Lesser Slave Watershed
2018 Water Monitoring Report

Prepared for: Lesser Slave Watershed Council

Prepared by: Palliser Environmental Services Ltd.

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Cover Photo: Lower Driftpile River, July 4, 2018 (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 second year (2018) 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, and 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, phosphate-containing detergents, food processing plants, urban runoff, atmospheric deposition, and natural levels 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 health issues for humans and is toxic to 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 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 impedes 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 end of April through July, and monthly (August-October) at fifteen sites. 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 2018, the LSWC sampled May 8/9, May 22/23, June 4/5, June 18/19, July 3/4, July 16/17, July 30/31, August 13/14, Sep 11/17, and October 16/17. Note that sampling in 2018 was initiated in May compared to April in 2017.

LSWC staff completed the field sampling. Samples were only collected when flows could be visually detected. Sample bottles were submersed to mid-depth by hand or using a sample pole (with sample bottle attached) when the water was deep or fast-flowing. Each sample container was prepared using

standard protocols (e.g., triple rinsing and preservation, where required). Sterile sample containers were provided by the analytical laboratory. The water samples were kept on ice in coolers and transported to ALS Laboratories in Edmonton. ALS Laboratories Analytics is **CALA**[1] accredited for criteria and standards established by the Association under their Certificate of Laboratory Proficiency.

Samples were analysed using **APHA**[2] approved methods for 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 May 9, June 5, July 4 (upper and middle sites only), July 31, August 14, September 17, 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, compared to 5 samples at each site in 2017. The Lower Swan River was not sampled on July 4 as the site was inaccessible due to flooding.

3.2 Streamflow Data

Daily streamflow data for 2017 and 2018 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.).

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. Significant periods of missing data in 2018 limits the comparison of streamflows between years. All streamflow data should be considered interim, until the Water Survey of Canada validation is complete.

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

Site (Station Name)	2017	2018
Driftpile River near Driftpile (07BH003)	None	Apr 1-29; May 1-7; Jun 12-20 (45 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)
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)
East Prairie River near Enilda (07BF001)	Aug 16, 17; Oct 16 (3 d)	Apr 1-30; May 1-8; Jun 6 (39 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)
South Heart River near Big Prairie Settlement (07BF905)	None	Apr 1-30; May 1-8 (38 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)

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

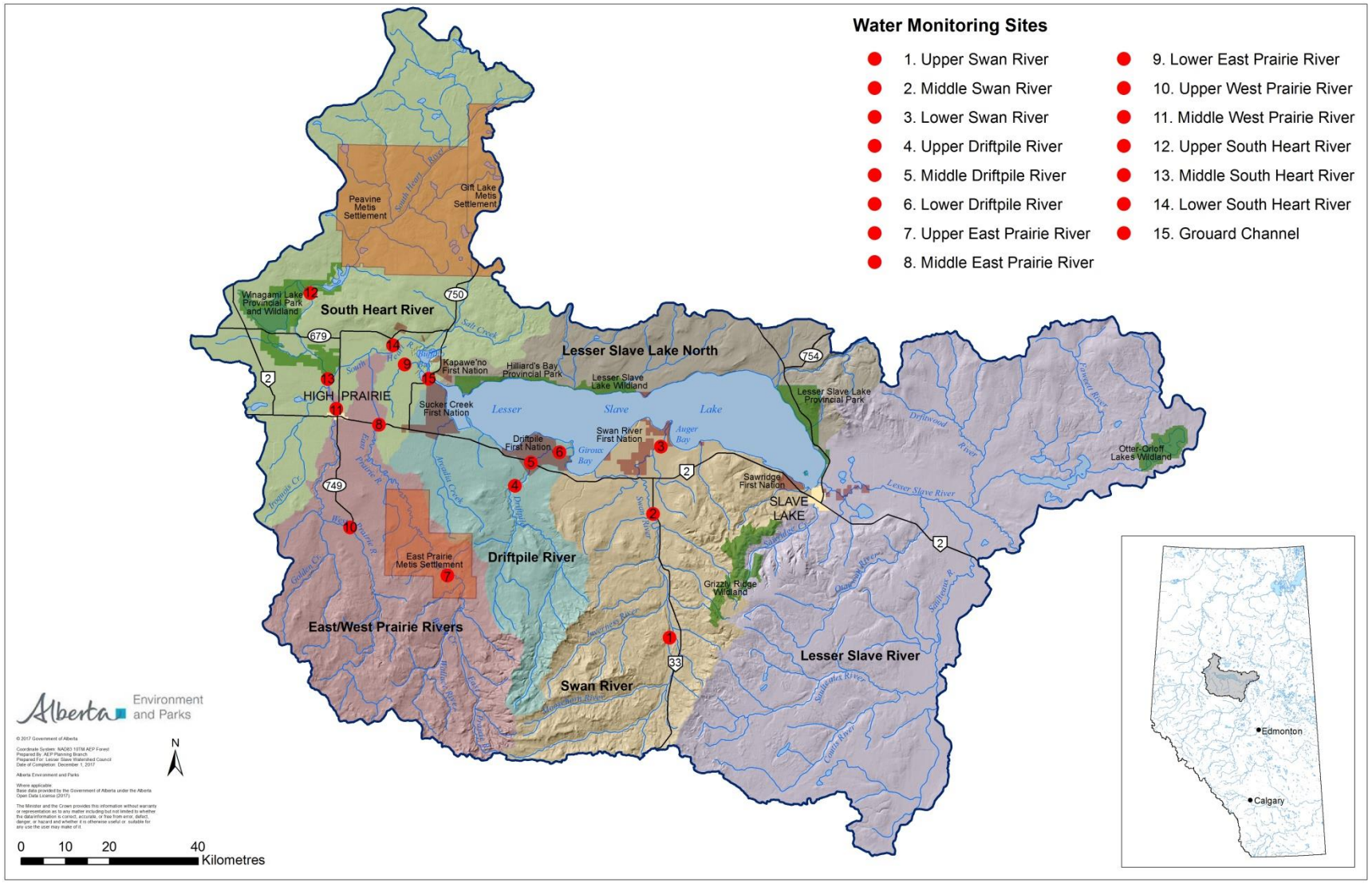

Figure 1. Water quality monitoring site locations in the Lesser Slave watershed, April-October, 2017 and 2018.

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, 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 it was not as relevant as other sites to the water monitoring program.

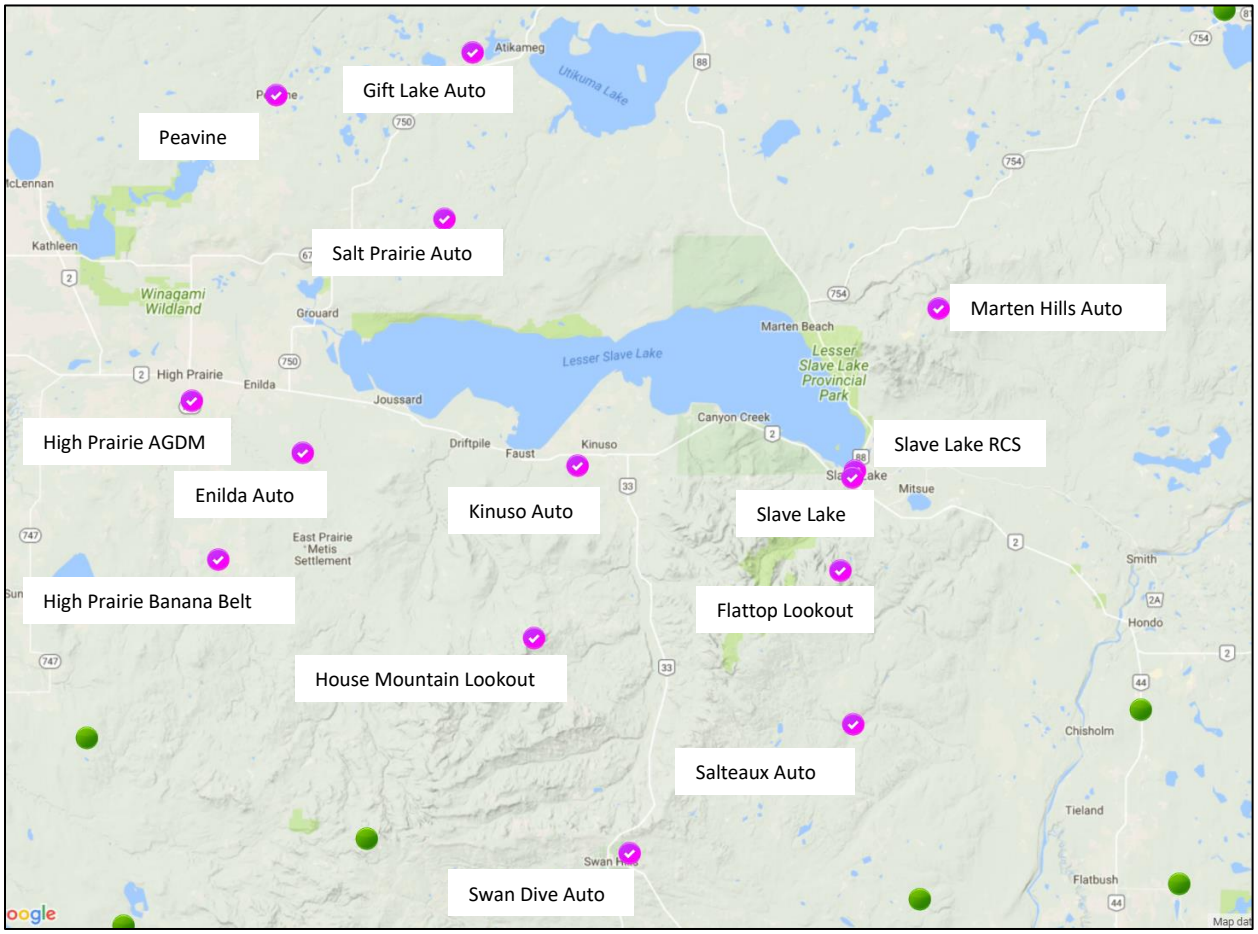

Figure 2. Weather stations in the Lesser Slave watershed.

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.

Table 2. Missing water quality data, 2017 and 2018.

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 site

The missing data at Lower Swan River site on July 4 results in an under-estimation of the 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).

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 2018, generally, less precipitation was recorded at weather stations in the north (347.6 to 370.0 mm at Peavine, High Prairie AGDM, Kinuso Auto, Slave Lake RCS and Slave Lake) compared to weather stations in the south (420.7 to 703.4 mm at High Prairie Banana Belt, Flat Top Lookout, House Mountain Lookout and Swan Dive Auto). The three weather stations located closest to Lesser Slave Lake (Kinuso Auto, Slave lake RCS and Slave Lake) had amongst the lowest April to October precipitation (347.6 to 363.0 mm) of the 10 weather stations.

In 2018, eight of the ten weather stations had less precipitation compared to 2017 (Table 4). Overall, precipitation in 2018 was 16.3% less than 2017.

Table 4. Monthly total precipitation (mm) at Lesser Slave watershed, April-October 2017 and 2018. 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**
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**
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**
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**
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**
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**
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**
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**
House Mountain Lookout – AFS HM	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**
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**

[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 and 2018 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 and 7.0 m^3/s in 2018. Peak discharge occurred on May 14 in 2017 when flow was 82.5 m^3/s during snowmelt, and on July 4 in 2018 when flow was 149 m^3/s during a rain event (Figure 3). The second highest flow occurred on September 21 (69.5 m^3/s) in 2017, and on May 8 in 2018 (29 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. 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.

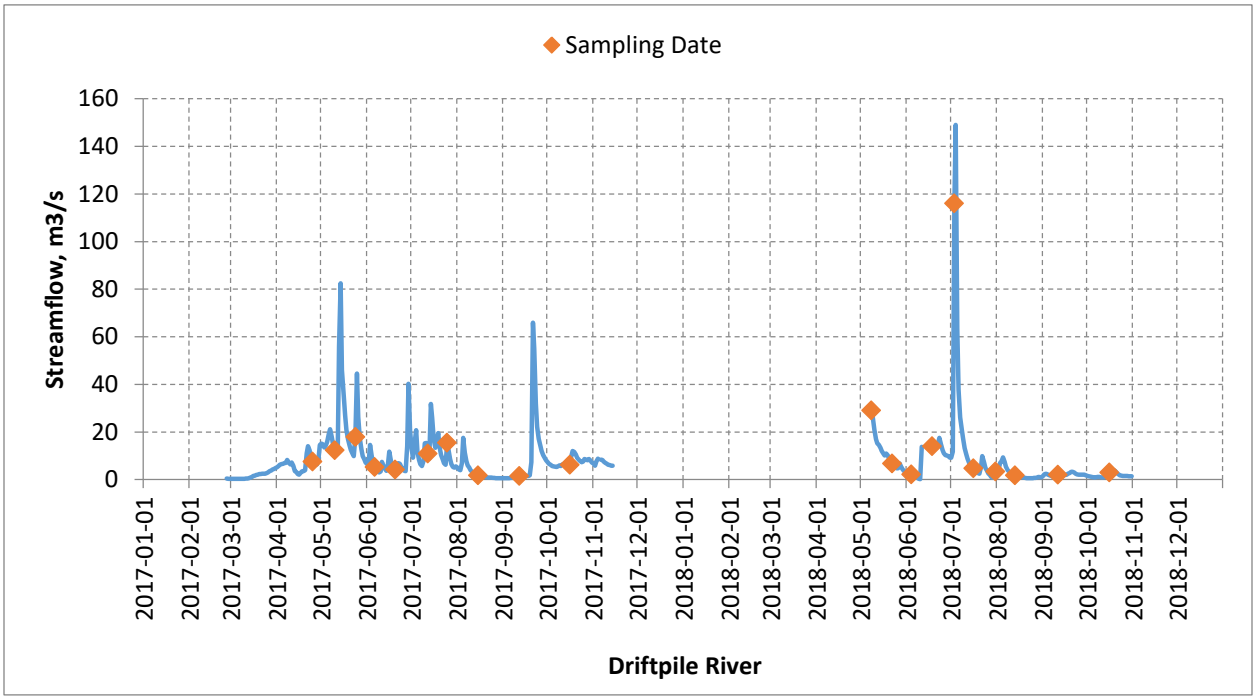

Figure 3. Average daily streamflow at Driftpile River, 2017 and 2018 (Near real-time flows (NRT) provided by AEP 2018, 2019).

At Swan River, average daily streamflow for the April-October monitoring period was 3.8 m^3/s in 2017 and 1.47 m^3/s in 2018 at Swan Hills and, 22.9 m^3/s (2017) and 23.3 m^3/s (2018) near Kinuso (Figure 4). Peak discharge occurred on May 13 in 2017 (29.7 m^3/s) and on June 11 in 2018 (23.4m^3/s) at Swan Hills. Note there were periods of missing data at the Swan Hills station periodically through 2018. At Kinuso, peak discharge occurred on May 14 in 2017 (176.0 m^3/s) and on June 13 in 2018 (498 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). 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). 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.

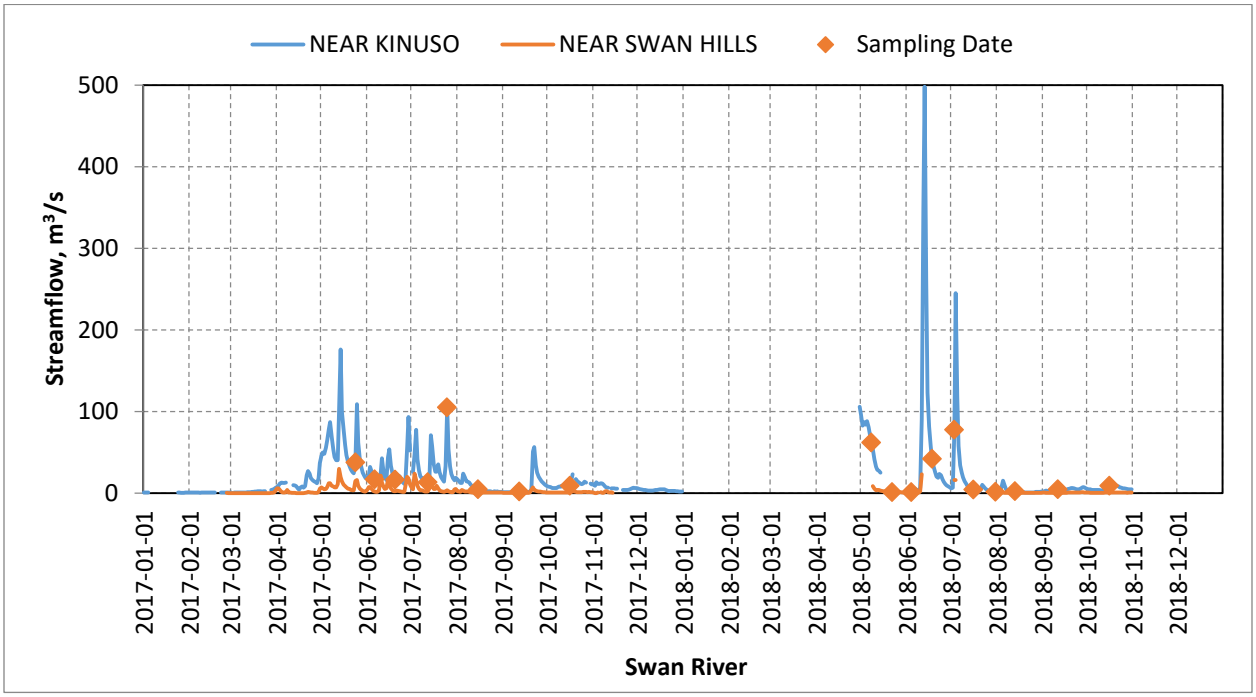

Figure 4. Average daily streamflow at Swan River, 2017 and 2018 (NRT-Flows provided by AEP, 2018, 2019).

At the East Prairie River (near Enilda), average daily streamflow for the April-October monitoring period was 12.8 m^3/s in 2017 and 11.6 m^3/s in 2018. Peak discharge occurred on May 14 in 2017 (152.0 m^3/s) and on July 4 in 2018 (234.0 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 2017, a period of prolonged low streamflow (<2 m^3/s) occurred from August 18 to September 19. In 2018, flows were similarly low as in 2017 from August through October.

At West Prairie River (near High Prairie), average daily streamflow for the April-October monitoring period was 10.7 m^3/s in 2017 and 6.9 m^3/s in 2018. Peak discharge occurred on May 14 in 2017 (237.0 m^3/s) and June 14 in 2018 (122 m^3/s). 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, and on June 12 (46.8 m^3/s), July 4 (55.4 $m^3/$), and July 22 (97.7 m^3/s) in 2018. 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.

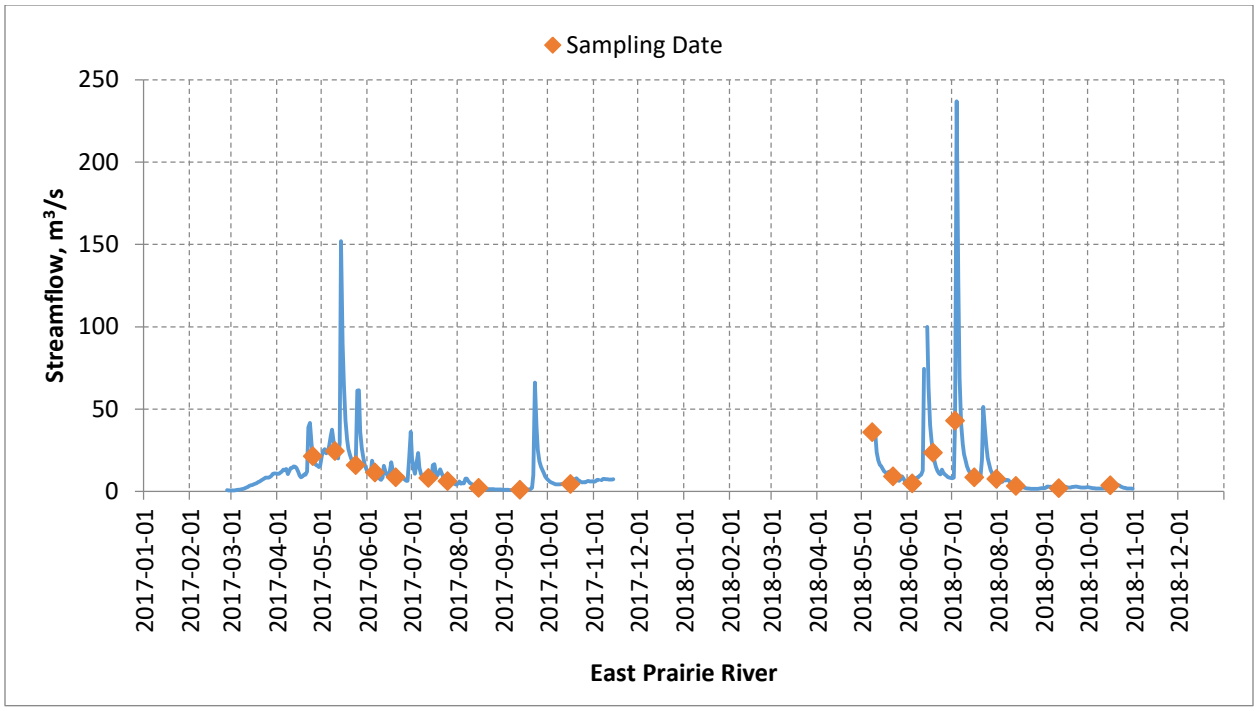

Figure 5. Average daily streamflow at East Prairie River, 2017 and 2018 (NRT-Flows provided by AEP, 2018, 2019).

