

LWF

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Assiniboine River; Photo: Paul Mutch

WINNIPEG  
RIVER SYSTEM

# 2022 regional report

LAKE WINNIPEG  
community-based monitoring network



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# Lake Winnipeg Community-Based Monitoring Network: Overview

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The Lake Winnipeg Community-Based Monitoring Network (LWCBMN), coordinated by the Lake Winnipeg Foundation (LWF), mobilizes citizens and watershed partners to collect water samples across Manitoba in order to measure phosphorus concentration. Phosphorus is the nutrient responsible for blue-green algae blooms on Lake Winnipeg. Phosphorus comes from diverse sources across the watershed, including municipal wastewater and agricultural runoff.

Different sub-watersheds contribute different proportions of Lake Winnipeg’s total phosphorus load. With the help of a strong network of watershed partners and citizen scientists, this long-term monitoring program is identifying phosphorus hotspots – localized areas that contribute higher amounts of phosphorus to waterways than other areas. Targeting actions to reduce phosphorus loading in hotspots will reduce the amount of phosphorus entering Manitoba’s lakes and rivers, and improve the health of Lake Winnipeg.

Snow melts, floods and heavy rainfall events are responsible for most of the phosphorus that is flushed from the land and carried into our waterways. LWCBMN samples frequently throughout the season, and particularly during the spring melt, to ensure we capture phosphorus runoff during these high-water events.

Most LWCBMN sampling is conducted at stations where water flow is continuously monitored by the [Water Survey of Canada](#) (WSC). By tracking flow online using the WSC’s real-time data, the network can notify partners and citizen scientists across the watershed to ensure frequent sampling during peak flows. Sampling at these stations provides corresponding real-time flow data, allowing LWCBMN data to be used to calculate **phosphorus loads**. We need several samples throughout the season, corresponding to changes in flow, to accurately calculate these loads. Phosphorus loads can subsequently be used to calculate **phosphorus export**, based on the area of the watershed.

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**Phosphorus load** is the total amount of phosphorus flowing past a sample site over a given period of time, expressed as tonnes per year.

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**Phosphorus export** is the amount of phosphorus exported by each hectare of land in a year, expressed as kg/ha/y.

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# Sample Collection & Site Map

Water samples are collected using a weighted sampling device that collects source water directly into a 500 mL Nalgene polyethylene bottle. The sampling device is lowered into the water just before it hits the bottom, the bottle is filled, then brought back to the surface. It is rinsed three times prior to sample collection. Next, a 60 mL Nalgene polyethylene bottle containing 1 mL 4N H<sub>2</sub>SO<sub>4</sub> is filled with whole water from the collection bottle.

In 2022, 1680 unfiltered water samples were collected and analyzed from 116 sites. Of these 116 LWCBMN sampling sites, 92 are located near flow-metered WSC stations, five are located near non-flow-metered WSC stations, four are located near Ontario Power Generation sites, two are located near Manitoba Hydro sites, one is located near a USGS station, and twelve are not located near any stations.

