17-Apr-19	9:50	0.0025	1090	0.16	1.49	60.6	5	0.0468	12.6	0.25	1.59	4.01	2330
Mid Swan River	17-Apr-19	10:25	0.0071	2070	0.17	2.48	95.3	5	0.114	9.89	0.25	3.06	7.26	4900
Lower Swan	17-Apr-19	not accessible												
Upper Swan River	15-May-19	9:50	0.0025	1570	0.18	1.75	723	5	0.0766	12.2	0.25	2.39	5.36	2580
Mid Swan River	15-May-19	10:25	0.0025	1180	0.18	1.66	66	5	0.0557	11	0.25	1.89	5.15	2550
Lower Swan River	15-May-19	11:10	0.0054	1690	0.2	2.13	72.3	5	0.0562	11.1	0.25	2.54	6.71	3480
Upper Swan River	12-Jun-19	9:40	0.0098	281	0.17	0.94	42.6	5	0.0171	16.3	0.25	0.58	2.24	841
Mid Swan River	12-Jun-19	10:25	0.0065	312	0.17	1.28	53.6	13	0.0242	14.8	0.25	1.13	2.76	1450
Lower Swan River	12-Jun-19	11:15	0.0148	468	0.2	1.54	60	12	0.0238	15.1	0.25	1.25	3.47	1770
field duplicate: Lower Swan			0.0071	369	0.17	1.33	49.6	13	0.0321	15.3	0.25	0.78	2.81	1470
Upper Swan River	17-Jul-19	10:00	0.0025	556	0.23	1.66	70.1	11	0.029	19.1	0.25	0.95	3.66	1520
Mid Swan River	17-Jul-19	10:35	0.0025	386	0.2	1.67	66.8	15	0.0392	15.8	0.25	0.81	3.4	1810
Lower Swan River	17-Jul-19	11:15	0.0025	536	0.22	1.84	68.4	14	0.025	16.9	0.25	0.97	3.76	2250
Upper Swan River	15-Aug-19	10:10	0.0025	915	0.57	1.72	70	5	0.0418	16.8	0.25	1.51	4.19	1970
Mid Swan River	15-Aug-19	10:55	0.0126	862	0.46	1.78	73.8	11	0.0523	14.4	0.25	1.44	4.73	2150
Lower Swan River	15-Aug-19	11:40	0.0149	1840	0.45	2.56	93.5	11	0.0655	15	0.25	2.94	7.41	3970
Upper Swan River	18-Sep-19	10:00	0.0092	338	0.26	1.54	66.8	5	0.0221	20.2	0.25	0.68	3.01	1230
Mid Swan River	18-Sep-19	10:45	0.0025	540	0.27	1.84	75.5	13	0.0336	19.1	0.25	1.12	3.77	2070
Lower Swan River	18-Sep-19	11:30	0.0076	1050	0.29	2.44	90.1	16	0.0408	19.8	0.25	1.73	5.35	3130
Upper Swan River	16-Oct-19	10:05	0.0025	91.2	0.19	1.23	61	5	0.0122	24.1	0.25	0.28	3.37	1190
Mid Swan River	16-Oct-19	10:45	0.0055	73.9	0.16	1.34	67.7	15	0.0152	23.1	0.25	0.32	1.48	2080
Lower Swan River	16-Oct-19	11:30	0.0025	73.6	0.16	1.45	85.4	16	0.0214	30.1	0.25	0.27	1.52	2360

Notes:

0.0183	Red shading indicates exceedance of chronic and 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 $CaCO_3$	
Nitrite - varies with chloride (see GoA to determine appropriate PAL guideline)	

Appendix B-2: Total Metals Data at Swan River Sites, April to October 2019.