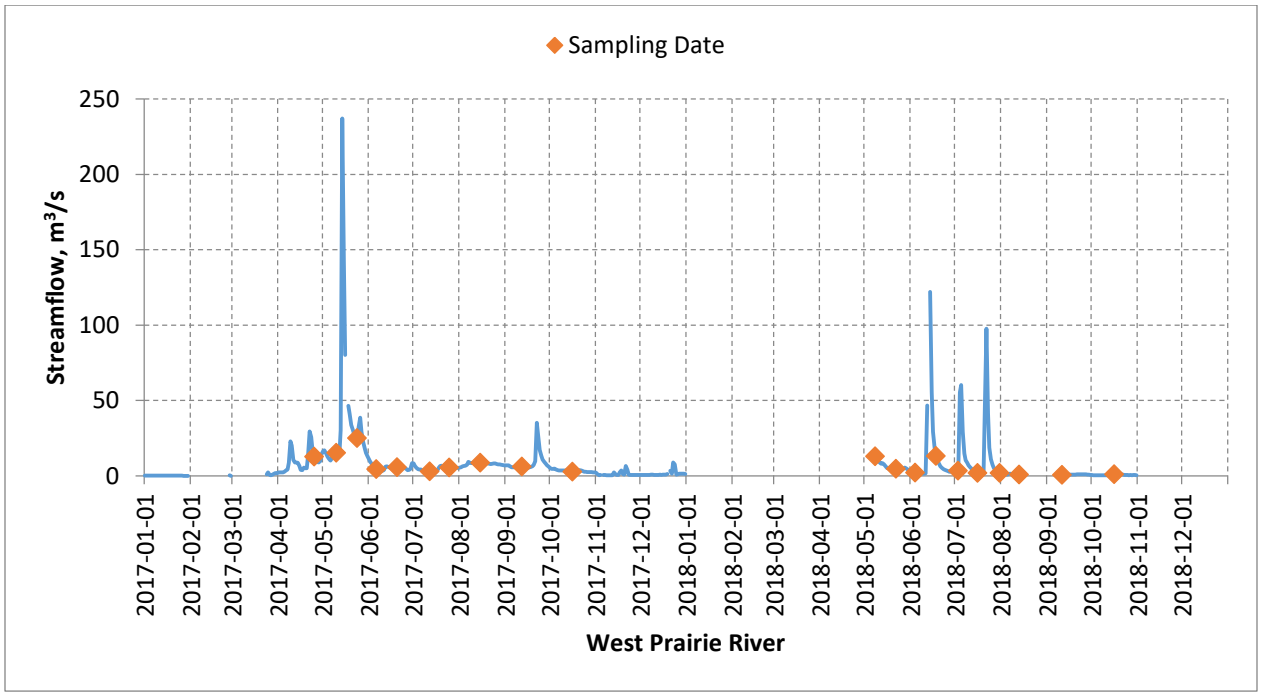

Figure 6. Average daily streamflow at West Prairie River, 2017 and 2018 (NRT-Flows provided by AEP, 2018, 2019).

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 at Peavine, and 10.4 m^3/s in 2017 and 16.5 m^3/s in 2018 at Big Prairie Settlement. Peak discharge occurred on May 16 at Peavine (8.4 m^3/s) in 2017 and on June 15 (28.5 m^3/s) in 2018. At Big Prairie Settlement, peak discharge occurred on May 16 (57.8 m^3/s) in 2017 and on June 18 (57.9 m^3/s) in 2018. Other 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.

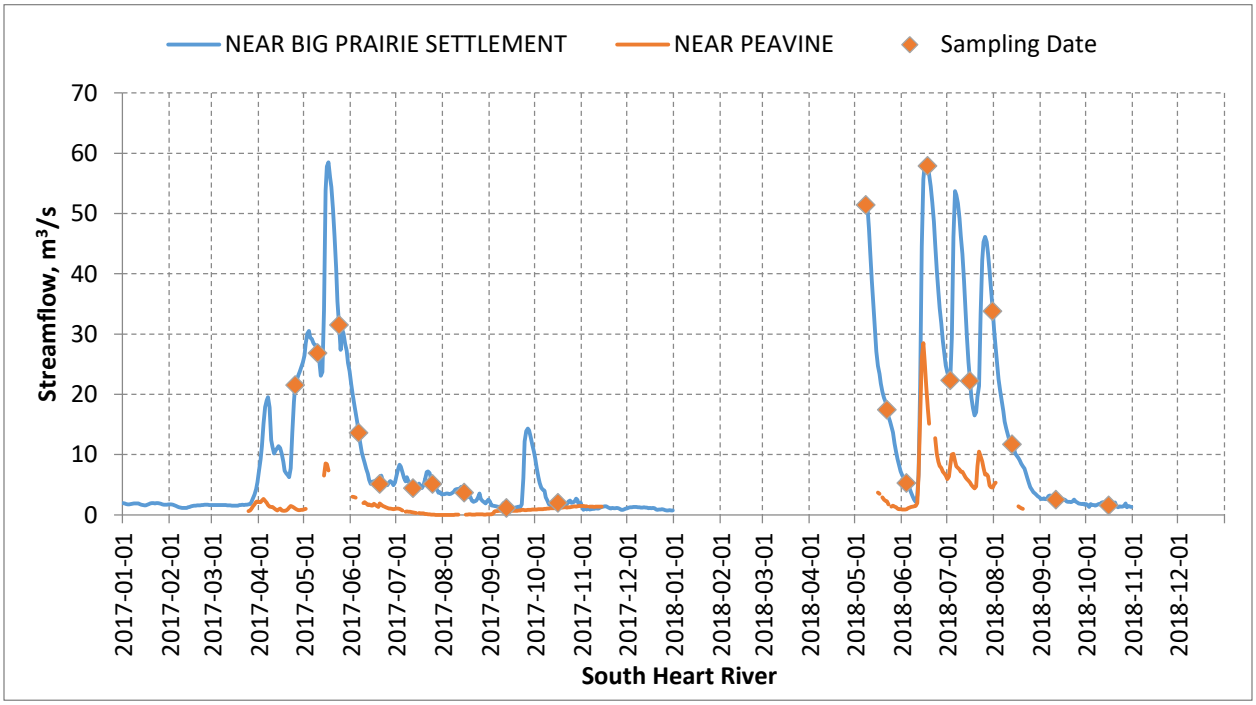

Figure 7. Average daily streamflow at South Heart River, 2017 and 2018 (NRT-Flows provided by AEP, 2018, 2019).

4.3 Routine Parameters

4.3.1 Swan River

In 2018, median water temperature ranged from 12.3°C at the Upper Swan River site to 17.5°C at the Lower Swan River site (Table 5). Maximum water temperatures ranged from 17.8°C at the Upper site to 20.5°C at the Lower site.

Median pH ranged from 7.85 at the Lower Swan River site to 8.14 at the Upper Swan River site and met the provincial aquatic life guideline (Table 6). Maximum pH values ranged from 8.33 at the Lower site to 8.94 at the Middle site. All pH samples in 2018 met the provincial guideline for the protection of aquatic life ($\geq$6.5 to $\leq$9.0) at the Upper, Middle and Lower Swan sites.

In 2018, median dissolved oxygen concentrations ranged from 8.49 mg/L at the Lower Swan River site to 10.31 mg/L at the Upper Swan River site (Table 7). Minimum DO concentrations ranged from 7.08 mg/L at the Lower site to 8.21 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 specific conductivity values ranged from 168 µS/cm at the Middle Swan River site to 186 µS/cm at the Lower Swan River site (Table 8). Maximum conductivity values ranged from 212 µS/cm at the Middle site to 256 µS/cm at the Lower site. In 2018, all samples met the provincial guidelines for safe irrigation (<1,000 µS/cm) at the three Swan River sites (GoA 2018).

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

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	10	11.1	0.3	13.8	10	12.3	2.8	17.8
Middle Swan	10	12.8	1.4	17.4	10	14.9	3.9	20.6
Lower Swan	10	13.6	2.7	17.5	9	17.5	4.9	20.5
Upper Driftpile	10	14.9	4.2	18.1	10	16.1	5.6	22.1
Middle Driftpile	10	14.3	2.9	17.4	10	16.0	4.7	21.5
Lower Driftpile	10	15.1	3.6	16.7	10	15.6	4.7	20.4
Upper East Prairie	10	15.4	4.4	19.0	10	16.0	4.0	24.0
Middle East Prairie	10	17.2	4.0	21.8	10	16.1	4.1	23.6
Lower East Prairie	9	17.1	2.0	18.3	9	14.6	3.9	22.3
Upper West Prairie	10	13.0	1.6	18.4	10	13.8	4.0	20.2
Middle West Prairie	10	14.3	2.2	20.3	10	14.6	3.7	21.4
Upper South Heart	10	17.1	4.6	19.9	10	16.0	3.8	21.0
Middle South Heart	10	16.0	3.7	19.7	10	16.0	3.3	21.3
Lower South Heart	10	15.1	2.0	23.5	10	15.6	4.0	22.0
Grouard Channel	10	17.3	1.3	21.7	10	16.2	3.7	21.5

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

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	10	8.02	7.34	8.72	10	8.14	7.59	8.51
Middle Swan	10	8.14	7.88	11.56	10	7.95	7.44	8.94
Lower Swan	10	7.96	7.68	8.23	9	7.85	7.29	8.33
Upper Driftpile	10	8.09	7.51	8.79	10	8.07	7.26	8.48
Middle Driftpile	9	8.15	7.70	9.67	10	8.03	7.27	8.31
Lower Driftpile	10	8.00	7.70	8.82	10	7.65	7.12	8.04
Upper East Prairie	10	8.18	7.64	8.74	10	8.15	7.67	8.50
Middle East Prairie	10	7.98	7.71	8.18	10	8.12	7.66	8.74
Lower East Prairie	9	7.68	7.32	8.27	9	7.84	7.13	8.65
Upper West Prairie	10	7.76	7.45	10.01	10	7.86	7.45	8.46
Middle West Prairie	10	7.87	7.59	8.04	10	7.99	7.62	8.36
Upper South Heart	10	8.11	7.50	8.57	10	8.00	7.69	8.12
Middle South Heart	10	8.01	7.79	8.22	10	8.06	7.87	8.27
Lower South Heart	10	7.85	7.50	8.95	10	7.83	7.38	8.56
Grouard Channel	10	7.76	7.56	9.25	10	7.71	7.11	8.13

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			
	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	10	9.90	9.40	11.90	10	10.31	8.21	11.86
Middle Swan	10	9.70	8.72	11.20	10	9.45	7.38	11.73
Lower Swan	10	8.90	8.51	11.60	9	8.49	7.08	11.56
Upper Driftpile	10	9.35	8.70	11.90	10	9.45	7.74	12.13
Middle Driftpile	10	10.01	8.80	11.60	10	9.25	7.50	11.70
Lower Driftpile	10	8.90	8.10	11.40	10	8.73	6.88	11.52
Upper East Prairie	10	10.54	8.70	11.36	10	9.48	7.30	11.74
Middle East Prairie	10	9.83	8.20	11.69	10	8.98	7.20	11.94
Lower East Prairie	9	8.77	7.43	11.69	9	7.70	4.61	11.44
Upper West Prairie	10	10.25	8.40	11.76	10	9.04	7.19	10.80
Middle West Prairie	10	10.20	8.40	11.00	10	9.12	7.46	11.62
Upper South Heart	10	9.98	8.90	11.29	10	9.39	7.80	11.58
Middle South Heart	10	9.05	8.00	10.56	10	8.39	6.87	11.55
Lower South Heart	10	8.34	7.34	10.01	10	7.44	4.05	11.38
Grouard Channel	10	8.69	7.00	10.61	10	6.93	3.88	11.20

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

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	130	85	217	10	175	66	215
Middle Swan	9	119	64	226	10	168	65	212
Lower Swan	9	111	65	268	9	186	66	256
Upper Driftpile	8	114	65	245	10	169	58	217
Middle Driftpile	10	113	69	269	10	183	63	249
Lower Driftpile	9	120	63	297	10	194	64	300
Upper East Prairie	9	197	114	313	10	271	89	339
Middle East Prairie	10	186	93	362	10	250	93	378
Lower East Prairie	9	197	111	374	9	247	160	377
Upper West Prairie	10	149	71	352	10	191	73	394
Middle West Prairie	10	188	88	457	10	243	90	490
Upper South Heart	10	336	294	419	10	266	253	422
Middle South Heart	10	359	300	407	10	327	252	422
Lower South Heart	10	232	126	337	10	274	136	388
Grouard Channel	10	217	146	289	10	276	152	367

4.3.2 Driftpile River

In 2018, median water temperature ranged from 15.6°C at the Lower Driftpile River site to 16.1°C at the Upper Driftpile River site (Table 5). Maximum water temperatures ranged from 22.1°C at the Upper site to 20.4°C at the Lower site.

Median pH ranged from 7.65 at the Lower Driftpile River site to 8.07 at the Upper Driftpile River site, and met the provincial guideline for the protection of aquatic life (PAL) ($\geq$6.5 to $\leq$9.0) (Table 6).

Maximum pH values ranged from 8.04 at the Lower site to 8.48 at the Upper site. All pH samples in 2018 met the provincial PAL guideline at the Upper, Middle and Lower Driftpile River sites.

Median dissolved oxygen concentrations ranged from 8.73 mg/L at the Lower Driftpile River site to 9.45 mg/L at the Upper Driftpile River site (Table 7). Minimum DO concentrations ranged from 6.88 mg/L at the Lower site to 7.74 mg/L at the Upper site. In 2018, 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).

In 2018, median specific conductivity values ranged from 169 µS/cm at the Upper Driftpile River site to 194 µS/cm at the Lower Driftpile River site (Table 8). Maximum conductivity values ranged from 217 µS/cm at the Upper site to 300 µS/cm at the Lower site. All samples met the provincial guidelines for safe irrigation (<1,000 µS/cm) (GoA 2018).

4.3.3 East Prairie River

In 2018, median water temperature ranged from 14.6°C at the Lower East Prairie River site to 16.1°C at the Middle East Prairie River site (Table 5). Maximum water temperatures ranged from 22.3°C at the Lower site to 24.0°C at the Upper site.

Median pH ranged from 7.84 at the Lower East Prairie River site to 8.15 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 8.50 at the Upper site to 8.74 at the Middle site. All pH samples in 2018 met the provincial PAL guideline at the Upper, Middle and Lower East Prairie River sites.

In 2018, median dissolved oxygen concentrations ranged from 7.70 mg/L at the Lower East Prairie site to 9.48 mg/L at the Upper East Prairie River site (Table 7). Minimum DO concentrations ranged from 4.61 mg/L at the Lower site to 7.30 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 one sample (4.61 mg/L) on July 31 at the Lower East Prairie River that exceeded the acute guideline.

Median specific conductivity values ranged from 247 µS/cm at the Lower East Prairie River site to 271 µS/cm at the Upper East Prairie River site (Table 8). Maximum conductivity values ranged from 339 µS/cm at the Upper site to 378 µS/cm at the Middle site. In 2018, all samples met the provincial guidelines for safe irrigation (<1,000 µS/cm) (GoA 2018).

4.3.4 West Prairie River

In 2018, the median water temperature was 13.8°C at the Upper West Prairie River site and 14.6°C at the Middle West Prairie River site (Table 5). Maximum water temperature was 20.2°C at the Upper site and 21.4°C at the Middle site.

Median pH was 7.86 at the Upper West Prairie River site and 7.99 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). Maximum pH was 8.36 at the Middle site and 8.46 at the Upper site. All pH samples in 2018 met the provincial PAL guideline at the Upper and Middle West Prairie River sites.

The median dissolved oxygen concentration was 9.04 mg/L at the Upper West Prairie site and 9.12 mg/L at the Lower West Prairie River site (Table 7). The minimum DO concentration was 7.19 mg/L at the Upper site and 7.46 mg/L at the Lower site. The medians and all sample 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 191 µS/cm at the Upper West Prairie River site and 243 µS/cm at the Middle West Prairie River site (Table 8). The maximum conductivity value was 394 µS/cm at the Upper site and 490 µS/cm at the Middle site. In 2018, 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 15.6°C at the Lower South Heart River site to 16.0°C at the Middle and Upper South Heart River site (Table 5). Maximum water temperatures ranged from 21.0°C at the Upper site to 22.0°C at the Lower site.

Median pH ranged from 7.83 at the Lower South Heart River site to 8.06 at the Middle 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 8.12 at the Upper site to 8.56 at the Lower site. All pH samples met the provincial PAL guideline at all sites.

Median dissolved oxygen concentrations ranged from 7.44 mg/L at the Lower South Heart site to 9.39 mg/L at the Upper South Heart River site (Table 7). Minimum DO concentrations ranged from 4.05 mg/L at the Lower site to 7.80 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 samples on June 18 and July 30 (4.74 mg/L and 4.05 mg/L, respectively) at the Lower South Heart River that exceeded the acute guideline.

Median specific conductivity values ranged from 266 µS/cm at the Upper South Heart River site to 327 µS/cm at the Middle South Heart River site (Table 8). Maximum conductivity values ranged from 388 µS/cm at the Lower site to 422 µS/cm at the Upper and Middle sites. All samples met the provincial guidelines for safe irrigation (<1,000 µS/cm) (GoA 2018).

At the Grouard Channel, median water temperature was 16.2°C, minimum water temperature was 3.7°C and maximum was 21.5°C (Table 5). The median pH was 7.71, minimum pH was 7.11 and maximum was 8.13 (Table 6). The median dissolved oxygen concentration was 6.93 mg/L, minimum dissolved oxygen concentration was 3.88 mg/L and maximum was 11.20 mg/L (Table 7). The median conductivity was 276 µS/cm, minimum conductivity was 152 µS/cm and maximum was 367 µS/cm (Table 8). All pH and conductivity values met the provincial guidelines for the protection of aquatic life and irrigation water quality, respectively. The median dissolved oxygen concentration met the provincial guideline for the protection of aquatic life (≥6.5 to ≤9.0); however, samples on June 18 and July 30 (4.49 mg/L and 3.88 mg/L, respectively) at the Grouard Channel exceeded the acute guideline.

4.4 Phosphorus

4.4.1 Swan River

The median total phosphorus (TP) concentration ranged from 0.030 mg/L at the Upper Swan River site to 0.048 mg/L at the Lower Swan River site (Table 9). Maximum TP concentration was higher at the Middle Site (0.940 mg/L) compared to the Upper site (0.619 mg/L) and Lower site (0.170 mg/L). The maximum TP concentration at the Middle Swan River site was more than five times the Lower site. Total dissolved phosphorus was generally less than the detection limit of the analytical equipment (0.020 mg/L) at the Upper and Middle sites. The median and maximum total dissolved phosphorus increased from the Upper to Lower site, and ranged from 0.010 to 0.023 mg/L (median) and 0.028 to 0.035 mg/L (maximum) (Table 10).

At the Middle Swan River site, the median TP concentration in 2017 (0.034 mg/L) and 2018 (0.039 mg/L) was lower compared to the historic[3] 1991-92 median (0.048 mg/L, Table 3). Minimum TP concentration in 2018 at the Middle site (0.029 mg/L) was similar compared to 1991-92 (0.026 mg/L) and both were higher than the minimum in 2017 (0.010 mg/L). The maximum TP concentration was higher in 2018 at the Middle Swan River site (0.940 mg/L) compared to 2017 (0.410 mg/L) and the historic 1991-92 maximum (0.173 mg/L).

At the Lower Swan River site, median TP concentration in 2018 (0.048 mg/L) and 2017 (0.050 mg/L) was marginally lower than the historic 2012-13 median (0.060 mg/L, Table 3). The minimum TP concentration in 2018 (0.034 mg/L) and 2017 (0.029 mg/L) was similar to the 2012-13 minimum (0.031 mg/L). The maximum TP concentration at the Lower Swan River site in 2018 (0.170 mg/L) was substantially lower than 2017 (1.060 mg/L) and higher than the maximum 2012-13 concentration (0.084 mg/L). The maximum TP concentration occurred on May 9 at the Lower site, and on July 4 at the Middle and Upper sites. Samples collected at the Upper and Middle sites on July 4 had the poorest water quality, likely due to the high streamflow (245 m^3/s) and mobilization of suspended solids. To account for missing data, the total phosphorus concentration at the Lower site was estimated using linear regression to better reflect water quality conditions (Appendix C-1). The TP concentration on July 4 was estimated to be 2.38 mg/L, the maximum TP concentration observed for the monitoring period. Total phosphorus at the Swan River was strongly correlated with total suspended solids concentration (R^2=0.99).