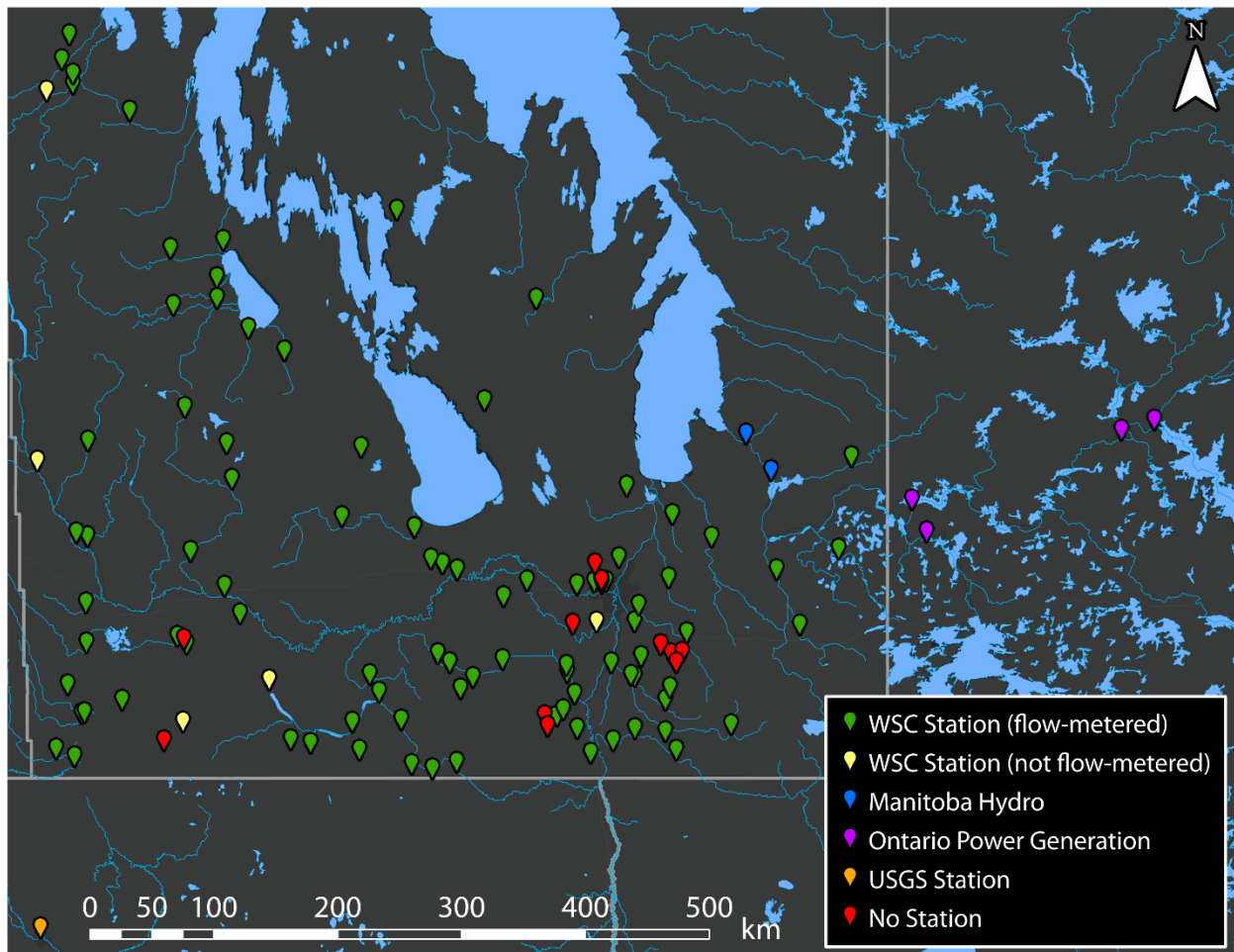


Figure 1: Map of LWCBMN sampling sites in 2022. Locations shown provided at least one sample. Colours indicate nearby station type.

# Laboratory & Data Analysis

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LWCBMN water samples are analysed for total phosphorus concentration. The analysis of a sample for total phosphorus (TP) is a two-step procedure involving first the chemical digestion/conversion of all P forms to orthophosphate ( $\text{PO}_4^{3-}$ ) followed by the analysis of the concentration of  $\text{PO}_4^{3-}$ . The digestion procedure is patterned after USGS [Water-Resources Investigations Report 03-4174](#). The concentration of  $\text{PO}_4^{3-}$  in the sample was determined following [Murphy & Riley \(1962\)](#). The result of this analytical method is determination of unfiltered total phosphorus in mg/L.

Laboratory analysis on LWCBMN water samples was conducted in partnership with Dr. Nora Casson at her laboratory at the University of Winnipeg. Quality assurance of laboratory methods for the determination of total phosphorus was completed on samples sent from [Proficiency Testing Canada](#). Proficiency testing allows us to assess the quality of our results as compared to the results of other laboratories across the country. We received an excellent passing grade of 92/100 (with anything over 70/100 considered “passing”) on our laboratory analysis method in November 2023.