Site	Date	TOTAL METALS										
		Lead (µg/L)	Magnesium (µg/L)	Manganese (µg/L)	Nickel (µg/L)	Potassium (µg/L)	Potassium (µg/L)	Selenium (µg/L)	Silver (µg/L)	Sodium (mg/L)	Uranium (µg/L)	Zinc (µg/L)
Upper Swan River	17-Apr-19	1.21	2640	120	5.02	1530	1.53	0.166	0.018	7.4	0.338	8.4
Mid Swan River	17-Apr-19	2.27	2750	83	10.6	2180	2.18	0.211	0.03	6.16	0.472	16.7
Lower Swan	17-Apr-19											
Upper Swan River	15-May-19	1.92	2550	109	5.68	1390	1.39	0.153	0.022	4.83	0.392	10.4
Mid Swan River	15-May-19	1.67	2440	116	5.91	1530	1.53	0.146	0.02	4.93	0.363	8.9
Lower Swan River	15-May-19	2.27	2700	118	7.31	1700	1.7	0.193	0.029	4.89	0.433	11.9
Upper Swan River	12-Jun-19	0.464	2310	37.5	2.65	1040	1.04	0.131	0.005	6.39	0.276	5.2
Mid Swan River	12-Jun-19	0.42	2740	61.4	4.18	1400	1.4	0.151	0.005	7.36	0.258	1.5
Lower Swan River	12-Jun-19	0.62	3140	42.3	4.79	1560	1.56	0.188	0.005	7.77	0.304	3.7
field duplicate: Lower Swan		0.593	2530	35.3	3.91	1360	1.36	0.134	0.005	6.35	0.296	3.2
Upper Swan River	17-Jul-19	0.747	3260	64.2	4.28	1350	1.35	0.14	0.011	7.86	0.38	3.8
Mid Swan River	17-Jul-19	0.612	3040	97	5.59	1530	1.53	0.169	0.005	7.74	0.321	3.7
Lower Swan River	17-Jul-19	0.845	3270	67.3	5.57	1570	1.57	0.161	0.005	7.43	0.372	6.5
Upper Swan River	15-Aug-19	1.14	3030	71.3	5.71	1190	1.19	0.183	0.015	6.05	0.367	8.9
Mid Swan River	15-Aug-19	2.05	2850	88.7	7.17	1350	1.35	0.152	0.017	5.64	0.401	7.5
Lower Swan River	15-Aug-19	2.43	3250	110	10.2	1690	1.69	0.19	0.032	5.45	0.553	13.8
Upper Swan River	18-Sep-19	0.431	3700	72	4.23	1360	1.36	0.142	0.005	7.53	0.3	4.1
Mid Swan River	18-Sep-19	0.886	3760	116	5.75	1750	1.75	0.154	0.014	7.89	0.343	5.8
Lower Swan River	18-Sep-19	1.42	4170	140	7.29	2100	2.1	0.174	0.014	8.33	0.461	8.5
Upper Swan River	16-Oct-19	0.143	4120	108	3.05	1310	1.31	0.091	0.005	9.84	0.368	1.5
Mid Swan River	16-Oct-19	0.499	4510	117	4.15	1670	1.67	0.147	0.005	10.4	0.333	1.5
Lower Swan River	16-Oct-19	0.171	6350	651	5.23	1860	1.86	0.083	0.005	10.2	0.73	5.2

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 $CaCO_3$	
Nitrite - varies with chloride (see GoA to determine appropriate PAL guideline)	

Appendix B-2: Dissolved Metals Data at Swan River Sites, April to October 2019.

Site	Date	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)	Iron (µg/L)	Lead (µg/L)	Magnesium (µg/L)
Upper Swan River	17-Apr-19	0.0025	110	0.13	0.67	44.7	5	0.0229	14.3	0.32	2.3	467	0.159	2550
Mid Swan River	17-Apr-19	0.0066	145	0.13	0.63	43.4	5	0.027	9.31	0.34	3.02	558	0.186	1940
Lower Swan	17-Apr-19													
Upper Swan River	15-May-19	0.0025	51.7	0.13	0.62	41.1	5	0.0153	11.8	0.18	2.59	223	0.135	2100
Mid Swan River	15-May-19	0.0025	57.6	0.14	0.62	42.8	5	0.018	10.5	0.23	3.84	332	0.164	2050
Lower Swan River	15-May-19	0.0053	49.7	0.15	0.59	35.8	5	0.0107	9.6	0.2	2.65	296	0.175	2030
Upper Swan River	12-Jun-19	0.0025	46.8	0.17	0.92	47.8	5	0.0105	17.6	0.17	1.97	457	0.122	3100
Mid Swan River	12-Jun-19	0.0071	65.9	0.17	0.93	48.9	12	0.0137	15.6	0.25	2.21	816	0.153	3010
Lower Swan River	12-Jun-19	0.0078	58	0.18	0.92	46.7	12	0.0134	15.7	0.22	2.35	738	0.168	2950
field duplicate: Lower Swan		0.0092	55.6	0.16	0.94	46.9	12	0.01	16.7	0.26	2.41	732	0.172	3230
Upper Swan River	17-Jul-19	0.0025	29.9	0.23	1.16	58.8	14	0.0157	19	0.19	2.29	429	0.133	3320
Mid Swan River	17-Jul-19	0.0025	52.4	0.22	1.19	58.8	12	0.0179	17.9	0.258	2.55	867	0.232	2990
Lower Swan River	17-Jul-19	0.0025	30.9	0.21	1.2	57.3	17	0.0169	16.9	0.23	2.66	845	0.196	3200
Upper Swan River	15-Aug-19	0.0025	48.9	0.2	0.96	55.5	5	0.017	16.6	0.26	2.4	400	0.14	2800
Mid Swan River	15-Aug-19	0.0025	52.1	0.15	1.01	58.4	13	0.0192	14.7	0.34	2.83	540	0.344	2640
Lower Swan River	15-Aug-19	0.0025	37.7	0.22	0.85	57	10	0.0193	14.4	0.32	3.32	415	0.193	2680
Upper Swan River	18-Sep-19	0.0025	57.9	0.15	1.1	57.3	5	0.0145	19.1	0.26	1.83	537	0.116	3690
Mid Swan River	18-Sep-19	0.0025	69.5	0.16	1.06	63.3	12	0.0244	17.9	0.38	2.4	788	0.237	3750
Lower Swan River	18-Sep-19	0.0081	44.8	0.2	1.14	61	13	0.0118	18.8	0.32	2.48	615	0.188	3900
Upper Swan River	16-Oct-19	0.0025	19.3	0.14	0.93	64.7	5	0.0086	24.3	0.11	1.17	777	0.066	4310
Mid Swan River	16-Oct-19	0.0025	25.1	0.12	0.97	67.4	13	0.0105	23.3	0.14	1.3	1520	0.307	4550
Lower Swan River	16-Oct-19	0.0025	21	0.12	0.99	81.7	14	0.0149	31.3	0.15	1.19	1680	0.085	6260