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

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	0.034	0.010	0.127	10	0.030	0.010	0.619
Middle Swan	9	0.034	0.010	0.410	10	0.039	0.029	0.940
Lower Swan	9	0.050	0.029	1.060	10 (9)	0.048	0.034	2.38 (0.170)
Upper Driftpile	8	0.039	0.010	0.148	10	0.047	0.028	0.970
Middle Driftpile	10	0.053	0.020	0.118	10	0.051	0.030	1.290
Lower Driftpile	9	0.045	0.024	0.108	10	0.046	0.031	1.280

[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.

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Upper East Prairie	9	0.025	0.010	0.110	10	0.029	0.010	1.590
Middle East Prairie	10	0.086	0.010	0.241	10	0.076	0.032	0.480
Lower East Prairie	9	0.073	0.025	0.129	9	0.071	0.031	0.180
Upper West Prairie	10	0.051	0.037	0.500	10	0.062	0.016	1.060
Middle West Prairie	10	0.055	0.030	0.362	10	0.065	0.024	0.333
Upper South Heart	10	0.092	0.064	0.239	10	0.097	0.019	0.137
Middle South Heart	10	0.094	0.072	0.193	10	0.144	0.043	0.282
Lower South Heart	10	0.153	0.109	0.602	10	0.138	0.089	0.229
Grouard Channel	10	0.118	0.039	0.248	10	0.107	0.046	0.341

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

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	0.010	0.010	0.031	10	0.010	0.010	0.028
Middle Swan	9	0.010	0.010	0.026	10	0.016	0.010	0.030
Lower Swan	9	0.010	0.010	0.028	9	0.023	0.010	0.035
Upper Driftpile	8	0.010	0.010	0.080	10	0.025	0.010	0.032
Middle Driftpile	9	0.010	0.010	0.028	10	0.025	0.010	0.035
Lower Driftpile	9	0.010	0.010	0.041	10	0.025	0.010	0.033
Upper East Prairie	9	0.010	0.010	0.021	10	0.010	0.010	0.238
Middle East Prairie	10	0.010	0.010	0.067	10	0.024	0.010	0.054
Lower East Prairie	9	0.010	0.010	0.010	9	0.037	0.010	0.092
Upper West Prairie	10	0.023	0.010	0.042	10	0.025	0.010	0.047
Middle West Prairie	10	0.022	0.010	0.132	10	0.028	0.010	0.066
Upper South Heart	10	0.051	0.010	0.165	10	0.069	0.010	0.187
Middle South Heart	10	0.034	0.010	0.165	10	0.052	0.010	0.082
Lower South Heart	10	0.023	0.010	0.169	10	0.050	0.010	0.088
Grouard Channel	10	0.010	0.010	0.120	10	0.051	0.010	0.279

4.4.2 Driftpile River

The median TP concentration ranged from 0.046 mg/L at the Lower Driftpile River site to 0.051 mg/L at the Middle Driftpile River site (Table 9). Maximum TP concentrations ranged from 0.970 mg/L at the Upper site to 1.208 mg/L at the Lower Driftpile site. Maximum TP concentrations occurred on July 4 at the three Driftpile River sites concurrent with the highest discharge and total suspended solids. In 2018, total phosphorus tended to increase from upstream to downstream, similar to 2017. Total phosphorus was correlated with total suspended solids at the Driftpile River (R^2=0.81).

The median total dissolved phosphorus was the same at all the Driftpile River sites (0.025 mg/L) (Table 10) and the maximum total dissolved phosphorus was similar at all sites (0.032 to 0.035 mg/L). The maximum total dissolved phosphorus occurred on August 14 at the three Driftpile River sites.

At the Middle Driftpile River site, the median TP concentration in 2018 (0.051 mg/L) and 2017 (0.053 mg/L) was higher compared to the 1991-92 median (0.040 mg/L, Table 3). The minimum TP

concentration in 2018 (0.030 mg/L) was higher than 2017 (0.020 mg/L) and 1991-92 (0.022 mg/L). The maximum TP concentration at the Middle Driftpile River in 2018 (1.280 mg/L) was substantially higher than 2017 (0.118 mg/L) and 1991-92 (0.129 mg/L).

Compared to historic data[4], the median TP concentration at the Lower Driftpile River site in 2017 (0.045 mg/L) and 2018 (0.046 mg/L) was similar to the 2012-13 median (0.051 mg/L, Table 3). The minimum TP concentration in 2018 (0.031 mg/L) was higher than 2017 (0.024 mg/L) and 2012-13 (0.020 mg/L). The maximum TP concentration at Lower Driftpile in 2018 (1.280 mg/l) was higher than 2017 (0.108 mg/L) and 2012-13 (0.873 mg/L).

4.4.3 East Prairie River

The median TP concentration ranged from 0.029 mg/L at the Upper East Prairie River site to 0.076 mg/L at the Middle East Prairie River site (Table 9). Maximum TP concentrations ranged from 0.180 mg/L at the Lower site to 1.590 mg/L at the Upper East Prairie site. Maximum TP concentrations occurred on May 8 at the Lower and Middle sites, and on July 3 at the Upper site. Total dissolved phosphorus (TDP) was generally less than the detection limit of the analytical equipment (0.020 mg/L) at the Upper site. The median total dissolved phosphorus increased from the Upper to Lower site (0.010 to 0.037 mg/L) and the maximum TDP ranged from 0.054 to 0.238 mg/L (Table 10). Total phosphorus was strongly correlated with total suspended solids at the East Prairie River (R^2=0.87).

The median TP concentration at the Middle East Prairie River site in 2018 (0.076) and 2017 (0.086 mg/L) was similar compared to the historic median[5] (2012-13: 0.076 mg/L, Table 3). The minimum TP concentration in 2018 (0.032) was higher than 2017 (0.010 mg/L) but similar to historic data from 2012-13 (0.028 mg/L). The maximum TP concentration at the Middle East Prairie River site in 2018 (0.480 mg/L) was higher than 2017 (0.241 mg/L) but both the 2017 and 2018 maximum TP was substantially lower compared to 2012-13 (1.120 mg/L).

4.4.4 West Prairie River

The median TP concentration was 0.062 mg/L at the Upper West Prairie River site and 0.065 mg/L at the Middle West Prairie River site (Table 9). The maximum TP concentration was 0.333 mg/L at the Middle site and 1.060 mg/L at the Upper West Prairie site. Maximum values occurred on May 10 at the Upper site, and on April 25 at the Middle site. The median total dissolved phosphorus concentration was 0.025 mg/L at the Upper West Prairie River site and 0.028 mg/L at the Middle West Prairie River site. The maximum TDP concentration was 0.047 mg/L at the Upper site and 0.066 mg/L at the Middle West Prairie site. Maximum TP concentration occurred on June 18 at the Upper site, and on May 8 at the Middle site. The median total dissolved phosphorus was 0.025 and 0.028 mg/L at the Upper and Middle sites and maximum total dissolved phosphorus occurred on July 3 (0.047 and 0.066 mg/L). Total phosphorus was also strongly correlated with total suspended solids concentration at the West Prairie River (R^2=0.98).

[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.

The median TP concentration at the Middle West Prairie River site in 2018 (0.065 mg/L) and 2017 (0.055 mg/L) was similar compared to the historic[6] 2012-13 median (0.053 mg/L, Table 3). The minimum TP concentration in 2018 (0.024 mg/L) and 2017 (0.030 mg/L) was similar to the historic data from 2012-13 (0.028 mg/L). The maximum TP concentration at the Middle West Prairie River site in 2018 (0.333 mg/L) and in 2017 (0.362 mg/L) was substantially lower than 2012-13 (1.150 mg/L).

4.4.5 South Heart River and Grouard Channel

At the South Heart River, the median TP concentration ranged from 0.097 mg/L at the Upper South Heart site to 0.153 mg/L at the Middle South Heart site (Table 9). Maximum TP concentrations ranged from 0.137 mg/L at the Upper site to 0.282 mg/L at the Middle South Heart River site. Maximum TP concentrations occurred on August 13 at the Upper site, May 8 at the Middle site, and on June 18 at the Lower site. The median total dissolved phosphorus concentration ranged from 0.050 mg/L at the Lower South Heart River site to 0.069 mg/L at the Upper South Heart River site. Maximum TDP concentrations ranged from 0.088 mg/L at the Lower site to 0.187 mg/L at the Upper site. Maximum TDP concentrations occurred on May 8 at the Upper site, July 3 at the Middle site and July 16 at the Lower site. Total phosphorus was correlated with total suspended solids at the South Heart River (R^2=0.84).

Compared to historic data[7], the median TP concentration at the Lower South Heart River site in 2018 (0.138 mg/L) and 2017 (0.153 mg/L) was higher compared to the 1991-92 median (0.094 mg/L, Table 3) and similar to the 2012-13 median (0.143 mg/L, Table 3). The minimum TP concentration in in 2018 (0.089 mg/L) and 2017 (0.109 mg/L) was higher compared to 1991-92 (0.050 mg/L) and 2012-13 (0.079 mg/L). The maximum TP concentration at the Lower South Heart River site in 2018 (0.229 mg/L) was similar to 1991-92 (0.190 mg/L), but lower compared to 2017 (0.602 mg/L) and 2012-13 (0.838 mg/L).

At the Grouard Channel site, the median TP concentration was 0.107 mg/L, and ranged from 0.046 mg/L to 0.341 mg/L (Table 5). The median and minimum TP concentrations were lower at the Grouard Channel compared to the Lower South Heart River site but the maximum TP concentration at the Grouard Channel was higher compared to the Lower South Heart River site. The maximum TP concentration occurred on July 30. The median TDP at Grouard Channel in 2018 was 0.051 mg/L (range: 0.010 to 0.279 mg/L) and was higher than 2017 (median: 0.010, range: 0.010 to 0.0120 mg/L) (Table 10). The maximum TDP concentration occurred on July 30 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 0.325 mg/L at the Upper Swan River site to 0.410 mg/L at the Lower Swan River site (Table 13). The maximum TN concentrations ranged from 0.790

[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 in 2017 and 2018.

[7] 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 in 2017 and 2018.

mg/L at the Lower site to 1.370 mg/L at the Middle site. Maximum TN concentrations occurred on July 4 at the Upper and Middle sites, and May 9 at the Lower site.

At the Lower Swan River site, the median TN concentration in 2018 (0.410 mg/L) and 2017 (0.400 mg/L) was lower than the historic 2012-13 median (0.518 mg/L, Table 3). The minimum TN concentration in 2018 and 2017 (0.100 mg/L) was lower compared to the 2012-13 minimum (0.201 mg/L). The maximum concentration 2018 (0.790 mg/L) was lower than 2017 (3.430 mg/L) and 2012-13 (2.110 mg/L).

At the Middle Swan River site, the median TN concentration in 2018 (0.395 mg/L) was similar to the historic 1991-92 median (0.431 mg/L, Table 3) and higher than the 2017 median (0.270 mg/L). The minimum TN concentration in 2018 and 2017 (0.100 mg/L) was lower compared to the 1991-92 minimum (0.275 mg/L). The maximum concentration in 2018 (1.370 mg/L) was similar to 2017 (1.570 mg/L) and both 2017 and 2018 maximum TN was higher than 1991-92 (0.832 mg/L).

4.5.2 Driftpile River

The median TN concentration ranged from 0.520 mg/L at the Lower Driftpile River site to 0.685 mg/L at the Middle Driftpile River site in 2018 (Table 13). Maximum TN concentrations ranged from 1.290 mg/L at the Lower site to 2.980 mg/L at the Upper Driftpile site. Maximum TN concentrations occurred on June 5 at the Upper site, and July 4 at the Middle and Lower sites.

Compared to historic data[8], the median TN concentration at Lower Driftpile River site in 2018 (0.520 mg/L) and 2017 (0.450 mg/L) was similar compared to the 2012-13 median (0.546 mg/L, Table 3). Minimum TN concentration in 2018 (0.240 mg/L) was similar to 2012-13 (0.262 mg/L) but higher than in 2017 (0.100 mg/L). Maximum TN concentration in 2018 (1.290 mg/L) and 2017 (1.120 mg/L) at the Lower Driftpile River was considerably lower than the maximum TN in 2012-13 (7.878 mg/L).

At the Middle Driftpile River site, the median TN concentration in 2018 (0.685 mg/L) was higher than 2017 (0.455 mg/L) and the 1991-92 median (0.482 mg/L, Table 3). The minimum total TN concentration in 2018 (0.220 mg/L) and 2017 (0.100 mg/L) was lower compared to 1991-92 (0.281 mg/L). The maximum TN concentration in 2018 (1.130 mg/L) and 2017 (1.030 mg/L) was similar compared to the 1991-92 maximum TN (0.976 mg/L).

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

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	0.011	0.011	0.025	10	0.011	0.003	0.011
Middle Swan	9	0.011	0.011	0.044	10	0.011	0.003	0.040
Lower Swan	9	0.011	0.011	0.045	9	0.011	0.003	0.041
Upper Driftpile	8	0.011	0.010	0.025	10	0.011	0.011	0.049
Middle Driftpile	10	0.011	0.011	0.027	10	0.011	0.011	0.031
Lower Driftpile	9	0.011	0.011	0.198	10	0.011	0.011	0.025
Upper East Prairie	9	0.011	0.011	0.057	10	0.011	0.011	0.080

[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.

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Middle East Prairie	10	0.011	0.011	0.075	10	0.011	0.011	0.075
Lower East Prairie	9	0.011	0.011	0.040	9	0.011	0.011	0.044
Upper West Prairie	10	0.011	0.011	0.061	10	0.011	0.011	0.030
Middle West Prairie	10	0.011	0.011	0.040	10	0.011	0.011	0.035
Upper South Heart	10	0.011	0.011	0.111	10	0.022	0.011	0.081
Middle South Heart	10	0.011	0.010	0.239	10	0.032	0.011	0.146
Lower South Heart	10	0.023	0.011	0.095	10	0.011	0.011	0.239
Grouard Channel	10	0.011	0.011	0.067	10	0.011	0.011	0.054

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

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	0.230	0.100	0.690	10	0.325	0.100	1.280
Middle Swan	9	0.270	0.100	1.570	10	0.395	0.100	1.370
Lower Swan	9	0.400	0.100	3.430	9	0.410	0.100	0.780
Upper Driftpile	8	0.370	0.100	0.990	10	0.610	0.300	2.980
Middle Driftpile	10	0.455	0.100	1.030	10	0.675	0.220	1.100
Lower Driftpile	9	0.450	0.100	1.120	10	0.520	0.240	1.290
Upper East Prairie	9	0.100	0.100	0.830	10	0.390	0.100	1.010
Middle East Prairie	10	0.485	0.100	1.700	10	0.555	0.280	1.090
Lower East Prairie	9	0.520	0.380	1.800	9	0.500	0.240	1.260
Upper West Prairie	10	0.760	0.490	1.710	10	0.715	0.310	1.100
Middle West Prairie	10	0.805	0.560	1.890	10	0.725	0.360	1.520
Upper South Heart	10	1.425	0.670	2.240	10	1.150	0.890	1.620
Middle South Heart	10	1.295	0.720	2.070	10	1.295	0.910	1.900
Lower South Heart	10	1.240	0.910	3.650	10	1.205	0.960	1.570
Grouard Channel	10	0.860	0.340	2.420	10	1.040	0.560	1.520

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

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	0.230	0.100	0.690	10	0.325	0.100	1.280
Middle Swan	9	0.270	0.100	1.570	10	0.395	0.100	1.370
Lower Swan	9	0.400	0.100	3.430	9	0.410	0.100	0.790
Upper Driftpile	8	0.370	0.100	0.990	10	0.610	0.300	2.980
Middle Driftpile	10	0.455	0.100	1.030	10	0.685	0.220	1.130
Lower Driftpile	9	0.450	0.100	1.120	10	0.520	0.240	1.290
Upper East Prairie	9	0.100	0.100	0.830	10	0.390	0.100	1.010
Middle East Prairie	10	0.485	0.100	1.730	10	0.555	0.280	1.160
Lower East Prairie	9	0.520	0.380	1.800	9	0.500	0.240	1.310
Upper West Prairie	10	0.760	0.490	1.710	10	0.715	0.310	1.130
Middle West Prairie	10	0.805	0.560	1.930	10	0.725	0.360	1.550
Upper South Heart	10	1.425	0.780	2.350	10	1.165	0.920	1.700
Middle South Heart	10	1.295	0.720	2.310	10	1.305	1.030	2.050

Site	2017				2018			
Lower South Heart	10	1.260	0.910	3.700	10	1.220	0.980	1.630
Grouard Channel	10	0.860	0.340	2.420	10	1.070	0.560	1.520

4.5.3 East Prairie River

In 2018, the median TN concentration ranged from 0.390 mg/L at the Upper East Prairie River site to 0.555 mg/L at the Middle East Prairie River site (Table 13). Maximum TN concentrations ranged from 1.010 mg/L at the Upper site to 1.310 mg/L at the Lower East Prairie River site. Maximum TN concentrations occurred on July 3 at the Upper site, and May 8 at the Middle and Lower sites.

The median TN concentration at Middle East Prairie in 2018 (0.555 mg/L) was similar to the historic median[9] (2012-13: 0.565 mg/L, Table 3) and higher than 2017 (0.485 mg/L). The minimum TN concentration in 2018 (0.280 mg/L) was similar to 2012-13 (0.249 mg/L) but higher than 2017 (0.100 mg/L). The maximum TN concentration in 2018 (1.160 mg/L) and 2017 (1.730 mg/L) was substantially lower compared to 2012-13 (2.972 mg/L).

4.5.4 West Prairie River

In 2018, the median TN concentration was 0.715 mg/L at the Upper West Prairie River site and 0.725 mg/L at the Middle West Prairie River site (Table 13). The maximum TN concentration was 1.130 mg/L at the Upper site and 1.550 mg/L at the Middle West Prairie site. Maximum TN concentrations occurred on May 8 at the Middle and Upper sites.

The median TN concentration at Middle West Prairie River in 2018 (0.725 mg/L) and 2017 (0.805 mg/L) was similar compared to the historic[10] 2012-13 median (0.859 mg/L, Table 3). The minimum TN concentration in 2018 (0.360 mg/L) was lower than 2017 (0.560 mg/L) but similar to 2012-13 (0.411 mg/L). The maximum TN concentration in 2018 (1.550 mg/L) and 2017 (1.930 mg/L) was substantially lower compared to 2012-13 (3.786 mg/L).

4.4.5 South Heart River and Grouard Channel

At the South Heart River in 2018, the median TN concentration ranged from 1.165 mg/L at the Upper South Heart River site to 1.305 mg/L at the Middle South Heart River site (Table 13). Maximum TN concentrations ranged from 1.630 mg/L at the Lower site to 2.050 mg/L at the Middle site. Maximum TN concentrations occurred on May 8 at the Upper site and on July 16 at the Middle and Lower sites.

Compared to historic data[11], the median TN concentration at the Lower South Heart River site in 2018 (1.220 mg/L) and 2017 (1.260 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 minimum TN concentration in 2018 (0.980 mg/L) and 2017 (0.910 mg/L) was similar compared to 1991-92 (1.052 mg/L) but higher compared to 2012-13 (0.724 mg/L). The maximum TN concentration in 2018 (1.630 mg/L) was lower compared to 2017 (3.700 mg/L), 1991-92 (1.955 mg/L) and 2012-13 (2.762 mg/L).

[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 in 2017 and 2018.

At Grouard Channel in 2018, the median TN concentration was 1.070 mg/L, and ranged from 0.560 to 1.520 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 July 16.

4.6 Total Suspended Solids (TSS)

4.6.1 Swan River

In 2018 the median total suspended solids (TSS) concentration ranged from 11 mg/L at the Middle Swan River site to 19 mg/L at the Upper Swan River site (Table 14). Maximum TSS concentrations nearly doubled at the Middle site (2110 mg/L) compared to the Upper site (1160 mg/L) but maximum TSS decreased to 257 mg/L at the Lower site. A sample was not obtained at Lower Swan River on July 4 due to flooding and site accessibility. Therefore, the maximum TSS at the Lower Swan River site was likely much higher. Similar to TP concentrations, maximum TSS concentrations occurred on July 4 at the Upper and Middle sites (1160 and 2110 mg/L). To account for missing data, the TSS concentration at the Lower site was estimated using linear regression to better reflect water quality conditions (Appendix C-1). The TSS concentration on July 4 was estimated to be 6200 mg/L, the maximum TSS concentration observed during the monitoring period.

At the Middle Swan River site, the median TSS concentration in 2018 (11 mg/l) and 2017 (12 mg/L) was somewhat lower compared to the historic 1991-92 median (21 mg/L, Table 3). The minimum TSS concentration in 2018 (5 mg/L) and 2017 (2 mg/L) was similar compared to the 1991-92 minimum (4 mg/L). The maximum TSS concentration in 2018 (2110 mg/L) and 2017 (1030 mg/L) was substantially higher than the TSS maximum 1991-92 (187 mg/L).