Our laboratory results provide a record of the phosphorus concentrations for every day that water samples were collected, but we are equally interested in reporting the actual load of phosphorus each year in each watershed that we sample. To create this record, we multiply concentrations by the volume of water that flowed past the station every day. The Water Survey of Canada (WSC) records daily flows at most of our stations. For each station, gaps between concentration observations are filled by linear interpolation to create a continuous daily record. For the WSC flow record before or after the first or last water sample collected, we estimate the missing daily mean concentrations to be equal to the first or last measured concentration, respectively. These measured and estimated daily concentrations are then multiplied by daily flow to create a record of daily phosphorus loads.

Larger watersheds generate greater river flow and typically larger phosphorus loads. Comparing the intensity of phosphorus sources, especially among watersheds of varying sizes, is possible through the calculation of average load exported from each unit area of the watershed. Hence, we also report phosphorus export, which is simply the annual load divided by the watershed area that contributed to this load.

Load and export are each useful in their own way. The export per unit area is indicative of the relative intensity of the sources generating phosphorus export, even among watersheds of different sizes. This is why we display maps of phosphorus export (and not load) in this report. Hotspots identified in these reports export several times more phosphorus per hectare than non-hotspot watersheds. Identifying hotspots can help government agencies to focus phosphorus reduction programs efficiently throughout the Province.

# LWCBMN By the Numbers - 2022

Table 1: Summary of 2022 LWCBMN sampling activity by region.

Region	Number of sites	Number of samples	Site with highest regional total phosphorus (TP) export (kg/ha/y)	Mean % of spring* water load	Mean % of spring* TP load
Assiniboine West	10	170	Little Saskatchewan River near Minnedosa (0.44)	58.63	60.54
Central Assiniboine	2	48	Cypress River near Bruxelles (1.37)	87.85	80.32
City of Winnipeg	5	103	Omand's Creek near Empress Street (1.45)	87.84	91.60
East Interlake	3	24	Netley Creek near Petersfield (0.91)	67.88	81.05
Inter-Mountain	7	110	Ochre River near Ochre River (2.72)	66.73	77.45
Northeast Red	4	34	Devil's Creek near Libau (1.31)	63.71	68.56
Pembina Valley	16	216	Rivière aux Marais near Christie (3.22)	80.87	83.45
Redboine	15	195	South Tobacco Creek near Miami (3.99)	80.86	84.10
Souris River	13	122	Elgin Creek near Souris (0.26)	63.41	54.70
Seine Rat Roseau	19	333	Joubert Creek at St-Pierre-Jolys (2.74)	70.73	74.38
Swan Lake	6	90	Birch River near Birch River (0.83)	79.69	92.88
West Interlake	2	39	Burnt Lake Drain Northwest of Lundar (0.077)	19.56	17.44
Whitemud	4	54	Big Grass River near Glenella (0.78)	59.70	56.13
Winnipeg River	10	142	Winnipeg River at McArthur Generating Station (2.50)	33.44	36.35

\*LWCBMN defines "Spring" as March 1 to May 31, inclusive.

# Winnipeg River System

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The Winnipeg River is the largest contributor of water (49% of annual water load) and the second largest contributor of phosphorus (15% of annual phosphorus load) to Lake Winnipeg (State of Lake Winnipeg Report, 2011). The Winnipeg River drains an area largely covered by boreal forest and Canadian Shield lakes. Within the Winnipeg River system there is extensive cottage development, as well as many hydro-electric generating stations.

In partnership with LWCBMN, Manitoba Hydro staff, Ontario Power Generation staff and volunteers collected samples at 10 sites in the Winnipeg River system, all of which were at actively monitored WSC flow meters or at hydro-electric generating stations where flow data is collected.

## Characteristics of the 2022 Field Season

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The 2022 field season was historically wet. The winter of 2021-2022 provided most of southern Manitoba with 150+ cm of snow, the third highest amount of snowfall since 1872. Additionally, record precipitation in April and May saw large amounts of rain and snow falling on mostly frozen, impermeable soils. Specifically, in the month of April, southern Manitoba and the US portion of the Red River watershed received 400-600% of their normal precipitation (120-160 mm). Flooding was a huge issue across the southern part of the province, where almost all LWCBMN sites are located. The mean peak discharge date across all LWCBMN sites with analyzed water samples was May 10, 2022 (with a standard deviation of 19 days). In 2022, an average of 65.83% of stream discharge occurred in the spring (March 1 – May 31) across LWCBMN sites (with a standard deviation of 21.10%). During the period of extreme flooding, safety concerns prevented sampling from occurring at some sites. As a result, some load/export calculations may be less accurate than they would be had sampling remaining frequent during these times.