Notes:

0.0183	Red shading indicates exceedance of chronic and 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 $CaCO_3$

Nitrite - varies with chloride (see GoA to determine appropriate PAL guideline)

Appendix B-2: Dissolved Metals Data at Swan River Sites, April to October 2019.

Site	Date	DISSOLVED METALS							
		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	17-Apr-19	54.7	3.35	1530	0.147	0.005	8.77	0.244	6.2
Mid Swan River	17-Apr-19	66.3	4.83	1840	0.116	0.005	6.25	0.213	8
Lower Swan	17-Apr-19								
Upper Swan River	15-May-19	19.7	2.51	1060	0.077	0.005	4.98	0.192	0.5
Mid Swan River	15-May-19	32	3.44	1230	0.111	0.005	4.82	0.197	1.1
Lower Swan River	15-May-19	7.07	3.47	1260	0.11	0.005	4.79	0.187	0.5
Upper Swan River	12-Jun-19	4.06	2.73	1270	0.097	0.005	8.33	0.242	0.5
Mid Swan River	12-Jun-19	2.85	3.7	1480	0.11	0.005	7.88	0.243	0.5
Lower Swan River	12-Jun-19	2.98	3.63	1530	0.115	0.005	7.57	0.241	0.5
field duplicate: Lower Swan		2.95	3.78	1600	0.143	0.005	8.16	0.263	0.5
Upper Swan River	17-Jul-19	38.3	3.32	1240	0.179	0.005	8.38	0.3	1.7
Mid Swan River	17-Jul-19	65.9	4.9	1460	0.134	0.005	8.09	0.327	1.1
Lower Swan River	17-Jul-19	14.6	4.46	1470	0.119	0.005	7.91	0.281	1.6
Upper Swan River	15-Aug-19	13.8	4.02	1020	0.151	0.005	6.32	0.245	0.5
Mid Swan River	15-Aug-19	21.9	5.32	1300	0.137	0.011	5.75	0.248	0.5
Lower Swan River	15-Aug-19	6.21	6.07	1320	0.146	0.005	5.84	0.26	0.5
Upper Swan River	18-Sep-19	36.1	3.52	1250	0.136	0.005	7.59	0.26	0.5
Mid Swan River	18-Sep-19	77.9	4.93	1710	0.116	0.005	7.85	0.2847	4.2
Lower Swan River	18-Sep-19	8.83	4.99	1920	0.154	0.005	8.63	0.337	0.5
Upper Swan River	16-Oct-19	72.5	2.85	1330	0.086	0.005	10.2	0.361	0.5
Mid Swan River	16-Oct-19	34.5	3.76	1750	0.113	0.005	11.1	0.336	0.5
Lower Swan River	16-Oct-19	70.6	4.5	2070	0.126	0.005	10.7	0.795	0.5

Notes:

0.0183	Red shading indicates exceedance of chronic and 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 $CaCO_3$	
Nitrite - varies with chloride (see GoA to determine appropriate PAL guideline)	

Appendix B-2: Miscellaneous Water Quality Data at Swan River Sites, April to October 2019.