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

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	8	2	183	10	19	2	1160
Middle Swan	9	12	2	1030	10	11	5	2110
Lower Swan	9	31	3	3060	10 (9)	16	7	6200 (257)
Upper Driftpile	8	15	2	254	10	14	3	2230
Middle Driftpile	10	39	2	153	10	18	6	3570
Lower Driftpile	9	37	5	136	10	16	4	3380
Upper East Prairie	9	15	2	168	10	9	4	3200
Middle East Prairie	10	83	2	445	10	37	5	576
Lower East Prairie	9	36	6	125	9	21	9	65
Upper West Prairie	10	24	7	200	10	31	7	541
Middle West Prairie	10	18	2	451	10	17	6	440
Upper South Heart	10	3	2	16	10	5	4	12
Middle South Heart	10	15	7	75	10	72	8	125
Lower South Heart	10	75	26	818	10	30	21	144
Grouard Channel	10	25	5	270	10	15	4	143

4.6.2 Driftpile River

In 2018, the median TSS concentration ranged from 14 mg/L at the Upper Driftpile River site to 18 mg/L at the Middle Driftpile River site (Table 14). Maximum TSS concentrations ranged from 2230 mg/L at the Upper site to 3570 mg/L at the Middle site. Maximum TSS concentrations occurred on July 4 at the three Driftpile River sites.

The 2017 and 2018 TSS data at the Lower Driftpile River site cannot be compared to historic data as TSS data was not collected in 2012-13. At the Middle Driftpile River site, the median TSS concentration in 2018 (18 mg/L) and 2017 (39 mg/L) was higher compared to the 1991-92 median (14 mg/L, Table 3). The minimum TSS concentration in 2018 (6 mg/L) and 2017 (5 mg/L) was higher compared to 1991-92 (2 mg/L). The maximum TSS concentration at the Middle Driftpile River site in 2018 (3570 mg/L) was substantially higher than 2017 (136 mg/L) and the 1991-92 maximum (128 mg/L).

4.6.3 East Prairie River

The median TSS concentration ranged from 9 mg/L at the Upper East Prairie River site to 37 mg/L at the Middle East Prairie River site in 2018 (Table 14). Maximum TSS concentrations ranged from 65 mg/L at the Lower site to 3200 mg/L at the Upper site. Maximum TSS concentrations occurred on July 3 at the Upper Site, May 8 at the middle site and May 22 at the Lower site.

Compared to historic data[12], minimum TSS concentrations in 2018 (5 mg/L) and 2017 (2 mg/L) were lower compared to 2012-13 (12 mg/L, Table 3). Similarly, compared to historic data, maximum TSS concentrations in 2018 (576 mg/L) and 2017 (445 mg/L) were lower compared to 2012-13 (1150 mg/L).

4.6.4 West Prairie River

In 2018, the median TSS concentration was 17 mg/L at the Middle West Prairie River site and 31 mg/L at the Upper West Prairie River site (Table 14). The maximum TSS concentration was 440 mg/L at the Middle site and 541 mg/L at the Upper site. The maximum TSS concentration occurred on July 3 at the Upper site and on May 8 at the Middle site.

The minimum TSS concentration at Middle West Prairie River in 2018 (6 mg/L) and 2017 (2 mg/L) was similar compared to the historic[13] 2012-13 minimum (6 mg/L, Table 3). The maximum TSS concentration in 2018 (440 mg/L) and 2017 (451 mg/L) was substantially lower 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 72 mg/L at the Middle South Heart River site (Table 14). The maximum TSS concentration ranged from 12 mg/L at the Upper site to 144 mg/L at the Lower site. The maximum TSS concentrations occurred on May 8 at the Upper and Middle sites and June 18 at the Lower site.

[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.

Compared to historic data[14], the median TSS concentration at the Lower South Heart River site in 2018 (30 mg/L) and 2017 (75 mg/L) was higher compared to the 1991-92 median (10 mg/L). Minimum TSS concentration in in 2018 (21 mg/L) and 2017 (26 mg/L) was higher compared to 1991-92 (5 mg/L). Maximum TSS concentration in 2018 (144 mg/L) was similar compared to 1991-92 (132 mg/L) and lower than 2017 (818 mg/L) (Table 3 and 14).

At Grouard Channel in 2018, the median TSS concentration was 15 mg/L, and ranged from 4 to 143 mg/L (Table 14). The TSS median and range in 2018 was less than 2017 (Table 14). The maximum TSS concentration occurred on June 18 at the Grouard Channel.

4.7 Fecal Coliform Bacteria (FCB)

4.7.1 Swan River

The median fecal coliform bacteria (FCB) count ranged from 13 cfu/100 mL at the Upper Swan River site to 31 cfu/100 mL at the Middle Swan River site (Table 15). Maximum FCB counts ranged from 65 cfu/100 mL at the Lower site to 620 cfu/100 mL at the Middle site. Maximum FCB concentrations occurred on July 4 at the Upper and Middle sites and June 5 at the Lower site. No sample was obtained from the Lower site on July 4 due to site accessibility.

Compared to historic data, the median FCB count at the Middle Swan River site in 2018 (31 cfu/100 mL) and 2017 (46 cfu/100 mL) was lower compared to the 1991-92 median (60 cfu/100 mL) (Table 3). Minimum FCB counts in 2018 (9 cfu/100 mL) and 2017 (5 cfu/100 mL) were lower compared to 1991-92 (20 cfu/100 mL). In 2018, the maximum FCB count (620 cfu/100 mL) was higher compared to 2017 (250 cfu/100 mL) and 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-October, 2017 and 2018.

Site	2017				2018			
	N	Median	Min	Max	N	Median	Min	Max
Upper Swan	9	22	1	120	10	13	1	420
Middle Swan	9	46	5	250	10	31	9	620
Lower Swan	9	110	5	870	9	20	7	65
Upper Driftpile	8	20	8	160	10	12	1	2400
Middle Driftpile	10	20	3	200	10	16	1	220
Lower Driftpile	9	71	3	210	10	15	1	1100
Upper East Prairie	9	11	1	44	10	30	1	520
Middle East Prairie	10	45	5	200	10	43	7	110
Lower East Prairie	9	64	20	220	9	25	2	190
Upper West Prairie	10	110	20	330	10	48	10	810
Middle West Prairie	10	145	20	330	10	98	11	330
Upper South Heart	10	5	1	10	10	1	1	4
Middle South Heart	10	64	5	200	10	30	1	330
Lower South Heart	10	67	10	1400	10	17	2	360
Grouard Channel	10	20	5	48	10	3	1	54

[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 in 2017 and 2018.

4.7.2 Driftpile River

The median fecal coliform count ranged from 12 cfu/100 mL at the Upper Driftpile River site to 16 cfu/100 mL at the Middle Driftpile River site (Table 15). Maximum FCB counts ranged from 220 cfu/100 mL at the Middle site to 2400 cfu/100 mL at the Upper site. Maximum FCB concentrations occurred on July 4 at all Driftpile River sites.

Compared to historic data, the median FCB count at the Middle Driftpile River site in 2018 (16 cfu/100 mL) and 2017 (20 cfu/100 mL) was similar compared to the 1991-92 median (15 cfu/100 mL, Table 3). Minimum FCB counts in 2018 (1 cfu/100 mL) and 2017 (3 cfu/100 mL) were similar compared to 1991-92 (2 cfu/100 mL). In 2018, maximum FCB counts (220 cfu/100 mL) were similar compared to 2017 (200 cfu/100 mL) and 1991-92 (200 cfu/100 mL) (Table 3 and 15).

4.7.3 East Prairie River

In 2018, the median fecal coliform count ranged from 25 cfu/100 mL at the Lower East Prairie River site to 43 cfu/100 mL at the Middle East Prairie River site (Table 15). Maximum FCB counts ranged from 110 cfu/100 mL at the Middle site to 520 cfu/100 mL at the Upper site. Maximum FCB concentrations occurred on July 3 at the Upper site and on June 4 at the Middle and Lower sites.

4.7.4 West Prairie River

In 2018, the median fecal coliform count was 48 cfu/100 mL at the Upper West Prairie River site and 98 cfu/100 mL at the Middle West Prairie River site (Table 15). The maximum FCB count was 330 cfu/100 mL at the Middle site and 810 cfu/100 mL at the Upper site. Maximum FCB concentrations occurred on June 4 at both West Prairie River sites.

4.7.5 South Heart River and Grouard Channel

In 2018 at the South Heart River, the median fecal coliform count ranged from 1 cfu/100 mL at the Upper South Heart River site to 30 cfu/100 mL at the Middle South Heart River site (Table 15). The maximum FCB count ranged from 4 cfu/100 mL at the Upper site to 360 cfu/100 mL at the Lower site. The maximum FCB concentrations occurred on May 8 at the Upper site, July 30 at the Middle site, and on September 11 at the Lower site.

Compared to historic data, the median FCB count at the Lower South Heart River site in 2018 (17 cfu/100 mL) was similar to the 1991-92 median (20 cfu/100 mL, Table 3) and lower than 2017 (67 cfu/100 mL). Minimum FCB counts in 2018 (2 cfu/100 mL) and 2017 (10 cfu/100 mL) were similar compared to 1991-92 (4 cfu/100 mL). Maximum FCB counts in 2018 (360 cfu/100 mL) and 2017 (1400 cfu/100 mL) were higher compared to 1991-92 (264 cfu/100 mL) (Table 3 and 15).

In 2018 at the Grouard Channel, the median fecal coliform count was 3 cfu/100 mL, and ranged from 1 to 54 cfu/100 mL (Table 15). The maximum FCB concentration occurred on July 30 at the Grouard Channel.

4.8 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 2018. Results showed that 10 metals exceeded the provincial guideline for the protection of aquatic life (PAL) at the upper site, 11 metals exceeded the guideline at the middle site, and 7 metals exceeded at the lower site (Figure 8). In 2018, seven metals exceeding the guideline that were common to all sites were total mercury, total cadmium, total lead, total boron, total copper, dissolved aluminum and dissolved iron. Total mercury, total boron and dissolved iron were the metals that most often exceeded guidelines.

In addition to the seven metals that exceeded the provincial PAL guideline at all three Swan River sites, total arsenic, total nickel, total silver and total zinc exceeded PAL guidelines at one or two Swan River sites. There were no guideline exceedances of hexavalent chromium, total selenium, total uranium or dissolved zinc.

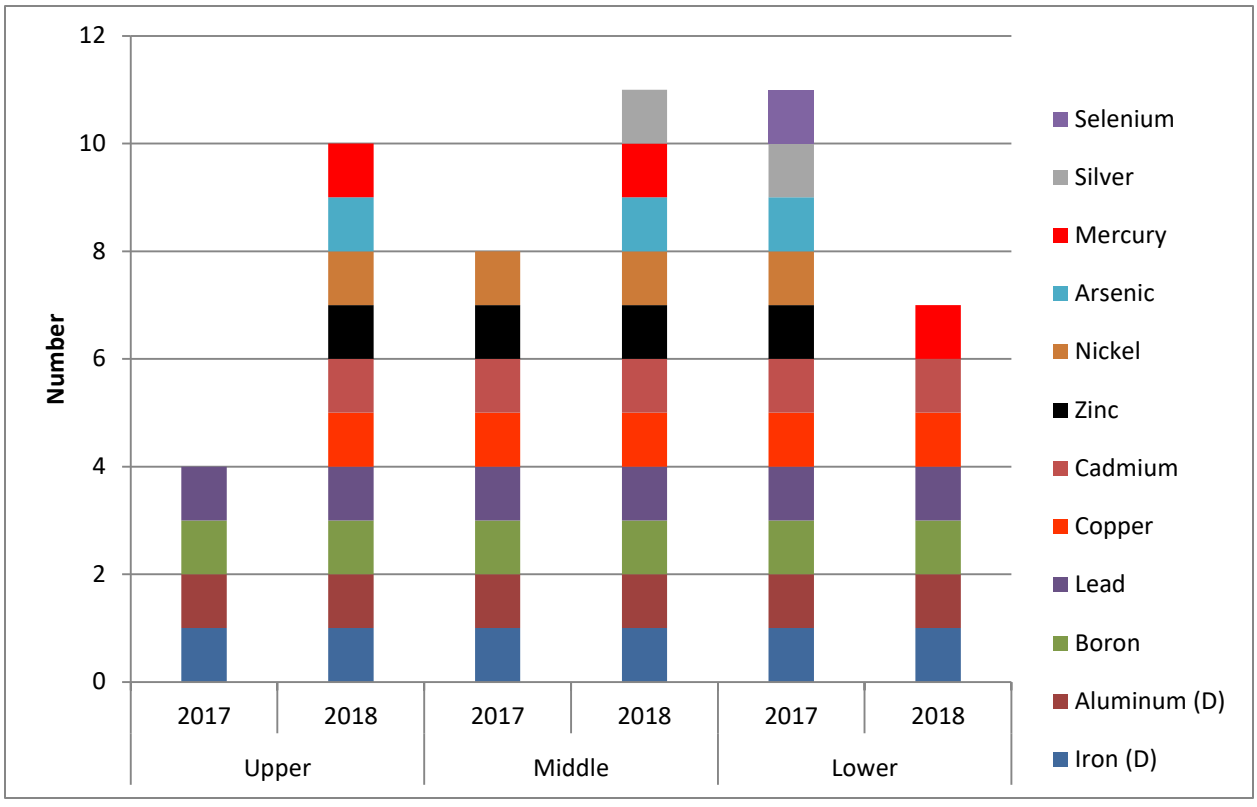

Figure 8. Number of metals detected that exceeded the provincial PAL guideline at the upper, middle and lower Swan River sites, June to September 2017 (N=5) and May to October 2018 (N=7).

Total Arsenic

Total arsenic ranged from 0.00127 to 0.018 mg/L with a median of 0.00194 at the Swan River sites in 2018. Two of 20 samples (10%) exceeded the chronic total arsenic guideline in 2018 at the Swan River sites. The samples exceeded the chronic total arsenic guideline by a factor of 2.0 and 3.6 times.

Arsenic ranks as the 53rd element in abundance in the earth's crust, and is more common in the earth's crust than are other common elements such as mercury, cadmium and silver (CCREM 1987). Smelting, refining industries and combustion of fossil fuels, especially coal are anthropogenic sources of arsenic. Arsenic is used in metallurgical applications and in manufacturing wood preservatives. Arsenic compounds are also used in herbicide, pharmaceutical, and glass manufacturing. The largest natural source of arsenic entering surface waters is that from weathered rocks and soils. Levels of total arsenic in uncontaminated surface waters are generally less than 0.002 mg/L (CCME 2001). The estimated amount of arsenic released to the global environment annually as a result of human activities is about twice that reaching the environment from weathering. Most of the arsenic reaching the environment is sorbed by soils and sediment (CCREM 1987).

Total Boron

Total boron ranged from <0.010 to 0.027 mg/L with a median of 0.017 at the Swan River sites in 2018. Thirteen of 20 samples (65%) exceeded the chronic total boron guideline in 2018 at the Swan River sites. The samples exceeded the chronic total boron guideline by a factor of 7 to 18 times. The remaining seven samples had a detection limit that was above the chronic guideline. Therefore, it is not known if the sample concentration is above or below the guideline. Boron is ubiquitous in the environment, occurring naturally in greater than 80 minerals and constituting 0.001% of the Earth's crust. The highest concentrations of boron are found in sediments and sedimentary rock. Due to the extensive occurrence of clay-rich sedimentary rocks on the Earth's surface, the majority of boron mobilized into soils and the aquatic environment probably stems from natural weathering processes. Surface water total boron concentrations have been found to range from 0.0001 to 0.082 mg/L in Alberta (CCME 2009).

Total Cadmium

In 2018, total cadmium concentrations at the Swan River sites ranged from 0.0000105 to 0.000987 mg/L with a median of 0.0000289 mg/L. Five of 20 samples (25%) exceeded the chronic total cadmium guideline in 2018 at the Swan River sites. Two of the 20 samples (10%) had total cadmium concentrations below the detection limit of the analytical equipment. The samples exceeded the chronic total cadmium guideline by a factor of 1.2 to 16.5 times. 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 <0.0001 to 0.112 mg/L (an extreme value); average concentrations range from 0.0002 to 0.0003 mg/L (CCME 2014). Typical background dissolved cadmium concentrations in freshwaters of the United States ranged from 0.000002 to 0.00008 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 0.0101 mg/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 0.00047 to 0.00197 mg/L while Arctic Grayling and Mountain Whitefish have a 96 h LC50 with cadmium concentrations between 0.00489 to 0.00492 mg/L (CCME 2014).

Total Copper

The median total copper concentration at the Swan River sites in 2018 was 0.002 mg/L (range: 0.00096 to 0.0677 mg/L). Five of 20 samples (25%) exceeded the acute total copper guideline in 2018 at the Swan River sites. Two of the 20 samples (10%) had total copper concentrations below the detection limit of the analytical equipment. The samples exceeded the acute total copper guideline by a factor of 1.3 to 18 times. Total copper exceeded the acute PAL guideline at all sites on May 9 and July 4. 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 on May 9 and July 4. At 11 interprovincial border sites in the prairies, total copper concentrations varied from below detection to 0.085 mg/L; most median values were around 0.003 mg/L with some median values as high as 0.008 mg/L (AEP 1996).

Total Lead

The median total lead concentration at the Swan River sites in 2018 was 0.000409 mg/L (range: 0.000128 to 0.0306 mg/L). Five of 20 samples (25%) exceeded the chronic total lead guideline in 2018 at the Swan River sites. Concentrations of total lead on May 9 ranged between 0.00286 to 0.00385 mg/L and on July 4 between 0.0169 to 0.0306 mg/L. The samples exceeded the chronic total lead guideline by a factor of 2.9 to 30.6 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,

[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.

such as organic matter, hydrous oxides and clays. The total lead exceedances at the Swan River sites occurred on May 9 and July 4 concurrent with the highest suspended solids concentrations.

Total Mercury

Total mercury at the Swan River sites in 2018 ranged from 0.000005 to 0.000117 mg/L with a median of 0.00000405 mg/L. Ten of 20 samples (50%) exceeded the chronic or acute total mercury guideline in 2018 at the Swan River sites. Five samples exceeded the chronic total mercury PAL guideline by a factor of 1.1 to 2.4 times on August 14 and September 17. Five samples exceeded the acute PAL guideline by a factor of 2.0 to 9.0 times on May 9, July 4 and July 31. 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 <0.00002 to 0.00024 mg/L (CCREM 1987). In freshwater habitats, mercury compounds sorb to particulate matter and to sediment. Mercury sorption onto sediments is an important process for determining its abiotic fate in the aquatic environment. Sediment binding capacity is related to organic content. Mercury tends to combine with sulphur in anaerobic bottom sediments (CCREM 1987).

Total Nickel

The median total nickel concentration at the Swan River sites in 2018 was 0.00548 mg/L (range: 0.00321 to 0.0713 mg/L). Two of 20 samples (10%) exceeded the chronic total nickel guideline in 2018 at the Swan River sites. Total nickel exceeded the chronic PAL on July 4 at the Upper site (0.038 mg/L) and Middle site (0.0713 mg/L). The samples exceeded the chronic total nickel guideline by a factor of 2.0 and 3.4 times. Nickel ranks as the 23rd element in order of abundance in the earth's crust, and occurs in nature mainly in combination with sulphur, arsenic and antimony. The uses of nickel are based on its resistance to corrosion, high strength over a wide temperature range, alloying properties and appearance. The manufacture of stainless steel, nickel plating and high-nickel alloys constitutes the main uses of nickel. High-nickel alloys are used in chemical, marine, electronic, nuclear and aerospace applications. Nickel is also used as a catalyst in industrial processes and in oil refining. Nickel enters the environment primarily through the weathering of minerals and rocks, and as a result of human activities. The major contributor of nickel released to the environment by human activity is the burning of fossil fuels, primarily crude oil and coal (CCREM 1987).

Total Silver

At the Swan River sites in 2018, total silver ranged from <0.000010 to 0.000276 mg/L with a median of 0.000005 mg/L. One of 20 samples (5%) exceeded the chronic total silver guideline in 2018 at the Swan River sites. The sample exceeded the chronic total silver guideline by a factor of 1.1 times. Fourteen of the 20 samples (70%) had total silver concentrations below the detection limit of the analytical equipment. The total silver exceedance (0.000276 mg/L) at the middle Swan River occurred on July 4 and coincided with a total suspended solids concentration of 2110 mg/L (the highest TSS in 2018); therefore, the total silver was likely naturally occurring from the erosion of streambanks and substrate.

Silver is a naturally occurring element, and roughly 60% of silver in water comes from natural sources with the rest coming from anthropogenic inputs such as mining operations and metal production. Concentrations of silver in water are higher near mineral deposits. Silver is found in very low concentrations elsewhere in the environment, especially compared to other metals. In Canada, between 2008 and 2013, total silver concentrations were measured in thousands of surface water samples with varying water chemistry and varying levels of anthropogenic influence. In Alberta, Manitoba, Saskatchewan and the Northwest Territories the concentrations ranged from <0.000001 mg/L to 0.000690 mg/L with a mean of 0.000005 mg/L (CCME 2015).