# Manitoba Watershed District Map

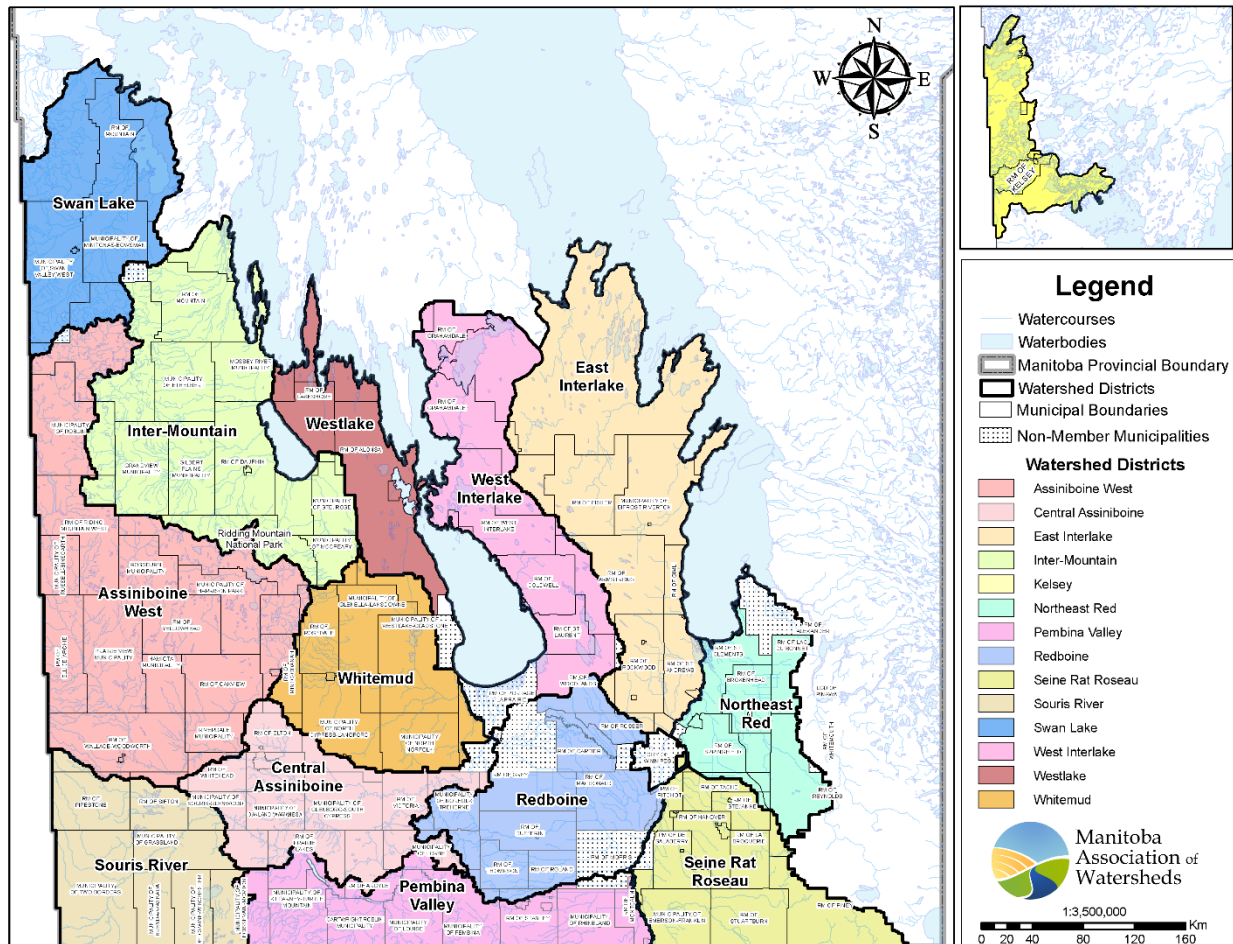


Figure 2: Manitoba Watershed District Boundaries. There are 14 total watershed districts, with 12 of 14 participating in LWCBMN (all but Kelsey & Westlake). Map provided by Manitoba Association of Watersheds (updated July 2022).