Site	Date	MISCELLANEOUS PARAMETERS (mg/L except for units in brackets)										
		Fecal Coliforms (cfu/100 mL)	Total Dissolved Phosphorus	Total Phosphorus	Total Dissolved Solids	Total Suspended Solids	NO_2-N	NO_3-N+NO_2-N	NO_3-N	TKN	Total Nitrogen-calculated	Chloride
Upper Swan River	17-Apr-19	<1	0.02	0.074	138	91.9	<0.020	<0.0051	<0.010	0.32	0.32	2.22
Mid Swan River	17-Apr-19	<1	0.026	0.137	119	196	0.067	0.0668	<0.010	0.9	0.96	1.37
Lower Swan	17-Apr-19											
Upper Swan River	15-May-19	<1	<0.020	0.075	130	130	<0.020	<0.022	<0.010	0.33	0.33	0.55
Mid Swan River	15-May-19	<1	<0.020	0.064	94	86.6	0.021	<0.022	<0.010	0.41	0.43	0.53
Lower Swan River	15-May-19		<0.020	0.084	94	123	0.028	0.028	<0.010	0.46	0.48	<0.5
Upper Swan River	12-Jun-19	12	<0.020	0.022	116	16.8	<0.020	<0.022	<0.010	0.47	0.47	0.92
Mid Swan River	12-Jun-19	34	<0.020	0.027	113	13.1	<0.020	<0.022	<0.010	0.51	0.51	0.94
Lower Swan River	12-Jun-19	50	<0.020	0.033	121	21.9	<0.020	<0.022	<0.010	0.44	0.44	1.02
field duplicate: Lower Swan		<1	<0.020	0.036	120	20.6	<0.020	<0.022	<0.010	0.43	0.43	1
Upper Swan River	17-Jul-19	30	<0.020	0.022	127	29.6	<0.020	<0.022	<0.010	<0.2	<0.2	0.76
Mid Swan River	17-Jul-19	64	0.023	0.034	132	14.5	<0.020	<0.022	<0.010	0.26	0.26	0.79
Lower Swan River	17-Jul-19	62	0.021	0.044	138	30.7	<0.020	<0.022	<0.010	0.42	0.42	0.85
Upper Swan River	15-Aug-19	12	0.024	0.058	120	54.8	<0.020	<0.022	<0.010	0.71	0.71	0.56
Mid Swan River	15-Aug-19	30	<0.020	0.063	121	64.5	<0.020	<0.022	<0.010	0.61	0.61	0.56
Lower Swan River	15-Aug-19	64	<0.020	0.1	120	122	<0.020	<0.022	<0.010	0.67	0.67	0.55
Upper Swan River	18-Sep-19	9	<0.020	<0.020	126	10.8	<0.020	<0.022	<0.010	0.68	0.68	0.57
Mid Swan River	18-Sep-19	19	<0.020	0.024	147	23.6	<0.020	<0.022	<0.010	0.63	0.63	0.63
Lower Swan River	18-Sep-19	31	<0.020	0.055	143	53.5	<0.020	<0.022	<0.010	0.64	0.64	1.05
Upper Swan River	16-Oct-19	4	<0.020	<0.020	126	<3.0	<0.020	<0.022	<0.010	0.29	0.29	0.77
Mid Swan River	16-Oct-19	49	<0.020	<0.020	122	<3.0	<0.020	<0.022	<0.010	0.33	0.33	1.09
Lower Swan River	16-Oct-19	20	<0.020	0.027	158	3.5	<0.020	<0.022	<0.010	0.53	0.53	1.43

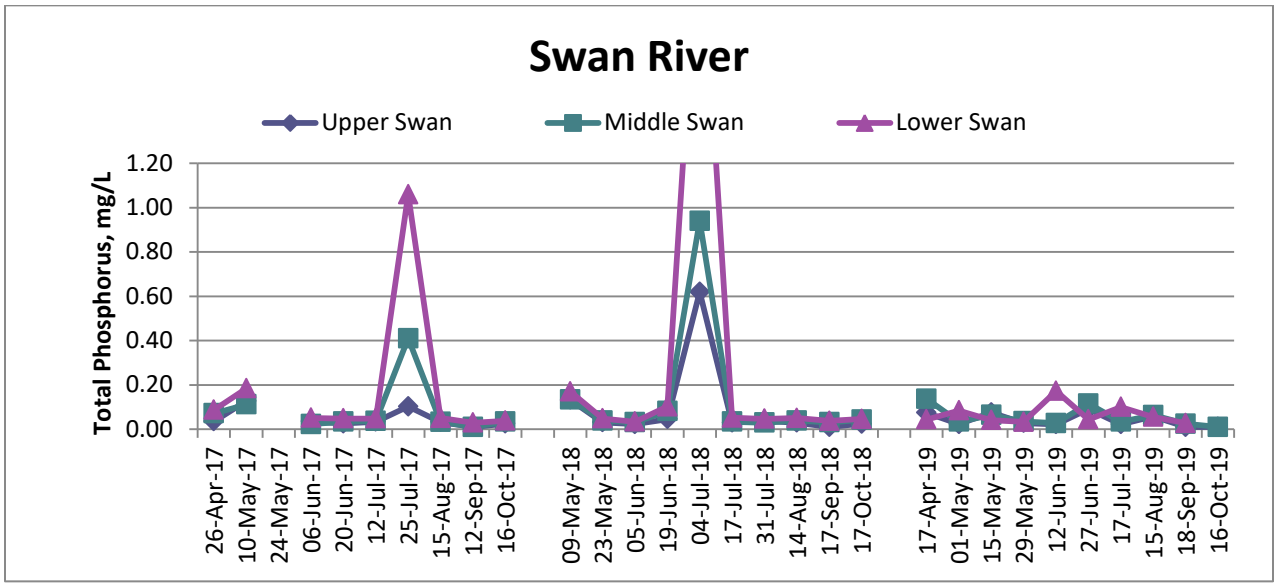
Notes:	
0.0183	Red shading indicates exceedance of chronic and acute Protection of Aquatic Life guidelines
0.019	Red font indicates exceedance of chronic Protection of Aquatic Life guidelines
Total cadmium, total copper, total lead, total nickel, dissolved zinc and dissolved manganese PAL guidelines 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 CaCO3	
Nitrite - varies with chloride (see GoA to determine appropriate PAL guideline)	