Total Zinc

At the Swan River sites in 2018, total zinc ranged from <0.0030 to 0.167 mg/L with a median of 0.00325 mg/L. Two of 20 samples (10%) exceeded the chronic total zinc guideline in 2018 at the Swan River sites. The samples exceeded the chronic total zinc guideline by a factor of 3.3 to 5.6 times. Ten of the 20 samples (50%) had total zinc concentrations below the detection limit of the analytical equipment. Total zinc concentration exceeded the chronic PAL guideline on July 4 at the Upper site (0.0993 mg/L) and the Middle site (0.167 mg/L) concurrent with the highest TSS concentrations. Zinc is the fourth most common metal in use, after iron, aluminum, and copper. Approximately half of mined zinc is used as an anti-corrosion agent by coating (galvanizing) iron or steel to protect the metals against corrosion. Galvanization is used on chain-link fencing, culverts, guard rails, cathodic anodes, suspension bridges, light posts, metal roofs, heat exchangers, and car bodies. The presence of elevated levels of total zinc at the Swan River in July 2018 at the upper and middle sites is probably due to anthropogenic uses. Surface water total zinc concentrations have been found to range from 0.0001 to 0.139 mg/L in the Athabasca region of Alberta (CCME 2018).

Dissolved Aluminum

At the Swan River sites in 2018, dissolved aluminum ranged from 0.0125 to 0.120 mg/L with a median of 0.03225 mg/L. Five of 20 samples (25%) exceeded the chronic or acute dissolved aluminum guideline in 2018 at the Swan River sites. Three samples exceeded the dissolved aluminum chronic PAL guideline by a factor of 1.3 to 1.5 times on May 9 (0.0644 to 0.0754 mg/L) and two samples exceeded the acute PAL guideline by a factor of 1.2 times at the Upper and Middle sites on July 4 (0.115 to 0.120 mg/L). 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 2018, dissolved iron ranged from 0.182 to 1.70 mg/L with a median of 0.7195 mg/L. Seventeen of 20 samples (85%) exceeded the chronic dissolved iron guideline in 2018 at the Swan River sites. Dissolved iron exceeded the chronic PAL guideline (0.300 mg/L) at all sites on all sample dates except May 9. Iron ranged from 0.182 to 0.600 mg/L at the Upper site, from 0.266 to 1.19 mg/L at the Middle site, and from 0.215 to 1.7 mg/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 and 2018) 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 metals concentration, and decreasing trend in dissolved metals concentration from upstream to downstream was noted for the Swan River by Hutchinson et al. (2015). The authors suggested that changes in metals concentration 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 mixedwood natural region where soils are primarily organic.

5.0 SUMMARY

This report summarizes the second 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 in 2017 and 2018. 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 2 monitoring results. Table 16 compares the 2017 and 2018 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 was 16% less in 2018 compared to 2017.
- Average flow decreased but peak flows increased in 2018 compared to 2017 at Driftpile, Swan and East Prairie rivers.
- Average flow and peak flow decreased at West Prairie River in 2018 compared to 2017.
- Average flow and peak flow increased at South Heart River in 2018 compared to 2017.

- Peak streamflow generally occurred on May 14 at all sites in 2017. In 2018, peak streamflow occurred on July 4 at Driftpile and East Prairie rivers, June 13 at Swan River (near Kinuso), June 14 at West Prairie River and, on June 18 at the South Heart River (at Big Prairie Settlement).

Swan River

- Routine parameters (dissolved oxygen, pH and conductivity) met guidelines.
- Total phosphorus concentrations were highest at the Lower Swan River site and tended to increase from upstream to downstream.
- The missing July 4 sample at the Lower Swan River site leads to an underestimation of maximum water quality values. Maximum total phosphorus and total suspended solids concentrations were estimated using linear regression. A strong correlation was observed between total phosphorus and total suspended solids (R^2=0.99).
- Median fecal coliform counts were lower at the Swan River in 2018 compared to 2017, however maximum counts were higher in 2018 at the Upper and Middle sites.

Metals

- At Swan River, there were 5 sampling events and 15 samples for metal in 2017 compared to 7 sampling events and 20 samples for metals in 2018.
- In 2018, no sample was obtained at the Lower Swan River site on July 4 due to flooding; however, there were several metals exceedances at two other sites on July 4. 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 exceedances of guidelines per metal increased slightly for some metals in 2018 compared to 2017, but this may be due to the increased number of samples collected
- Total mercury did not exceed the PAL guideline in 2017; however, in 2018 it exceeded the guideline in half of the samples (10 times); 5 chronic and 5 acute guideline exceedances occurred.
- Total selenium exceeded the PAL guideline once in 2017, but did not exceed the guideline in 2018.

Driftpile River

- Routine parameters (dissolved oxygen, pH and conductivity) met guidelines.
- Total phosphorus concentration was generally lowest at the Upper site, and similar at the Middle and Lower sites. Occasionally, the Middle site total phosphorus concentration exceeded the Lower site.
- Similar to total phosphorus concentration, total suspended solids concentration was generally lowest at the Upper site, and similar at the Middle and Lower sites. Spring TSS was highest in the spring at the Lower site, but was highest at the Middle site in October.
- A strong correlation was observed between total phosphorus and total suspended solids (R^2=0.99) in 2018.
- Median and maximum fecal coliform bacteria counts at the Middle Driftpile River site were similar to 2017 and historic counts. Maximum fecal coliform bacteria counts were higher at the Upper site (2400 cfu/100 mL) and Lower site (1100 cfu/100 mL) in 2018 compared to 2017 (160 cfu/100 mL and 210 cfu/100 mL, respectively).

Table 16. Comparison of 2017 and 2018 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	South Heart				West Prairie			East Prairie			Driftpile				Swan			
		1991-92	2012-13	2017[a]	2018[a]	2012-13	2017[b]	2018[b]	2012-13	2017[b]	2018[b]	1991-92	2012-13	2017[c]	2018[c]	1991-92	2012-13	2017[c]	2018[c]
		N=9	N=12	N=10	N=10	N=12	N=10	N=10	N=12	N=10	N=10	N=11	N=12	N=10	N=10	N=11	N=11	N=10	N=10 (9)
Temperature, °C	Median	16.5	12.7	15.1	15.6	12.8	14.3	14.6	13.4	17.2	16.1	16.2	13.9	15.1	15.6	15.6	14.5	13.6	17.5
	Min	12.0	0.9	2.0	4.0	3.3	2.2	3.7	1.3	4	4.1	0.7	1.6	3.6	4.7	0.8	2.5	2.7	4.9
	Max	21.5	21.3	23.5	22.0	21.7	20.3	21.4	22.6	21.8	23.6	21.7	23.1	16.7	20.4	20.0	22.6	17.5	20.5
Dissolved Oxygen, mg/L	Median	-	8.36	8.34	7.44	9.95	10.20	9.12	9.62	9.83	8.98	9.00	9.72	8.90	8.73	8.60	9.60	8.90	8.49
	Min	-	6.05	7.34	4.05	8.23	8.40	7.46	7.94	8.20	7.20	8.00	7.54	8.10	6.88	8.16	7.80	8.51	7.08
	Max	-	15.87	10.01	11.38	13.85	11.00	11.62	16.04	11.69	11.94	13.18	15.32	11.40	11.52	12.89	12.18	11.60	11.56
Total Phosphorus, mg/L	Median	0.094	0.143	0.153[d]	0.138	0.053	0.055	0.065	0.076	0.086	0.076	0.040	0.051	0.045[d]	0.046	0.048	0.060	0.050[d]	0.048
	Min	0.050	0.079	0.109	0.089	0.028	0.030	0.024	0.028	0.010	0.032	0.022	0.020	0.024	0.031	0.026	0.031	0.029	0.034
	Max	0.190	0.838	0.602	0.229	1.150	0.362	0.333	1.120	0.241	0.480	0.129	0.873	0.108	1.280	0.173	0.084	1.060	2.380 (0.170)
Total Dissolved Phosphorus, mg/L	Median	0.027	0.024	0.023	0.050	0.018	0.022	0.028	0.013	0.010	0.024	0.016	0.012	0.010[d]	0.025	0.015	0.012	0.010[d]	0.023
	Min	0.015	0.012	0.010	0.010	0.006	0.010	0.010	0.004	0.010	0.010	0.007	0.005	0.010	0.010	0.010	0.009	0.010	0.010
	Max	0.058	0.064	0.162	0.088	0.033	0.132	0.066	0.032	0.067	0.054	0.021	0.025	0.041	0.033	0.016	0.023	0.028	0.035
Total Nitrogen, mg/L	Median	1.197	1.187	1.260	1.220	0.859	0.805	0.725	0.565	0.485	0.555	0.482	0.546	0.450[d]	0.520	0.431	0.518	0.400[d]	0.410
	Min	1.052	0.724	0.910	0.980	0.411	0.560	0.360	0.249	0.100	0.280	0.281	0.262	0.100	0.240	0.275	0.201	0.100	0.100
	Max	1.955	2.762	3.700	1.630	3.786	1.930	1.550	2.972	1.730	1.160	0.976	7.878	1.120	1.290	0.832	2.110	3.430	0.790
Nitrate+Nitrite Nitrogen, mg/L	Median	0.039	0.032	0.023	0.011	0.009	0.011	0.011	0.009	0.011	0.011	0.003	0.006	0.011[d]	0.011	0.002	0.012	0.011[d]	0.011
	Min	0.002	0.003	0.011	0.011	0.003	0.011	0.011	0.003	0.011	0.011	0.001	0.003	0.011	0.011	0.001	0.003	0.011	0.003
	Max	0.083	0.072	0.095	0.239	0.086	0.040	0.035	0.152	0.075	0.075	0.026	0.148	0.198	0.025	0.032	0.093	0.045	0.041
Total Suspended Solids, mg/L	Median	10	-	75	30	-	18	17	-	83	37	14	-	37[a]	16	21	-	31[a]	16
	Min	5	-	26	21	6	2	6	12	2	5	2	-	5	4	4	-	3	7
	Max	132	-	818	144	1170	451	440	1150	445	576	128	-	136	3380	187	-	3060	6200 (257)
Fecal Coliform Bacteria, cfu/100 mL	Median	20	-	67	17	-	145	98	-	45	43	15	-	71[a]	15	60	-	110[a]	20
	Min	4	-	10	2	-	20	11	-	5	7	2	-	3	1	20	-	5	7
	Max	264	-	1400	360	-	330	330	-	200	110	200	-	210	1100	200	-	870	65

[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

East Prairie River

- Routine parameters (dissolved oxygen, pH and conductivity) met guidelines, except one dissolved oxygen concentration at the Lower East Prairie River site on July 31.
- Unlike the Driftpile and Swan rivers, total phosphorus concentration at the East Prairie River was generally highest at the Middle site, except on July 3, when the Upper site had a high concentration of TP (1.590 mg/L) mobilized during a rain event.
- Total suspended solids followed a similar trend as total phosphorus concentration, with highest TSS concentrations generally recorded at the Middle site, except on July 3 when the Upper site had a high concentration of TSS (3200 mg/L) mobilized during a rain event. In 2017, a similar trend occurred when double the TSS concentration was observed at the Upper site during a rain event (July 25, 2017).
- A strong correlation was observed between total phosphorus and total suspended solids (R^2=0.96) in 2018.
- The maximum fecal coliform bacteria count was highest at the Upper East Prairie site in 2018 (520 cfu/100 mL), and higher compared to the 2017 maximum count (44 cfu/100 mL).

West Prairie River

- Routine parameters (dissolved oxygen, pH and conductivity) met guidelines.
- In 2018, total phosphorus concentrations were highest at the Upper site compared to the Middle site during periods of higher streamflow (June 2018).
- Total suspended solids concentration did not follow the same trend as total phosphorus in 2018. During the first rain and highest rain event in June, total suspended solids concentration was highest at the Middle site. During the second event in July, the Upper site had substantially higher total suspended solids concentration compared to the Middle site.
- A weak correlation was observed between total phosphorus and total suspended solids (R^2=0.31) in 2018.
- The maximum fecal coliform bacteria count was highest at the Upper East Prairie River site (810 cfu/100 mL) in 2018, and the median count was highest at the Middle site (98 cfu/100 mL).

South Heart River and Grouard Channel

- Routine parameters (dissolved oxygen, pH and conductivity) generally met guidelines, except on June 18 and July 30 when dissolved oxygen did not meet the acute guideline for Protection of Aquatic Life at the Lower South Heart River and the Grouard Channel.
- Total phosphorus concentration generally increased from the Upper South Heart River site to the Lower site, except in May when the Middle site had the highest total phosphorus. concentration. The Grouard Channel had the highest concentration of total phosphorus in July following a series of high streamflow events.
- Total suspended solids concentration was generally highest at the Middle South Heart River site throughout the monitoring period, except on June 18 when it was highest at the Lower site and at the Grouard Channel.
- Total phosphorus and total suspended solids were weakly correlated at the South Heart River (R^2=0.46) and at the Grouard Channel (R^2=0.15) in 2018.
- Maximum fecal coliform bacteria counts increased from upstream to downstream at the South Heart River in 2018. The median count was highest at the Middle site. Fecal coliform bacteria counts were generally lower in 2018 compared to 2017.

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 in 2017 and 2018 should be undertaken for at least the next three 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.

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.

7.0 REFERENCES

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APPENDIX A. WATER MONITORING SAMPLE LOCATIONS, 2017 AND 2018.

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.

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	Lab 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 mg/L
Upper West Prairie	08-May-18	09:20:00	7.5		73.2	9.32	89.2	10	0.178	0.035	0.03	0.03	0.005	1.1	230	1.13	30
Mid West Prairie	08-May-18	10:20:00	7.66		90.3	8.82	84.9	10.9	0.333	0.035	0.035	0.035	0.005	1.52	440	1.55	30
Mid South Heart	08-May-18	10:45:00	7.92		405	8.8	85	10.9	0.282	0.032	0.094	0.094	0.005	1.67	125	1.77	21
Upper South Heart	08-May-18	11:25:00	7.69		422	9.36	86.6	8.9	0.0186	0.187	0.081	0.081	0.005	1.62	11.7	1.7	4
Lower South Heart	08-May-18	12:10:00	7.42		136	5.97	60.9	13.6	0.126	0.041	0.043	0.043	0.005	1.2	50.1	1.24	3
Lower East Prairie	08-May-18	13:15:00	7.13		232	5.58	58.1	14.1	0.18	0.092	0.034	0.044	0.01	1.26	15.8	1.31	2
Grouard Channel	08-May-18	12:40:00	7.33		152.2	6	62.5	14.3	0.156	0.021	0.045	0.045	0.005	1.13	64.7	1.17	10
Upper East Prairie	08-May-18	14:15:00	7.67		92.6	10.6	92.1	8.6	0.193	0.021	0.08	0.08	0.005	0.77	266	0.85	0.5
Mid East Prairie	08-May-18	15:10:00	8.03		92.6	8.62	87.2	12.8	0.48	0.023	0.075	0.075	0.005	1.09	576	1.16	10
Upper Swan	09-May-18	10:20:00	7.77		65.9	10.82	91	5	0.133	0.01	0.01	0.011	0.005	0.56	159	0.56	30
Mid Swan	09-May-18	11:15:00	7.87		65.4	10.28	90	7.1	0.133	0.01	0.04	0.04	0.005	0.57	183	0.61	10
Lower Swan	09-May-18	12:05:00	8.33		66	9.02	84.6	9.6	0.17	0.01	0.041	0.041	0.005	0.75	257	0.79	10
Mid Driftpile	09-May-18	14:25:00	7.64		68.5	9.74	90.2	9.2	0.133	0.01	0.022	0.022	0.005	0.7	145	0.72	30
Lower Driftpile	09-May-18	13:10:00	7.12		66.1	9.19	85.7	9.7	0.168	0.01	0.025	0.025	0.005	0.81	280	0.83	10
Upper Driftpile	09-May-18	13:45:00	7.6		64.1	9.79	90.5	9	0.089	0.022	0.049	0.049	0.005	0.63	99.3	0.68	10
Upper West Prairie	22-May-18	8:15	8		116.6	8.92	93.9	14.3	0.069	0.025	0.01	0.011	0.005	0.72	39.5	0.72	27
Mid West Prairie	22-May-18	9:00	8.21		154.8	8.97	97.8	16.3	0.083	0.027	0.01	0.011	0.005	0.77	55.4	0.77	18
Mid South Heart	22-May-18	9:35	8.27		312	8.09	88.5	16.5	0.178	0.04	0.01	0.011	0.005	1.26	98.9	1.26	4
Upper South Heart	22-May-18	10:18	8.04		275	9.42	102.6	16.1	0.098	0.039	0.01	0.011	0.005	1.1	7.8	1.1	1
Lower South Heart	22-May-18	11:00	7.9		275	6.82	77.8	18.5	0.089	0.039	0.01	0.011	0.005	0.98	21.6	0.98	2
Lower East Prairie	22-May-18	12:15	7.62		160	6.86	77.9	18.2	0.08	0.027	0.01	0.011	0.005	0.5	65.4	0.5	5
Grouard Channel	22-May-18	11:45	8.07		282	7.27	83.6	19	0.094	0.047	0.01	0.011	0.005	0.9	14.4	0.9	2
Upper East Prairie	22-May-18	14:15	8.28		173.3	9.12	105.3	18.5	0.035	0.01	0.01	0.011	0.005	0.31	25.7	0.31	29
Mid East Prairie	22-May-18	13:30	8.16		155	8.63	101.5	20	0.095	0.023	0.01	0.011	0.005	0.54	81.6	0.54	15
Upper Swan	23-May-18	9:25	8.44		130.8	9.95	104	13.7	0.031	0.01	0.01	0.011	0.005	0.31	19.8	0.31	2

Site	Date	Time	pH	TDS mg/L	Lab 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 mg/L
Mid Swan	23-May-18	10:10	8.94		128.4	8.94	100	17.2	0.039	0.01	0.01	0.011	0.005	0.41	18	0.41	80
Lower Swan	23-May-18	10:50	7.95		131.7	8.49	97.5	18.3	0.048	0.021	0.01	0.011	0.005	0.42	26.6	0.42	50
Mid Driftpile	23-May-18	12:25	8.13		130.2	8.76	102.2	19.4	0.041	0.025	0.01	0.011	0.005	0.48	18.9	0.48	5
Lower Driftpile	23-May-18	12:05	8.03		129.8	8.27	96	18.5	0.048	0.024	0.01	0.011	0.005	0.5	24.1	0.5	6
Upper Driftpile	23-May-18	13:10	8.19		126.1	9.1	106.1	19.2	0.038	0.025	0.01	0.011	0.005	0.43	11.7	0.43	6
Badger Creek	23-May-18								0.04	0.025	0.01	0.011	0.005	0.45	13.3	0.45	34
Upper West Prairie	04-Jun-18	8:35	8.18		194.9	9.03	96.4	13.9	0.049	0.01	0.01	0.011	0.005	0.53	27.3	0.53	810
Mid West Prairie	04-Jun-18	9:20	7.96		239	9.54	101.6	14.8	0.048	0.024	0.01	0.011	0.005	1.08	18.9	1.08	330
Mid South Heart	04-Jun-18	9:50	8.04		298	8.47	91.7	15.5	0.1	0.047	0.035	0.035	0.005	1.63.	33.1	1.67	61
Upper South Heart	04-Jun-18	10:30	7.99		282	9.55	105	15.9	0.068	0.058	0.01	0.011	0.005	1.23	4	1.23	0.5
Lower South Heart	04-Jun-18	11:15	8.05		290	8.8	93.2	14.9	0.164	0.072	0.01	0.011	0.005	1.48	39.5	1.48	8
Lower East Prairie	04-Jun-18	12:30	7.84		247	8.69	92.2	14.6	0.071	0.024	0.01	0.011	0.005	0.24	38.1	0.24	190
Grouard Channel	04-Jun-18	12:00	7.7		288	6.82	72.3	14.5	0.102	0.054	0.01	0.011	0.005	1.25	11.6	1.25	24
Upper East Prairie	04-Jun-18	14:10	8.18		259	9.64	104.2	15.2	0.01	0.01	0.01	0.011	0.005	0.37	7.9	0.37	97
Mid East Prairie	04-Jun-18	13:10	8.1		249	9.37	100.8	15.3	0.05	0.024	0.01	0.011	0.005	0.37	26.7	0.37	110
Upper Swan	05-Jun-18	9:15	8.28		173.3	10.67	104.9	10.8	0.023	0.01	0.01	0.011	0.005	0.1	20.1	0.1	67
Mid Swan	05-Jun-18	10:00	7.99		169.3	9.96	101.8	13.2	0.031	0.01	0.01	0.011	0.005	0.1	6	0.1	110
Lower Swan	05-Jun-18	10:45	7.95		174	9.51	100.5	14.8	0.034	0.023	0.01	0.011	0.005	0.1	11.5	0.1	65
Mid Driftpile	05-Jun-18	12:25	8.15		187.7	9.89	103.8	14.4	0.031	0.024	0.01	0.011	0.005	0.76	7.6	0.76	55
Lower Driftpile	05-Jun-18	12:00	7.93		191.7	9.52	98.4	13.8	0.039	0.025	0.01	0.011	0.005	0.46	9.3	0.46	49
Upper Driftpile	05-Jun-18	12:50	8.48		175.7	10.22	107	14.5	0.033	0.021	0.01	0.011	0.005	2.98	5.1	2.98	88
Upper West Prairie	18-Jun-18	8:30	7.45		103.9	8.94	93.8	14.5	1.06	0.01	0.01	0.011	0.005	0.31	233	0.31	110
Mid West Prairie	18-Jun-18	9:15	7.62		138	8.72	94.6	16.3	0.3	0.01	0.01	0.011	0.005	0.67	370	0.67	140
Mid South Heart	18-Jun-18	9:40	7.87		252	8.25	91.7	17.1	0.154	0.066	0.102	0.117	0.015	0.91	68.2	1.03	41
Upper South Heart	18-Jun-18	10:15	8		264	9.53	104.6	16.8	0.095	0.075	0.062	0.062	0.005	1.1	3.6	1.16	2
Lower South Heart	18-Jun-18	10:50	7.47		181.2	4.74	53	17.8	0.229	0.038	0.228	0.239	0.012	0.96	144	1.14	60
Grouard Channel	18-Jun-18	11:15	7.11		201.7	4.49	50.4	18	0.234	0.036	0.044	0.044	0.005	1.12	143	1.16	30
Upper East Prairie	18-Jun-18	12:40	7.85		158.8	9.05	100.4	17	0.063	0.01	0.01	0.011	0.005	0.42	75.8	0.42	30
Mid East Prairie	18-Jun-18	12:00	7.66		131.1	8.61	95.3	17.3	0.291	0.01	0.01	0.011	0.005	0.95	330	0.95	7
Lower East Prairie	18-Jun-18	Not accessible, road under water. Lower EP is a field duplicate of upper EP							0.069	0.01	0.01	0.011	0.005	0.41	90.9	0.41	31
Upper Swan	19-Jun-18	9:25	7.85		113.8	9.52	100.4	14.3	0.045	0.01	0.01	0.011	0.005	0.41	29.9	0.41	15