# 2022 Results – Winnipeg River System Summary

Table 2: Summary of 2022 LWCBMN results in the Winnipeg River System. Letters correspond to drainage areas in Figure 3. Data shown represents sites with sampling efforts adequate enough to calculate loads/exports. <sup>1</sup>See footnote for explanation of acronyms/abbreviations.

	Site Name	WSC Station	GDA (km <sup>2</sup> )	IDA (km <sup>2</sup> )	Gross/Incr.	TP load (tonnes/y)	TP export (kg/ha/y)
A	Birch River near Prawda	05PH007	1054.26	NA	gross	15.50	0.15
B	Bird River outlet of Bird Lake	05PJ001	1040.13	NA	gross	20.51	0.20
C	Caribou Falls	NA	67546.00	15646.39	incr.	-217.35	-0.14
D	Ear Falls Generating Station	NA	41825.00	NA	gross	353.27	0.08
E	Manitou Falls Generating Station	NA	51910.00	10092.08	incr.	98.53	0.10
F	Whitedog Falls	NA	71670.00	NA	gross	558.79	0.08
G	Whitemouth River near Whitemouth	05PH003	3739.61	2685.36	incr.	37.23	0.14
H	Whiteshell River at outlet of Jessica Lake	05PG001	904.12	NA	gross	14.94	0.17
I	Winnipeg River at McArthur Generating Station	05PF068	150343.87	5591.28	incr.	1397.50	2.50
J	Winnipeg River at Pine Falls Generating Station	05PF069	151879.87	1535.76	incr.	-113.28	-0.74

To compare 2022 results to other years of data, please see the LWCBMN regional reports attached to the LWCBMN dataset (<https://datastream.org/en-ca/dataset/f10bb610-63cc-46c1-81b1-74a6b0310655>) which resides in Lake Winnipeg DataStream (<https://lakewinnipegdatastream.ca/explore/#/dataset/f10bb610-63cc-46c1-81b1-74a6b0310655/>).

<sup>1</sup> WSC = Water Survey of Canada.  
 GDA = gross drainage area (i.e., the total watershed area).  
 IDA = incremental drainage area (i.e., the total watershed area minus the total watershed area of any contained upstream sites with data adequate for load/export calculation).  
 Gross/Incr. = whether or not the adjacent TP load/export listed is from the gross or incremental (“Incr.”) drainage area of a site.