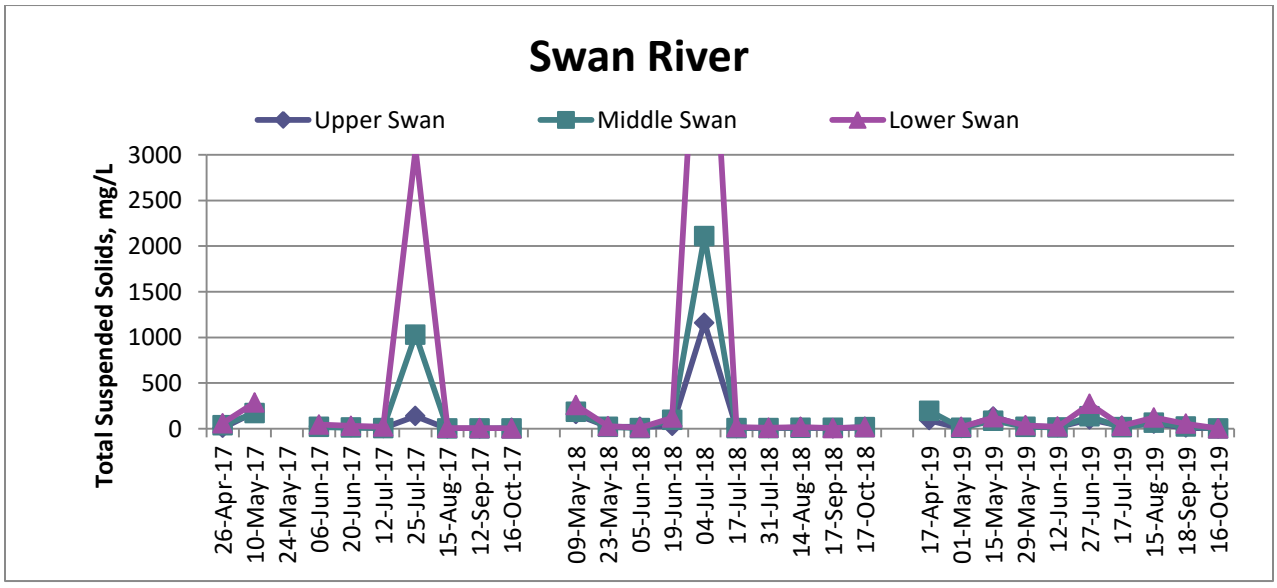
Appendix B-2: Miscellaneous Water Quality Data at Swan River Sites, April to October 2019.

Site	Date	MISCELLANEOUS PARAMETERS (mg/L except for units in brackets)										
		Flouride	Ion Balance (%)	Total Dissolved Solids-calculated	Hardness $CaCO_3$	Sulfate SO_4	pH (units)	Conductivity (µS/cm)	Bicarbonate HCO_3	Carbonate CO3	Hydroxide OH	Alkalinity $CaCO_3$
Upper Swan River	17-Apr-19	0.046	111	65.7	46.2	5.19	7.65	111	63.3	<5.0	<5.0	51.9
Mid Swan River	17-Apr-19	0.039	low EC	46.2	31.2	3.76	7.43	79.7	43.4	<5.0	<5.0	35.6
Lower Swan	17-Apr-19											
Upper Swan River	15-May-19	0.05	low EC	44.5	38.1	3.53	7.78	86.1	41.6	<5.0	<5.0	34.1
Mid Swan River	15-May-19	0.051	low EC	45.9	34.7	3.48	7.75	82.1	47	<5.0	<5.0	38.5
Lower Swan River	15-May-19	0.052	low EC	44.4	32.3	3.49	7.7	78.9	46.8	<5.0	<5.0	38.4
Upper Swan River	12-Jun-19	0.071	109	74.3	56.7	5.35	7.74	134	76.6	<5.0	<5.0	62.8
Mid Swan River	12-Jun-19	0.069	111	67.8	51.3	4.78	7.61	122	69.2	<5.0	<5.0	56.7
Lower Swan River	12-Jun-19	0.07	110	68	51.4	5.05	7.57	124	69.3	<5.0	<5.0	56.8
field duplicate: Lower Swan		0.068	118	69.7	55	5.09	7.58	123	68.9	<5.0	<5.0	56.5
Upper Swan River	17-Jul-19	0.072	105	80	61.1	4.83	7.97	146	86.3	<5.0	<5.0	70.7
Mid Swan River	17-Jul-19	0.068	114	72.2	57	3.96	7.92	128	75	<5.0	<5.0	61.5
Lower Swan River	17-Jul-19	0.071	107	72.9	55.4	4.35	7.8	135	77.6	<5.0	<5.0	63.6
Upper Swan River	15-Aug-19	0.051	113	63.8	53	2.68	7.67	112	68.6	<5.0	<5.0	56.2
Mid Swan River	15-Aug-19	0.049	116	57.2	47.6	2.57	7.61	102	60.3	<5.0	<5.0	49.4
Lower Swan River	15-Aug-19	0.05	120	56.1	47	2.78	7.44	101	57.8	<5.0	<5.0	47.4
Upper Swan River	18-Sep-19	0.06	109	77.5	62.9	3.74	7.64	130	84.4	<5.0	<5.0	69.2
Mid Swan River	18-Sep-19	0.063	112	75	60.1	3.65	7.6	127	80.3	<5.0	<5.0	65.8
Lower Swan River	18-Sep-19	0.063	113	79.9	63	4.42	7.55	135	83.6	<5.0	<5.0	68.5
Upper Swan River	16-Oct-19	0.074	104	102	78.4	7.37	7.85	178	109	<5.0	<5.0	89.3
Mid Swan River	16-Oct-19	0.077	107	102	76.9	6.78	7.83	174	107	<5.0	<5.0	88.1
Lower Swan River	16-Oct-19	0.084	106	126	104	7.2	7.73	215	137	<5.0	<5.0	112