Site	Date	Time	pH	TDS mg/L	Lab 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 mg/L
Mid Swan	19-Jun-18	10:10	7.52		117.2	8.87	97.7	16.9	0.081	0.023	0.01	0.011	0.005	0.59	96.3	0.59	27
Lower Swan	19-Jun-18	11:05	7.29		122.6	7.69	89.7	17.5	0.102	0.021	0.01	0.011	0.005	0.78	120	0.78	60
Mid Driftpile	19-Jun-18	12:25	7.45		130.1	8.67	97	17.6	0.107	0.23	0.01	0.011	0.005	0.84	108	0.84	26
Lower Driftpile	19-Jun-18	11:50	7.41		132.9	8.08	90.3	17.3	0.113	0.024	0.01	0.011	0.005	0.86	121	0.86	10
Upper Driftpile	19-Jun-18	13:10	7.57		113.9	8.97	100.5	17.6	0.075	0.026	0.01	0.011	0.005	0.72	67.4	0.72	14
Upper Badger Creek	19-Jun-18								0.138	0.026	0.01	0.011	0.005	0.4	146	0.4	26
Upper West Prairie	03-Jul-18	8:40	7.73		186.8	9.07	94	13.6	0.299	0.047	0.01	0.011	0.005	0.84	541	0.84	300
Mid West Prairie	03-Jul-18	9:25	8.01		335	10.03	103.4	14.1	0.06	0.066	0.01	0.011	0.005	0.68	15.6	0.68	120
Mid South Heart	03-Jul-18	9:45	7.89		268	8.64	92.4	15.4	0.139	0.082	0.115	0.139	0.023	0.91	42.4	1.05	22
Upper South Heart	03-Jul-18	10:20	7.87		256	9.72	104.8	15.8	0.104	0.086	0.064	0.064	0.005	1.09	4.6	1.15	2
Lower South Heart	03-Jul-18	10:50	7.75		265	8.05	83.9	14.5	0.16	0.059	0.073	0.073	0.005	1.11	27.6	1.18	31
Lower East Prairie	03-Jul-18	11:10	7.91		261	9.16	95	14.5	0.063	0.055	0.01	0.011	0.005	0.53	26.7	0.53	77
Grouard Channel	03-Jul-18	11:35	7.96		269	8.77	91.8	14.6	0.106	0.06	0.054	0.054	0.005	1	14.6	1.06	4
Upper East Prairie	03-Jul-18	13:00	7.93		88.8	10.5	98.4	9.4	1.59	0.238	0.01	0.011	0.005	1.01	3200	1.01	520
Mid East Prairie	03-Jul-18	12:05	8.06		251	9.78	101.6	14.4	0.081	0.054	0.01	0.011	0.005	0.57	45.8	0.57	99
Upper Swan	04-Jul-18	9:25	7.59	122	71.6	10.67	101.3	10.1	0.619	0.01	0.01	0.011	0.005	1.28	1160	1.28	420
Mid Swan	04-Jul-18	10:15	7.44	128	64.8	10.15	96.4	10.5	0.94	0.01	0.01	0.011	0.005	1.37	2110	1.37	620
Lower Swan	04-Jul-18	Could not access site, overland flooding.							2.38						6200		
Mid Driftpile	04-Jul-18	13:10	7.27		63.1	9.88	93.9	10.6	1.29	0.01	0.031	0.031	0.005	1.1	3570	1.13	220
Lower Driftpile	04-Jul-18	12:35	7.33		64.11	9.31	88.6	11	1.28	0.01	0.01	0.011	0.005	1.29	3380	1.29	1100
Upper Driftpile	04-Jul-18	13:40	7.26		57.5	10.21	97.6	10.9	0.97	0.01	0.01	0.011	0.005	1.21	2230	1.21	2400
Upper West Prairie	16-Jul-18	8:40	7.73		198.8	8.36	93.8	17.2	0.054	0.029	0.01	0.011	0.005	0.75	25.1	0.75	35
Mid West Prairie	16-Jul-18	9:25	7.83		247	8.69	99.9	18.8	0.075	0.032	0.01	0.011	0.005	0.8	14.1	0.8	75
Mid South Heart	16-Jul-18	10:05	8.08		422	8	92	19	0.171	0.059	0.13	0.146	0.016	1.9	93.6	2.05	32
Upper South Heart	16-Jul-18	10:35	7.93		256	8.69	100.5	19	0.108	0.071	0.062	0.062	0.005	1.41	3.7	1.41	1
Lower South Heart	16-Jul-18	11:10	7.65		272	6.48	75.4	19.6	0.173	0.088	0.059	0.059	0.005	1.57	21.9	1.63	14
Lower East Prairie	16-Jul-18	11:25	7.35		244	5.57	65.2	19.8	0.118	0.053	0.01	0.011	0.005	0.71	20.6	0.71	25
Grouard Channel	16-Jul-18	11:45	7.69		239	7.03	80.6	18.8	0.176	0.073	0.03	0.03	0.005	1.52	12	1.52	2
Upper East Prairie	16-Jul-18	13:00	8.1		282	8.54	101.9	20.3	0.032	0.01	0.01	0.011	0.005	0.41	7.8	0.41	5
Mid East Prairie	16-Jul-18	12:15	8.13		267	8.47	101.2	20.8	0.071	0.027	0.01	0.011	0.005	0.73	36.9	0.73	46
Upper Swan	17-Jul-18	9:35	8.04		177.5	8.9	101.7	17.8	0.029	0.01	0.01	0.011	0.005	0.34	6.2	0.34	4

Site	Date	Time	pH	TDS mg/L	Lab 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 mg/L
Mid Swan	17-Jul-18	10:10	7.77		193.6	8.25	97.5	20.1	0.034	0.025	0.01	0.011	0.005	0.35	6.4	0.35	9
Lower Swan	17-Jul-18	11:15	7.48		222	7.57	91	20.5	0.052	0.024	0.01	0.011	0.005	0.41	16.3	0.41	7
Mid Driftpile	17-Jul-18	12:35	8.27		227	8.19	99.8	21.5	0.054	0.031	0.01	0.011	0.005	0.81	16.4	0.81	10
Lower Driftpile	17-Jul-18	12:05	7.59		252	7.42	88.4	20	0.053	0.031	0.01	0.011	0.005	0.48	16.9	0.48	5
Upper Driftpile	17-Jul-18	13:05	7.92		197.3	8.43	103.6	22.1	0.039	0.026	0.01	0.011	0.005	0.6	7.4	0.6	4
Upper Badger Creek	17-Jul-18								0.05	0.024	0.01	0.011	0.005	0.58	22	0.58	33
Upper West Prairie	30-Jul-18	8:35	7.7		162.7	7.19	85.4	20.2	0.053	0.025	0.01	0.011	0.005	0.85	34.4	0.85	26
Mid West Prairie	30-Jul-18	9:10	7.84		188.8	7.46	89.3	21.4	0.07	0.03	0.01	0.011	0.005	1.1	40.3	1.1	38
Mid South Heart	30-Jul-18	9:35	8.03		363	6.87	82.5	21.3	0.149	0.056	0.01	0.011	0.005	1.4	123	1.4	330
Upper South Heart	30-Jul-18	10:10	8		253	7.8	93.5	21	0.094	0.063	0.01	0.011	0.005	1.17	4.5	1.17	0.5
Lower South Heart	30-Jul-18	11:00	7.38		235	4.05	49.3	22	0.145	0.07	0.01	0.011	0.005	1.23	26.4	1.23	49
Lower East Prairie	31-Jul-18	12:35	7.41		237	4.61	56.4	22.3	0.1	0.057	0.01	0.011	0.005	0.41	19.9	0.41	23
Grouard Channel	30-Jul-18	11:40	7.34		214.8	3.88	46.7	21.5	0.341	0.279	0.01	0.011	0.005	1.08	15.8	1.08	54
Upper East Prairie	30-Jul-18	13:00	8.11		285	7.3	93	24	0.026	0.01	0.01	0.011	0.005	0.46	9	0.46	4
Mid East Prairie	30-Jul-18	12:35	8		232	7.2	90.4	23.6	0.266	0.034	0.01	0.011	0.005	0.76	36.9	0.76	84
Upper Swan	31-Jul-18	8:40	8.13	147	196	8.21	92.9	17.7	0.037	0.028	0.01	0.011	0.005	0.1	4.9	0.1	0.5
Mid Swan	31-Jul-18	9:20	7.91	154	212.3	7.38	87.3	20.6	0.029	0.03	0.01	0.011	0.005	0.21	5.4	0.21	34
Lower Swan	31-Jul-18	10:05	7.64	171	256	7.08	83.4	20.4	0.047	0.033	0.01	0.011	0.005	0.1	10.4	0.1	13
Mid Driftpile	31-Jul-18	11:25	7.83		249	7.5	90	21.4	0.038	0.035	0.01	0.011	0.005	0.36	9	0.36	16
Lower Driftpile	31-Jul-18	11:00	7.7		281	6.88	80.9	20.4	0.038	0.028	0.01	0.011	0.005	0.54	3.7	0.54	22
Upper Driftpile	31-Jul-18	11:45	8.03		217.4	7.74	94.3	22	0.053	0.031	0.01	0.011	0.005	0.44	16.3	0.44	93
Upper West Prairie	13-Aug-18	8:30	7.98		291	9.04	92.3	12.8	0.0159	0.024	0.01	0.011	0.005	0.46	10.5	0.46	60
Mid West Prairie	13-Aug-18	9:15	8.04		393	9.26	96.9	14.4	0.053	0.029	0.01	0.011	0.005	0.49	15	0.49	160
Mid South Heart	13-Aug-18	9:35	8.2		399	8.3	90.7	16.6	0.043	0.074	0.029	0.029	0.005	1.33	75.3	1.35	30
Upper South Heart	13-Aug-18	10:10	7.8		261	8.19	93.6	18.6	0.137	0.085	0.01	0.011	0.005	1.18	5.7	1.18	0.5
Lower South Heart	13-Aug-18	11:05	8.06		375	8.08	87.7	16.3	0.11	0.062	0.01	0.011	0.005	1.3	20.7	1.3	20
Lower East Prairie	13-Aug-18	11:20	7.9		319	7.7	84.1	16.6	0.07	0.037	0.01	0.011	0.005	0.57	17	0.57	50
Grouard Channel	13-Aug-18	12:00	7.71		330	6.31	70.7	17.8	0.108	0.065	0.01	0.011	0.005	0.95	8	0.95	0.5
Upper East Prairie	13-Aug-18	13:00	8.29		335	9.32	103.1	16.7	0.01	0.01	0.01	0.011	0.005	0.35	3.5	0.35	30
Mid East Prairie	13-Aug-18	12:20	8.26		328	9.33	102.6	16.8	0.062	0.04	0.01	0.011	0.005	0.47	12.3	0.47	40
Upper Swan	14-Aug-18	9:45	8.51	167	201.4	9.21	99.7	14.4	0.029	0.01	0.01	0.011	0.005	0.43	15.4	0.43	30

Site	Date	Time	pH	TDS mg/L	Lab 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 mg/L
Mid Swan	14-Aug-18	10:25	8.05	162	197.3	8.79	97.1	16.5	0.039	0.026	0.01	0.011	0.005	0.38	7.7	0.38	10
Lower Swan	14-Aug-18	11:05	7.77	183	236	8.24	93.7	17.7	0.05	0.035	0.01	0.011	0.005	0.45	18.6	0.45	60
Mid Driftpile	14-Aug-18	12:50	7.93		246	8.52	99.7	19.3	0.048	0.035	0.01	0.011	0.005	0.65	8.4	0.62	20
Lower Driftpile	14-Aug-18	12:25	7.24		300	7.79	89.5	18.5	0.039	0.033	0.01	0.011	0.005	0.56	7.7	0.56	20
Upper Driftpile	14-Aug-18	13:10	8.11		212.9	8.89	104.8	19.6	0.043	0.032	0.01	0.011	0.005	0.52	4.3	0.52	10
Badger creek	14-Aug-18								0.046	0.03	0.01	0.011	0.005	0.57	7.9	0.57	0.5
Upper West Prairie	11-Sep-18	8:45	8.15		394	9.59	92.9	10.4	0.093	0.022	0.01	0.011	0.005	0.71	6.7	0.71	170
Mid West Prairie	11-Sep-18	9:25	8.21		490	10.01	96.5	10.6	0.024	0.01	0.01	0.011	0.005	0.36	6.3	0.36	140
Mid South Heart	11-Sep-18	9:50	8.15		310	9.5	91.9	10.8	0.081	0.046	0.01	0.011	0.005	1.05	8.1	1.05	30
Upper South Heart	11-Sep-18	10:30	8.04		267	9.24	93.3	11.9	0.101	0.067	0.032	0.032	0.005	0.89	4.5	0.92	0.5
Lower South Heart	11-Sep-18	11:15	8.34		388	9.32	86.6	8.9	0.13	0.024	0.01	0.011	0.005	1	94.4	1	360
Lower East Prairie	11-Sep-18	12:15	8.65		377	10.16	98.4	10.9	0.031	0.01	0.01	0.011	0.005	0.38	9	0.38	70
Grouard Channel	11-Sep-18	11:45	8.01		367	8.06	78.6	11.1	0.046	0.034	0.01	0.011	0.005	0.56	3.8	0.56	0.5
Upper East Prairie	11-Sep-18	14:00	8.5		339	10.3	105.2	11.8	0.01	0.01	0.01	0.011	0.005	0.1	3.7	0.1	30
Mid East Prairie	11-Sep-18	13:10	8.51		378	10.86	106.2	11.2	0.032	0.01	0.01	0.011	0.005	0.28	4.9	0.28	50
Upper Swan	17-Sep-18	9:40	8.33	150	215.1	11.86	101.9	5.5	0.01	0.01	0.01	0.011	0.005	0.1	1.5	0.1	10
Mid Swan	17-Sep-18	10:30	8.04	144	172.5	11.73	100	5.8	0.031	0.01	0.01	0.011	0.005	1.01	7.5	1.01	100
Lower Swan	17-Sep-18	11:15	7.85	159	200.4	11.56	98.6	6	0.037	0.023	0.01	0.011	0.005	0.35	6.5	0.35	20
Mid Driftpile	17-Sep-18	13:00	8.31		224	11.7	102.8	6.8	0.03	0.01	0.01	0.011	0.005	0.22	6.1	0.22	10
Lower Driftpile	17-Sep-18	12:20	8.03		246	11.52	99.1	6.3	0.031	0.023	0.01	0.011	0.005	0.27	5.2	0.27	0.5
Upper Driftpile	17-Sep-18	13:30	8.27		207.2	12.13	105.6	6.6	0.028	0.01	0.01	0.011	0.005	0.3	3.4	0.3	30
Upper West Prairie	16-Oct-18	9:00	8.46		318	10.8	88.4	4	0.047	0.01	0.01	0.011	0.005	0.6	19.1	0.6	10
Mid West Prairie	16-Oct-18	9:35	8.36		436	11.62	93.2	3.7	0.034	0.01	0.01	0.011	0.005	0.49	8.2	0.49	11
Mid South Heart	16-Oct-18	10:00	8.19		342	11.55	91.8	3.3	0.073	0.01	0.01	0.011	0.005	1.17	13.5	1.17	0.5
Upper South Heart	16-Oct-18	10:30	8.12		267	11.58	94	3.8	0.075	0.01	0.01	0.011	0.005	1.13	8.3	1.13	0.5
Lower South Heart	16-Oct-18	11:05	8.56		384	11.38	92	4	0.103	0.01	0.01	0.011	0.005	1.21	32.3	1.21	10
Lower East Prairie	16-Oct-18	11:20	8.31		354	11.44	92.4	3.9	0.053	0.01	0.01	0.011	0.005	0.35	27.5	0.35	23
Grouard Channel	16-Oct-18	11:50	8.13		358	11.2	89.3	3.7	0.057	0.01	0.01	0.011	0.005	0.73	21.3	0.73	0.5
Upper East Prairie	16-Oct-18	0:00	8.29		287	11.74	95.7	4	0.01	0.01	0.01	0.011	0.005	0.26	9.8	0.26	0.5
Mid East Prairie	16-Oct-18	12:15	8.74		334	11.94	96.9	4.1	0.056	0.01	0.01	0.011	0.005	0.36	12.1	0.36	14
Upper Swan	17-Oct-18	10:15	8.14		190.2	11.85	95.4	2.8	0.024	0.01	0.01	0.00255	0.005	0.1	17.9	0.1	0.5

Site	Date	Time	pH	TDS mg/L	Lab 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 mg/L
Mid Swan	17-Oct-18	11:00	8.09		165.7	11.58	94.2	3.9	0.042	0.021	0.01	0.00255	0.005	0.24	14.4	0.24	10
Lower Swan	17-Oct-18	11:45	7.94		185.5	11.22	93.6	4.9	0.046	0.023	0.01	0.00255	0.005	0.1	16.4	0.1	10
Mid Driftpile	17-Oct-18	13:15	8.16		178.8	11.46	96	4.7	0.06	0.025	0.01	0.011	0.005	0.65	34.7	0.65	0.5
Lower Driftpile	17-Oct-18	12:50	8.04		196.4	11.3	94	4.7	0.043	0.025	0.01	0.011	0.005	0.24	16	0.24	30
Upper Driftpile	17-Oct-18	13:45	8.21		162.3	11.23	96.3	5.6	0.05	0.024	0.01	0.011	0.005	0.62	25.4	0.62	0.5
Badger Creek	17-Oct-18	14:00							0.051	0.026	0.01	0.011	0.005	0.37	23.5	0.37	0.5

Appendix B-2: Swan River Total and Dissolved Metals Data at the Upper, Middle and Lower Sites, May to October 2018.