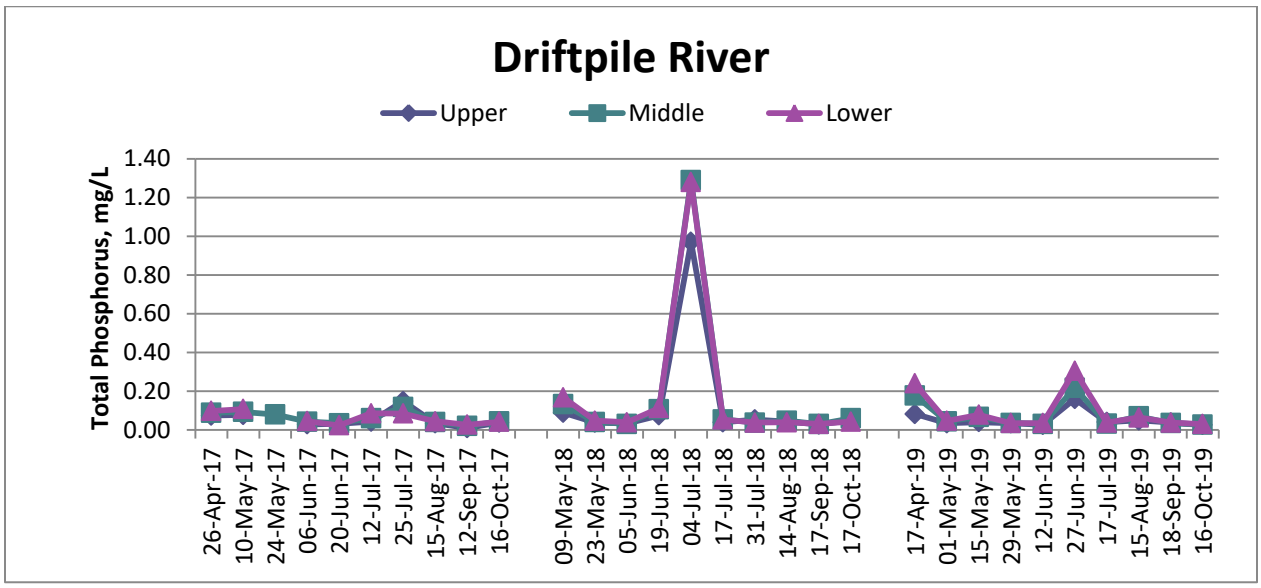
APPENDIX C. WATER QUALITY GRAPHS FOR SELECT PARAMETERS, 2017-2019.

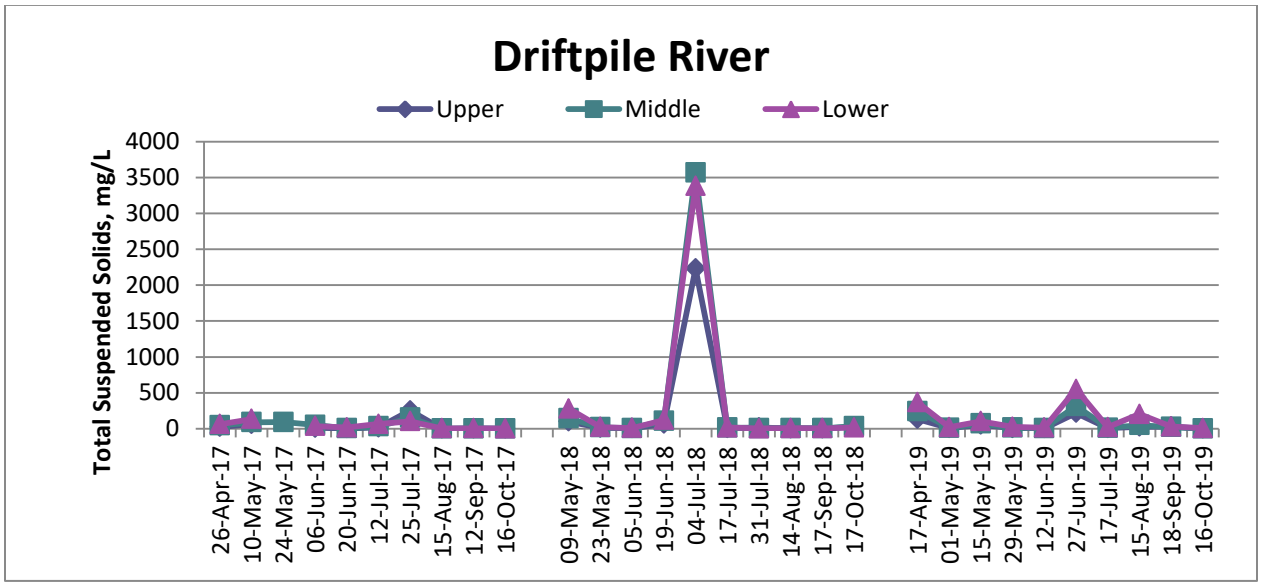
C-1. Swan River



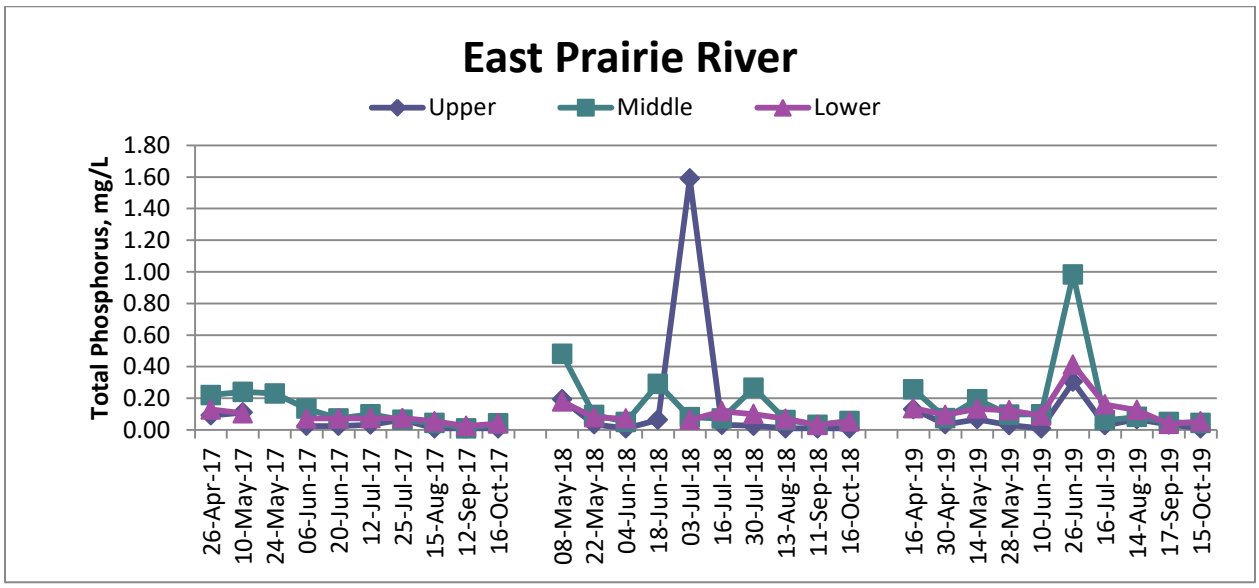


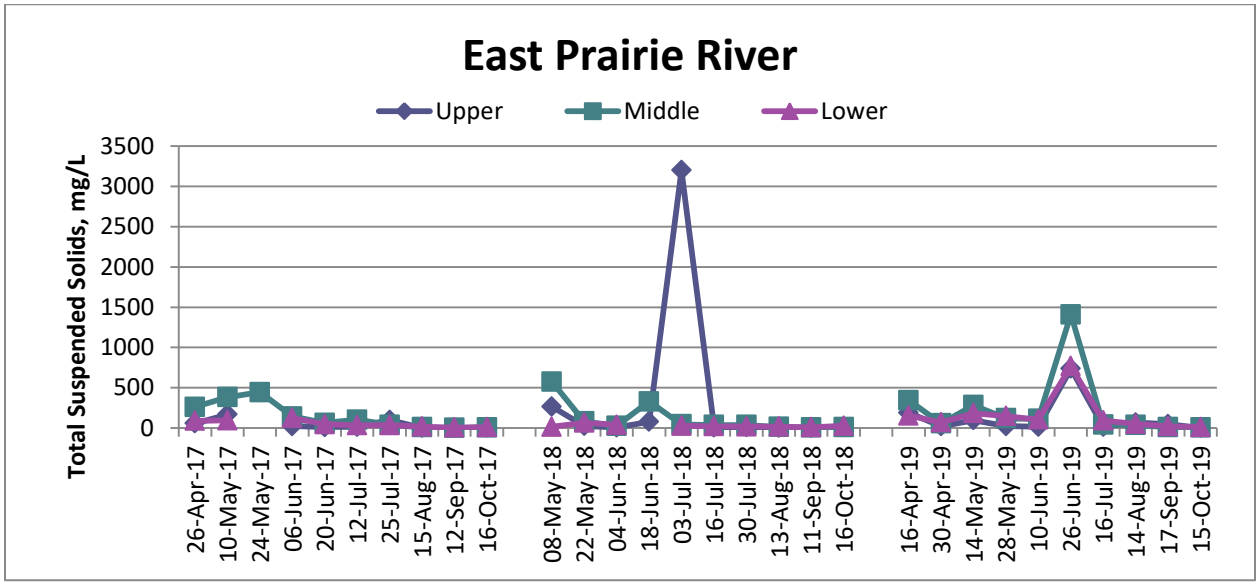
C-2. Driftpile River