Site	Date	Time	TOTAL METALS (mg/L)										
			Mercury (Hg)	Aluminum (Al)	Antimony (Sb)	Arsenic (As)	Barium (Ba)	Boron (B)	Cadmium (Cd)	Calcium (Ca)	Hexavalent Chromium	Chromium (Cr)	Copper (Cu)
Upper Swan River	09-May-18	10:20	0.0000448	1.95	0.00018	0.00217	0.0854	<0.010	0.0000749	11		0.00275	0.00669
Mid Swan River	09-May-18	11:15	0.0000366	1.96	0.00021	0.00234	0.0939	<0.010	0.0000923	10.2		0.0029	0.00776
Lower Swan River	09-May-18	12:05	0.0000450	2.8	0.00023	0.00308	0.111	<0.010	0.000107	10.6		0.00427	0.00995
Upper Swan River	05-Jun-18	9:16	<0.000005	0.557	<0.00050	0.00154	0.0852	<0.050	0.00003	21.1		0.00098	0.0044
Mid Swan River	05-Jun-18	10:00	<0.000005	0.195	<0.00050	0.00129	0.0667	<0.050	<0.000025	19.7		0.00051	<0.0025
Lower Swan River	05-Jun-18	10:45	<0.000005	0.237	<0.00050	0.00142	0.071	<0.050	<0.000025	20.9		<0.00050	<0.0025
Upper Swan River	04-Jul-18	9:25	<0.000005	10.1	0.00031	0.0102	0.359	0.016	0.000492	21.7	<0.00050	0.0152	0.0358
Mid Swan River	04-Jul-18	10:15	0.000117	17.9	0.00045	0.0180	0.688	0.025	0.000987	27.9	<0.00050	0.0273	0.0677
Lower Swan River	04-Jul-18	no sample - site not accessible due to flooding											
Upper Swan River	31-Jul-18	8:40	0.0000259	0.0919	0.00038	0.00182	0.0744	0.013	0.0000160	22.8	<0.00050	0.00067	0.00176
Mid Swan River	31-Jul-18	9:20	<0.000005	0.0623	0.00033	0.00195	0.0841	0.022	0.0000214	23.2	<0.00050	0.0007	0.00185
Lower Swan River	31-Jul-18	10:05	<0.000005	0.108	0.00034	0.00209	0.105	0.022	0.0000277	29.6	<0.00050	0.00072	0.00204
Upper Swan River	14-Aug-18	9:45	0.0000056	0.61	0.00023	0.00193	0.0763	0.015	0.0000254	24	<0.00050	0.00078	0.0021
Mid Swan River	14-Aug-18	10:25	0.0000060	0.138	0.00018	0.00209	0.0789	0.025	0.0000256	22.5	<0.00050	0.0004	0.00183
Lower Swan River	14-Aug-18	11:05	0.0000062	0.187	0.00021	0.00223	0.0997	0.027	0.0000372	29.2	<0.00050	0.00043	0.00222
Upper Swan River	17-Sep-18	9:40	0.0000120	0.0896	0.00017	0.00139	0.0697	0.011	0.0000105	25.7	<0.00050	0.00021	0.00096
Mid Swan River	17-Sep-18	10:30	<0.000005	0.199	0.00014	0.0015	0.0728	0.018	0.0000212	18.8	<0.00050	0.00044	0.00184
Lower Swan River	17-Sep-18	11:15	0.0000084	0.259	0.00022	0.002	0.103	0.019	0.0000273	22.9	<0.00050	0.00053	0.00237
Upper Swan River	17-Oct-18	10:15	<0.0000050	0.337	0.00015	0.00127	0.0664	<0.010	0.0000338	22.3	<0.00050	0.00056	0.00205
Mid Swan River	17-Oct-18	11:00	<0.0000050	0.32	0.00013	0.00143	0.0675	0.015	0.0000376	19.1	<0.00050	0.00065	0.00222
Lower Swan River	17-Oct-18	11:45	<0.0000050	0.281	0.00015	0.00148	0.0679	0.016	0.0000384	21.1	<0.00050	0.00052	0.00211

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
<0.00025	Yellow shading indicates the detection limit is above the chronic or acute guideline. Therefore, it is not known if the sample concentration is above or below the guideline.
Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L $CaCO_3$	
Total cadmium, total copper, total lead and total nickel PAL guidelines vary with hardness (see GoA 2018 to determine appropriate PAL guidelines)	

Appendix B-2: Swan River Total and Dissolved Metals Data at the Upper, Middle and Lower Sites, May to October 2018.

Site	Date	TOTAL METALS (mg/L)										
		Iron (Fe)	Lead (Pb)	Magnesium (Mg)	Manganese (Mn)	Nickel (Ni)	Potassium (K)	Selenium (Se)	Silver (Ag)	Sodium (Na)	Uranium (U)	Zinc (Zn)
Upper Swan River	09-May-18	2.34	0.00286	2.55	0.139	0.00704	1.44	0.000087	0.000034	3.88	0.000501	0.0154
Mid Swan River	09-May-18	3.81	0.00299	2.56	0.0155	0.00855	1.72	0.000145	0.000036	4.42	0.000569	0.0169
Lower Swan River	09-May-18	5.43	0.00385	2.95	0.181	0.0112	2.06	0.000164	0.000046	4.44	0.000679	0.022
Upper Swan River	05-Jun-18	1.4	0.00056	3.7	0.0647	0.008	1.55	<0.00025	<0.000050	11.6	0.00031	0.018
Mid Swan River	05-Jun-18	1.82	0.00051	3.74	0.0754	0.004	1.82	<0.00025	<0.000050	11.7	0.000281	<0.015
Lower Swan River	05-Jun-18	2.03	0.0004	4.07	0.0684	0.0039	1.92	<0.00025	<0.000050	11.1	0.00041	<0.015
Upper Swan River	04-Jul-18	20.5	0.0169	6.79	0.735	0.038	3.49	0.000371	0.000169	5.85	0.00278	0.0993
Mid Swan River	04-Jul-18	42.5	0.0306	10.7	1.6	0.0713	5.08	0.000789	0.000276	5.44	0.00518	0.167
Lower Swan River	04-Jul-18	no sample - site not accessible due to flooding										
Upper Swan River	31-Jul-18	1.15	0.000193	3.87	0.095	0.00451	<2.5	0.000134	<0.000010	11.7	0.000311	<0.0030
Mid Swan River	31-Jul-18	1.66	0.0002	4.4	0.111	0.00524	<2.5	0.000125	<0.000010	11.4	0.00036	<0.0030
Lower Swan River	31-Jul-18	2.29	0.0003	5.66	0.181	0.00546	<2.5	0.000122	<0.000010	10.7	0.000696	<0.0030
Upper Swan River	14-Aug-18	1.46	0.000445	4.41	0.0975	0.00421	1.77	0.000153	0.000012	12	0.000434	0.0032
Mid Swan River	14-Aug-18	2.22	0.000274	4.6	0.11	0.00566	2.2	0.000154	<0.000010	11.9	0.000356	<0.0030
Lower Swan River	14-Aug-18	2.84	0.000361	6.05	0.133	0.00627	2.42	0.000138	<0.000010	11.3	0.000617	<0.0030
Upper Swan River	17-Sep-18	1.37	0.000128	4.55	0.103	0.00321	1.63	0.000082	<0.000010	13.6	0.000438	<0.0030
Mid Swan River	17-Sep-18	2.19	0.000278	3.87	0.161	0.00513	<2.5	0.000097	<0.000010	10.6	0.000345	<0.0030
Lower Swan River	17-Sep-18	2.6	0.000328	4.8	0.196	0.0068	<2.5	0.000109	<0.000010	10.6	0.000541	<0.0030
Upper Swan River	17-Oct-18	1.33	0.000411	4.28	0.141	0.00384	1.53	0.000112	<0.000010	12.2	0.000414	0.003
Mid Swan River	17-Oct-18	2.1	0.000418	3.97	0.198	0.00529	1.8	0.000098	<0.000010	10.2	0.000348	0.0033
Lower Swan River	17-Oct-18	2.54	0.000407	4.58	0.1	0.0055	1.87	0.000078	<0.000010	10.6	0.000418	0.0042

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
<0.00025	Yellow shading indicates the detection limit is above the chronic or acute guideline. Therefore, it is not known if the sample concentration is above or below the guideline.
Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L $CaCO_3$	
Total cadmium, total copper, total lead and total nickel PAL guidelines vary with hardness (see GoA 2018 to determine appropriate PAL guidelines)	

Appendix B-2: Swan River Total and Dissolved Metals Data at the Upper, Middle and Lower Sites, May to October 2018.

Site	Date	DISSOLVED METALS (mg/L)										
		Mercury (Hg)	Aluminum (Al)	Antimony (Sb)	Arsenic (As)	Barium (Ba)	Boron (B)	Cadmium (Cd)	Calcium (Ca)	Chromium (Cr)	Copper (Cu)	Iron (Fe)
Upper Swan River	09-May-18	0.0000059	0.0644	0.0001	0.0005	0.0342	<0.010	0.0000125	9.25	0.00019	0.00211	0.182
Mid Swan River	09-May-18	0.0000056	0.0754	0.00013	0.00059	0.0383	<0.010	0.0000145	8.03	0.00028	0.00272	0.266
Lower Swan River	09-May-18	0.0000058	0.071	0.00014	0.00052	0.0383	<0.010	0.0000185	8	0.00026	0.00295	0.215
Upper Swan River	05-Jun-18	<0.000005	0.0215	<0.00050	0.00077	0.0549	<0.050	<0.000025	20.9	<0.00050	0.0015	0.477
Mid Swan River	05-Jun-18	<0.000005	0.0314	<0.00050	0.00089	0.0592	<0.050	<0.000025	20.1	<0.00050	0.0016	1.09
Lower Swan River	05-Jun-18	<0.000005	0.0298	<0.00050	0.00096	0.0645	<0.050	<0.000025	21.1	<0.00050	0.0018	1.16
Upper Swan River	04-Jul-18	0.0000073	0.115	0.00028	0.00088	0.0539	<0.010	0.0000279	10.8	0.00037	0.00561	0.339
Mid Swan River	04-Jul-18	0.0000083	0.12	0.00035	0.00079	0.0579	0.011	0.0000333	9.42	0.00043	0.00714	0.458
Lower Swan River	04-Jul-18	no sample - site not accessible due to flooding										
Upper Swan River	31-Jul-18	NA	0.0188	0.00027	0.00174	0.0721	0.014	0.0000108	23.3	0.00011	0.00128	0.6
Mid Swan River	31-Jul-18	NA	0.0151	0.00028	0.00179	0.0821	0.023	0.0000159	23.8	0.00015	0.00149	1.06
Lower Swan River	31-Jul-18	NA	0.0125	0.00029	0.00178	0.104	0.023	0.0000176	29.7	0.00015	0.00154	1.34
Upper Swan River	14-Aug-18	0.0000053	0.0197	<0.00050	0.00112	0.0658	<0.050	<0.000025	25.2	<0.00050	0.0014	0.348
Mid Swan River	14-Aug-18	0.0000063	0.0232	<0.00050	0.00151	0.0696	<0.050	<0.000025	23.4	<0.00050	0.0014	1.19
Lower Swan River	14-Aug-18	<0.000005	0.0237	<0.00050	0.00163	0.0908	<0.050	<0.000025	29.5	<0.00050	0.0018	1.7
Upper Swan River	17-Sep-18	<0.000005	0.0147	0.00015	0.00101	0.069	<0.010	<0.0000050	29.9	<0.00010	0.00076	0.541
Mid Swan River	17-Sep-18	<0.000005	0.047	0.00014	0.00115	0.0652	0.019	0.000009	20.2	0.00019	0.00144	1.19
Lower Swan River	17-Sep-18	<0.000005	0.0377	0.00014	0.00128	0.0795	0.018	0.0000138	24.2	0.00018	0.0015	1.49
Upper Swan River	17-Oct-18	<0.000005	0.0331	0.00014	0.00068	0.0568	<0.010	<0.0000050	21.4	0.00012	0.00124	0.315
Mid Swan River	17-Oct-18	<0.000005	0.0476	0.00013	0.00078	0.0547	0.013	0.0000074	18	0.00018	0.000142	0.839
Lower Swan River	17-Oct-18	<0.000005	0.0362	0.00012	0.00085	0.06	0.015	0.0000105	20.4	0.00018	0.00132	1.16

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
<0.00025	Yellow shading indicates the detection limit is above the chronic or acute guideline. Therefore, it is not known if the sample concentration is above or below the guideline.
Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L $CaCO_3$	
Total cadmium, total copper, total lead and total nickel PAL guidelines vary with hardness (see GoA 2018 to determine appropriate PAL guidelines)	

Appendix B-2: Swan River Total and Dissolved Metals Data at the Upper, Middle and Lower Sites, May to October 2018.

Site	Date	DISSOLVED METALS (mg/L)									
		Lead (Pb)	Magnesium (Mg)	Manganese (Mn)	Nickel (Ni)	Potassium (K)	Selenium (Se)	Silver (Ag)	Sodium (Na)	Uranium (U)	Zinc (Zn)
Upper Swan River	09-May-18	0.000152	1.49	0.0015	0.00216	0.9	0.00008	<0.00001	3.34	0.000159	<0.001
Mid Swan River	09-May-18	0.000176	1.54	0.00245	0.00318	1.1	0.000098	<0.00001	3.98	0.000188	0.0015
Lower Swan River	09-May-18	0.000178	1.59	0.00245	0.00371	1.21	0.000089	<0.00001	3.91	0.000192	0.001
Upper Swan River	05-Jun-18	<0.00025	3.5	<0.0050	<.0025	1.32	<0.00025	<0.000050	10.9	0.000264	<0.0050
Mid Swan River	05-Jun-18	<0.00025	3.89	<0.0050	0.0032	1.94	<0.00025	<0.000050	12.1	0.000269	<0.0050
Lower Swan River	05-Jun-18	<0.00025	4.19	<0.0050	0.003	2.02	<0.00025	<0.000050	11.3	0.000361	<0.0050
Upper Swan River	04-Jul-18	0.000243	1.91	0.00316	0.00611	1.12	0.000182	<0.00001	5.17	0.000282	0.0016
Mid Swan River	04-Jul-18	0.00036	1.88	0.00442	0.0071	1.38	0.000178	<0.00001	4.69	0.000386	0.002
Lower Swan River	04-Jul-18	no sample - site not accessible due to flooding									
Upper Swan River	31-Jul-18	0.000079	3.84	<0.025	0.00323	<2.5	0.000176	0.00001	11.5	0.000305	<0.0010
Mid Swan River	31-Jul-18	0.000119	4.51	<0.025	0.00401	<2.5	0.000207	<0.00001	11.5	0.000431	0.0011
Lower Swan River	31-Jul-18	0.000128	5.94	<0.025	0.0039	<2.5	0.000191	<0.00001	11.2	0.000729	0.0012
Upper Swan River	14-Aug-18	<0.00025	4.22	0.00157	0.0034	1.65	<0.00025	<0.000050	11.1	0.000377	<0.0050
Mid Swan River	14-Aug-18	<0.00025	4.32	0.00248	0.0046	2.08	<0.00025	<0.000050	11.2	0.000335	<0.0050
Lower Swan River	14-Aug-18	<0.00025	5.97	0.0043	0.0052	2.32	<0.00025	<0.000050	10.4	0.0006	<0.0050
Upper Swan River	17-Sep-18	<0.000050	4.91	0.0228	0.00283	1.71	0.000099	<0.000010	14.6	0.000356	<0.0010
Mid Swan River	17-Sep-18	0.000083	4.17	0.027	0.00462	<2.5	0.000125	<0.000010	11.5	0.000284	<0.0010
Lower Swan River	17-Sep-18	0.0001	5.11	<0.025	0.00491	<2.5	0.000127	<0.000010	11.1	0.000455	<0.0010
Upper Swan River	17-Oct-18	0.00007	3.77	0.00136	0.00226	1.48	0.00013	<0.000010	11.9	0.000346	<0.0010
Mid Swan River	17-Oct-18	0.000097	3.51	0.00195	0.0031	1.8	0.000088	<0.000010	10.2	0.000276	<0.0010
Lower Swan River	17-Oct-18	0.000099	4.14	0.00205	0.00345	1.91	0.000108	<0.000010	11	0.000339	<0.0010

Notes:

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Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L $CaCO_3$	
Total cadmium, total copper, total lead and total nickel PAL guidelines vary with hardness (see GoA 2018 to determine appropriate PAL guidelines)	

Appendix B-2: Swan River Total and Dissolved Metals Data at the Upper, Middle and Lower Sites, May to October 2018.

Site	Date	OTHER PARAMETERS (mg/L except for units in brackets)											
		Fecal Coliforms (cfu/100 mL)	TDP	TP	TDS	TSS	NO_2-N	NO_3-N+NO_2-N	NO_3-N	TKN	TN - calculated	Chloride	Flouride
Upper Swan River	09-May-18	30	<0.020	0.133	80	159	<0.020	<0.022	<0.010	0.56	0.56	<0.50	0.04
Mid Swan River	09-May-18	10	<0.020	0.133	91	183	0.040	0.040	<0.010	0.57	0.61	<0.50	0.037
Lower Swan River	09-May-18	10	<0.020	0.17	81	257	0.041	0.041	<0.010	0.75	0.79	<0.50	0.041
Upper Swan River	05-Jun-18	67	<0.020	0.023	116	20.1	<0.020	<0.022	<0.010	<0.2	<0.2	0.87	0.074
Mid Swan River	05-Jun-18	110	<0.020	0.031	117	6	<0.020	<0.022	<0.010	<0.2	<0.2	1.11	0.06
Lower Swan River	05-Jun-18	65	0.023	0.034	116	11.5	<0.020	<0.022	<0.010	<0.2	<0.2	1.17	0.63
Upper Swan River	04-Jul-18	420	<0.020	0.619	122	1160	<0.020	<0.022	<0.010	1.28	1.28	<0.50	0.05
Mid Swan River	04-Jul-18	620	<0.020	0.94	128	2110	<0.020	<0.022	<0.010	1.37	1.37	<0.50	0.05
Lower Swan River	04-Jul-18	no sample - site not accessible due to flooding											
Upper Swan River	31-Jul-18	<1	0.028	0.037	147	4.9	<0.020	<0.022	<0.010	<0.2	<0.2	0.63	0.076
Mid Swan River	31-Jul-18	34	0.03	0.029	154	5.4	<0.020	<0.022	<0.010	0.21	0.21	1.11	0.087
Lower Swan River	31-Jul-18	13	0.033	0.047	171	10.4	<0.020	<0.022	<0.010	<0.2	<0.2	1.65	0.085
Upper Swan River	14-Aug-18	30	<0.020	0.029	167	15.4	<0.020	<0.022	<0.010	0.43	0.43	1.73	0.08
Mid Swan River	14-Aug-18	10	0.026	0.039	162	7.7	<0.020	<0.022	<0.010	0.38	0.38	1.1	0.075
Lower Swan River	14-Aug-18	60	0.035	0.05	183	18.6	<0.020	<0.022	<0.010	0.45	0.45	1.85	0.09
Upper Swan River	17-Sep-18	10	<0.020	<0.020	150	<3.0	<0.020	<0.022	<0.010	<0.2	<0.2	1.16	0.076
Mid Swan River	17-Sep-18	100	<0.020	0.031	144	7.5	<0.020	<0.022	<0.010	1.01	1.01	0.92	0.07
Lower Swan River	17-Sep-18	20	0.023	0.037	159	6.5	<0.020	<0.022	<0.010	0.35	0.35	1.69	0.073
Upper Swan River	17-Oct-18	< 10	< 0.020	0.024	141	17.9	<0.020	<0.0051	<0.010	<0.2	<0.2	3.7	0.075
Mid Swan River	17-Oct-18	10	0.021	0.042	137	14.1	<0.020	<0.0051	<0.010	0.24	0.24	1.08	0.074
Lower Swan River	17-Oct-18	10	0.023	0.046	147	16.4	<0.020	<0.0051	<0.010	<0.2	<0.2	1.12	0.074

Notes:

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Total copper - chronic PAL guideline only applies to water with a hardness ≥ 50 mg/L $CaCO_3$	
Total cadmium, total copper, total lead and total nickel PAL guidelines vary with hardness (see GoA 2018 to determine appropriate PAL guidelines)	

Appendix B-2: Swan River Total and Dissolved Metals Data at the Upper, Middle and Lower Sites, May to October 2018.