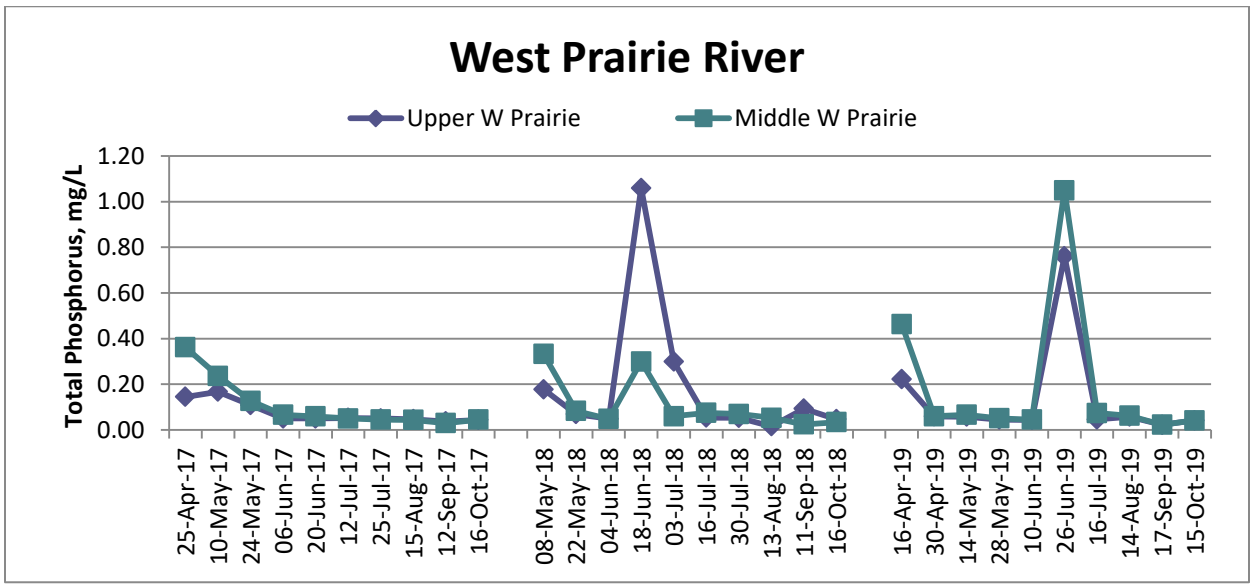


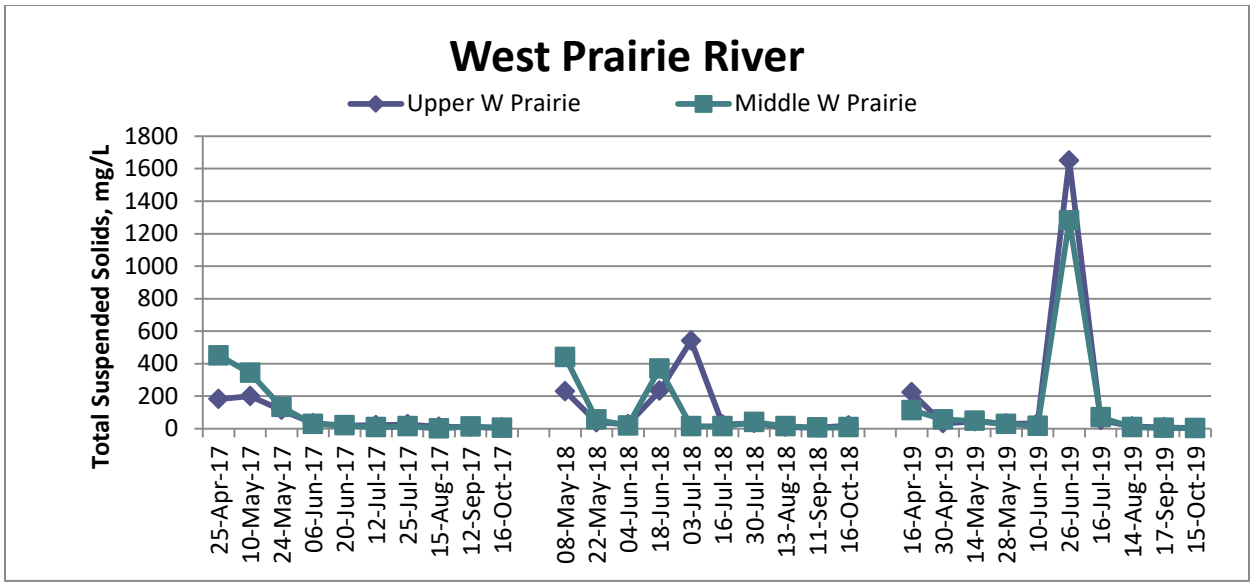
C-3. East Prairie River





C-4. West Prairie River





C-5. South Heart River and Grouard Channel