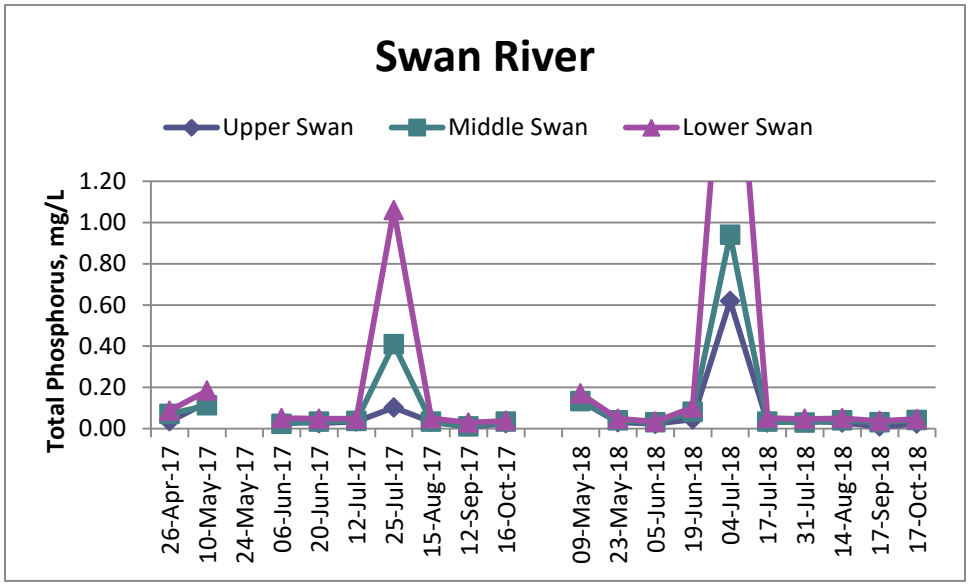
Site	Date	OTHER PARAMETERS (mg/L except for units in brackets)									
		Ion Balance (%)	TDS - calculated	Hardness - $CaCO_3$	Sulfate - SO_4	pH (units)	Conductivity (µS/cm)	Bicarbonate - HCO_3	Carbonate - CO_3	Hydroxide - OH	Alkalinity - $CaCO_3$
Upper Swan River	09-May-18	80.4	47.2	29.2	2.68	7.49	69.2	39	<5.0	<5.0	32
Mid Swan River	09-May-18	low EC	48.4	26.4	2.71	7.47	66.4	36	<5.0	<5.0	29.5
Lower Swan River	09-May-18	low EC	45.8	26.5	2.82	7.39	66.4	35.7	<5.0	<5.0	29.3
Upper Swan River	05-Jun-18	105	91.6	66.6	6	7.89	168	97.7	<5.0	<5.0	80.1
Mid Swan River	05-Jun-18	107	85.6	62.2	5.04	7.88	162	91	<5.0	<5.0	74.6
Lower Swan River	05-Jun-18	104	90	66.3	4.93	7.82	167	97.4	<5.0	<5.0	79.8
Upper Swan River	04-Jul-18	low EC	39.8	34.8	2.85	7.43	73.5	36.4	<5.0	<5.0	29.8
Mid Swan River	04-Jul-18	low EC	38.2	31.3	2.78	7.08	65.8	36.6	<5.0	<5.0	30
Lower Swan River	04-Jul-18	no sample - site not accessible due to flooding									
Upper Swan River	31-Jul-18	100	104	78	5.32	8.07	187	117	<5.0	<5.0	95.5
Mid Swan River	31-Jul-18	104	106	82.1	6.03	8.03	193	116	<5.0	<5.0	95.1
Lower Swan River	31-Jul-18	106	127	105	7.02	8.03	229	138	<5.0	<5.0	113
Upper Swan River	14-Aug-18	96.4	101	72.2	6.2	8.03	186	111	<5.0	<5.0	91.2
Mid Swan River	14-Aug-18	93.4	95.7	65.5	5.1	8.05	181	109	<5.0	<5.0	89.5
Lower Swan River	14-Aug-18	112	98.4	80.3	6.58	8.15	208	101	<5.0	<5.0	82.5
Upper Swan River	17-Sep-18	103	120	87.8	8.27	8	195	128	<5.0	<5.0	105
Mid Swan River	17-Sep-18	110	92.4	70.1	6.08	7.87	155	96.6	<5.0	<5.0	79.2
Lower Swan River	17-Sep-18	107	107	83	7.05	7.85	181	112	<5.0	<5.0	92.2
Upper Swan River	17-Oct-18	93.1	104	69	7.98	7.97	202	110	<5.0	<5.0	90.1
Mid Swan River	17-Oct-18	96.1	88.5	59.4	6.57	7.91	175	96	<5.0	<5.0	78.7
Lower Swan River	17-Oct-18	96.9	98.5	68	6.81	7.87	183	108	<5.0	<5.0	88.4

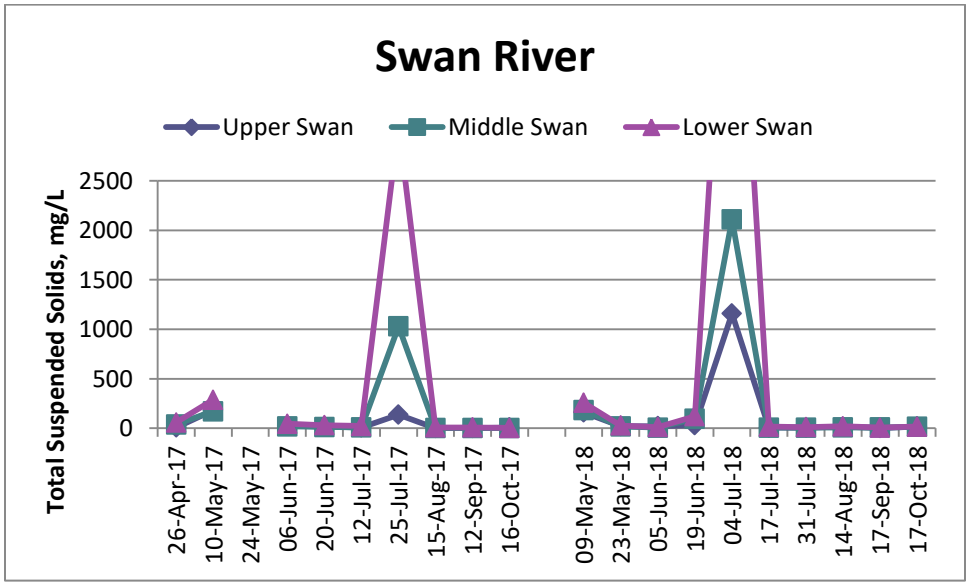
Provincial Protection of Aquatic Life (PAL) Guidelines for Metals (Total and Dissolved) and Other Parameters.

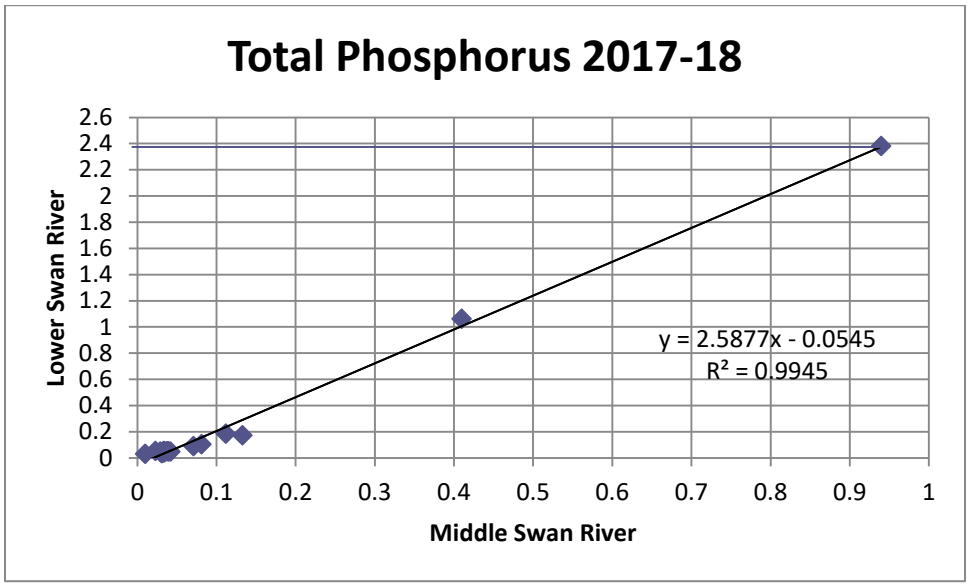
Parameter	PAL Guideline		Parameter	PAL Guideline		Parameter	PAL Guideline	
	Chronic	Acute		Chronic	Acute		Chronic	Acute
Total Mercury	**0.000005**	**0.000013**	Total Nickel	**0.016 to 0.054**	**0.145 to 0.490**	Dissolved Zinc	**0.007**	**0.037**
Total Arsenic	**0.005**		Total Selenium	**0.001**		NO_2-N	**0.02 to 0.04**	**0.06 to 0.12**
Total Boron	**0.0015**	**0.029**	Total Silver	**0.00025**		Chloride	**120**	**640**
Total Cadmium	**0.00005 to 0.00017**	**0.00051 to 0.0022**	Total Uranium	**0.015**	**0.033**	Sulfate (SO_4)	**128 to 309**	
Hexavalent Chromium	**0.001**		Total Zinc	**0.03**		pH (units)	**≥6.5 to ≤9.0**	
Total Copper	**0.007**	**0.0041 to 0.0170**	Dissolved Aluminum	**0.05**	**0.1**	All guidelines are mg/L except pH		
Total Lead	**0.001 to 0.0034**		Dissolved Iron	**0.3**		All guidelines are provincial (GoA 2018) except dissolved zinc (federal: CCME 2018)		

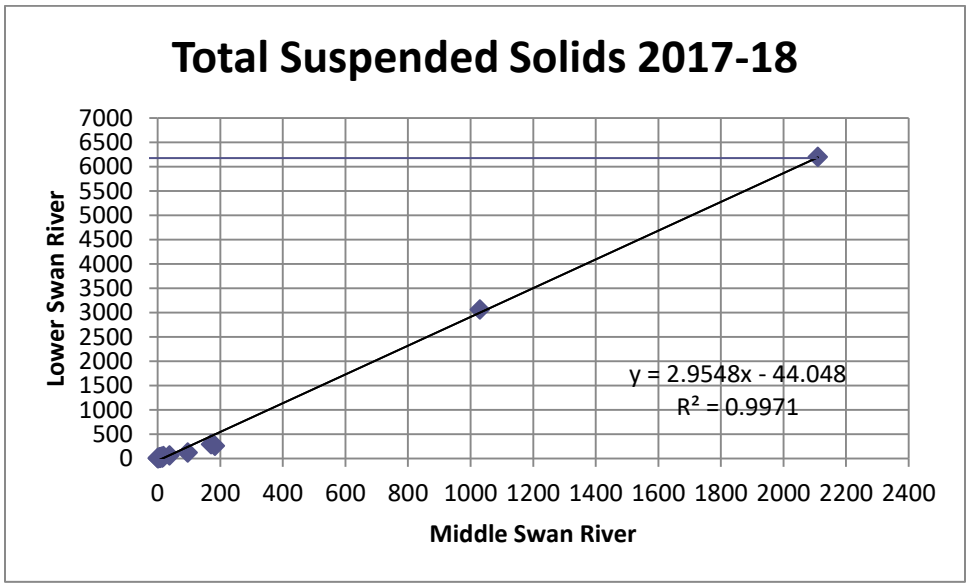
APPENDIX C. WATER QUALITY GRAPHS FOR SELECT PARAMETERS, 2017 AND 2018.

C-1. Swan River

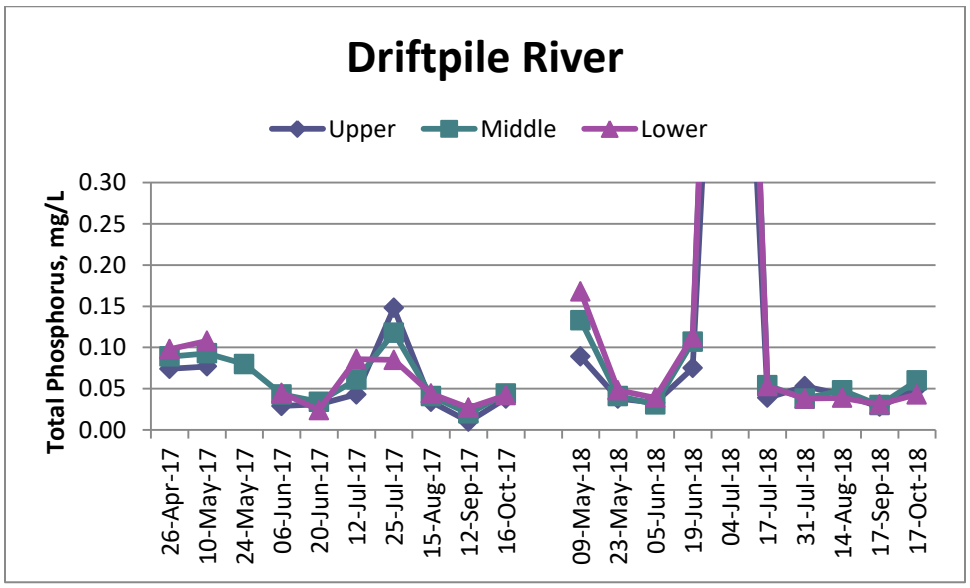


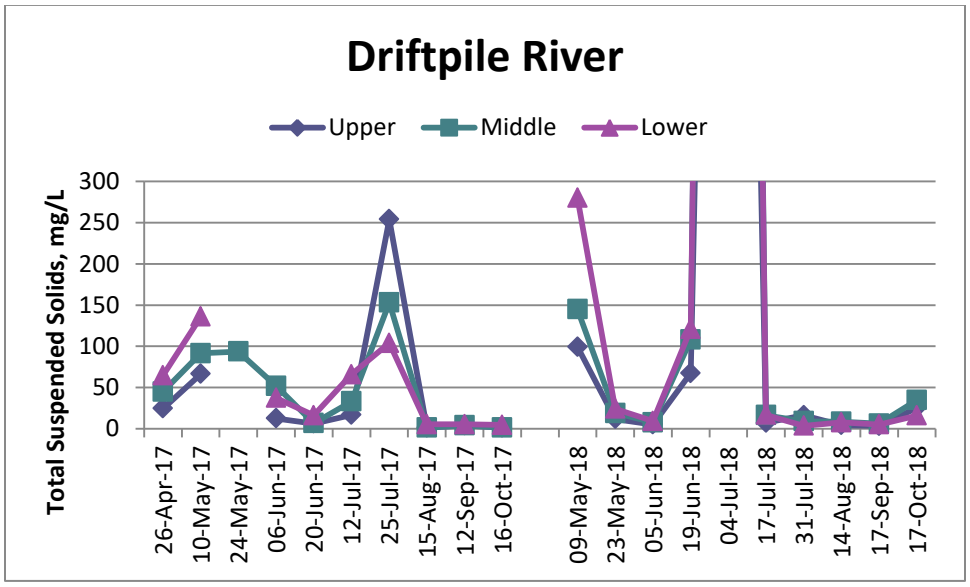



Total Phosphorus 2017-18
Lower Swan River
Middle Swan River
y = 2.5877x - 0.0545
R² = 0.9945
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

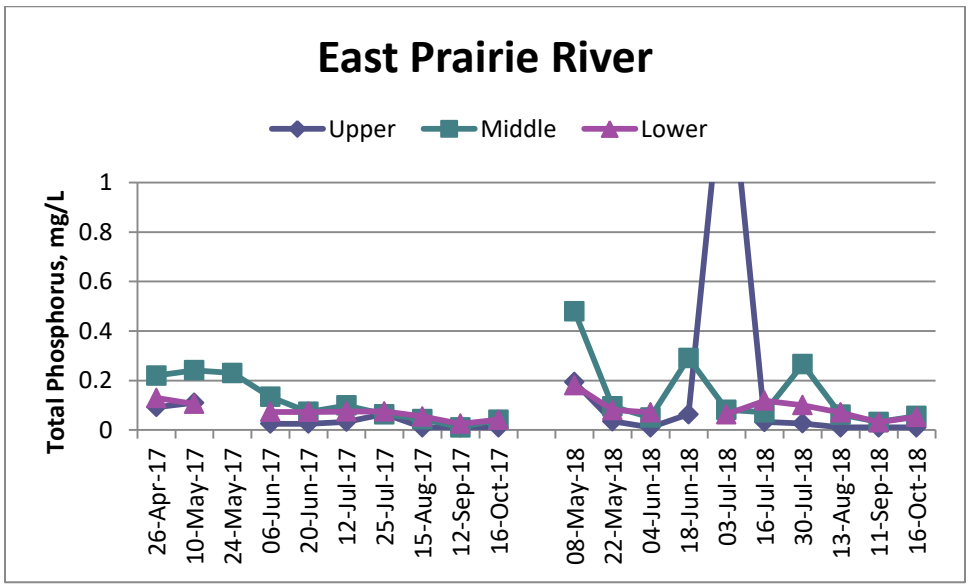

Total Suspended Solids 2017-18
Lower Swan River
Middle Swan River
y = 2.9548x - 44.048
R² = 0.9971
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400

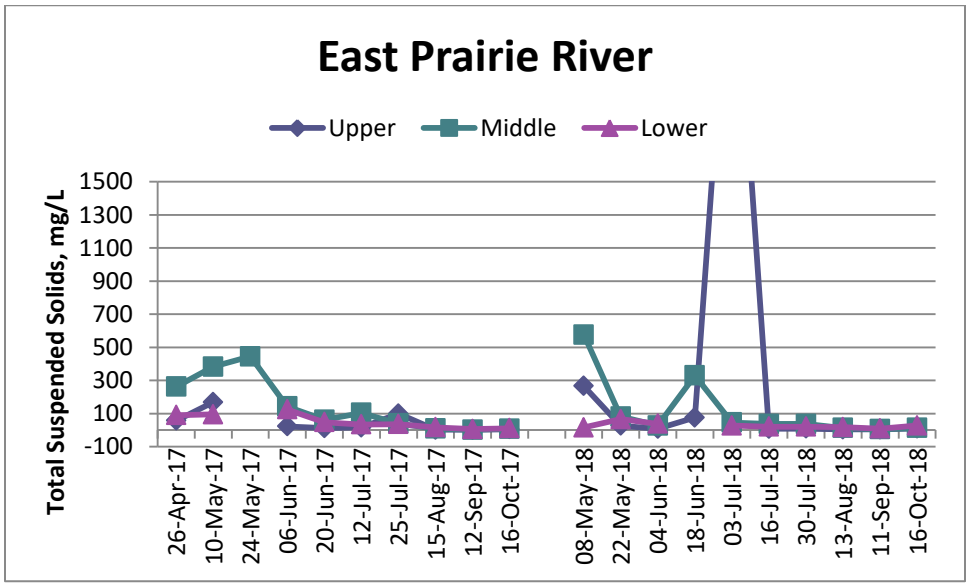
C-2. Driftpile River



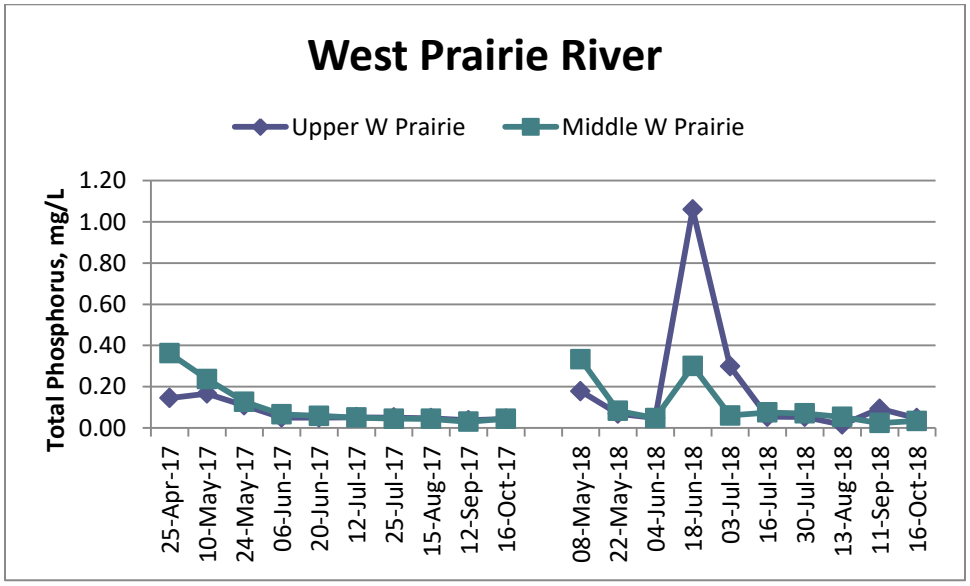


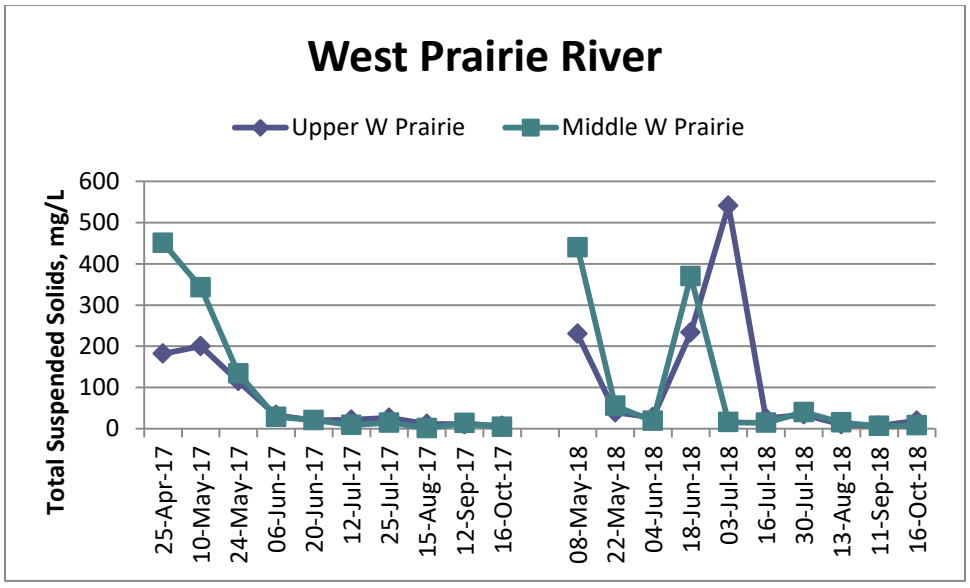
C-3. East Prairie River





C-4. West Prairie River





C-5. South Heart River and Grouard Channel