# 2022 Results – Hotspot Map

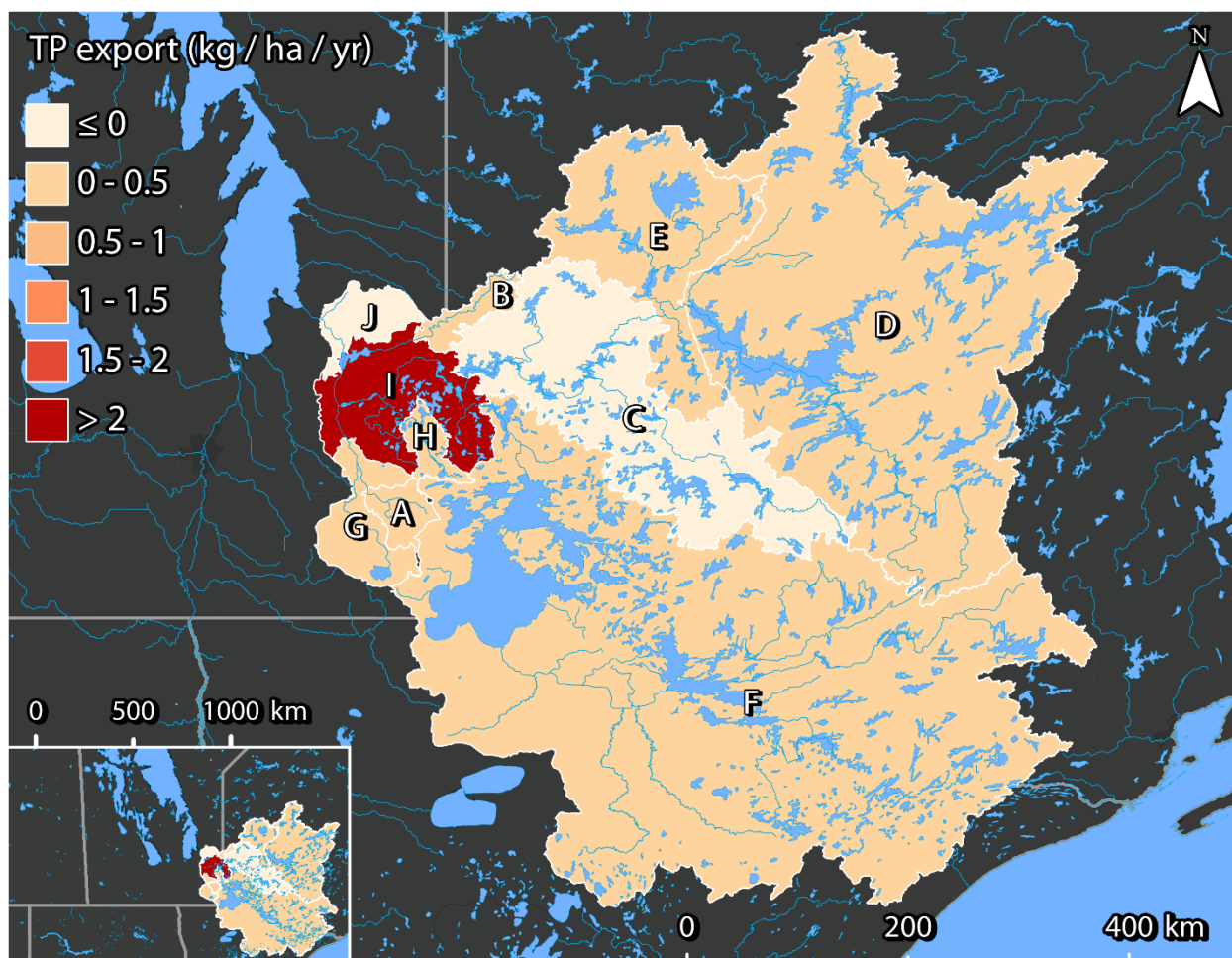


Figure 3: 2022 LWCBMN TP Export Hotspots in the Winnipeg River System. Letters correspond to sites listed in Table 2.

# 2022 Results – Individual Sites

## Winnipeg River at Pine Falls Generating Station

Pine Falls Generating Station is located on the Winnipeg River adjacent to Highway 11, ~13 km upstream of Lake Winnipeg. Flow data was collected by Manitoba Hydro and provided to LWCBMN. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 3: Indices of discharge and phosphorus from the incremental drainage area of Winnipeg River at Pine Falls Generating Station. See Supplemental Table 1 for gross calculations.

<b>Incremental drainage area:</b>	1535.76 km <sup>2</sup>
<b>Peak discharge:</b>	3839 m <sup>3</sup> s <sup>-1</sup> (2022-05-28)
<b>Peak TP concentration:</b>	0.14 mg/L (2022-05-09)
<b>% of water load in spring:</b>	25.27%
<b>% of TP load in spring:</b>	39.51%
<b><sup>1</sup>Incremental water load:</b>	0.46 km <sup>3</sup> y <sup>-1</sup>
<b><sup>1</sup>Incremental TP load:</b>	-113.28 tonnes P y <sup>-1</sup>
<b><sup>2</sup>Incremental water export:</b>	296.64 mm y <sup>-1</sup>
<b><sup>2</sup>Incremental TP export:</b>	-0.74 kg P ha <sup>-1</sup> y <sup>-1</sup>

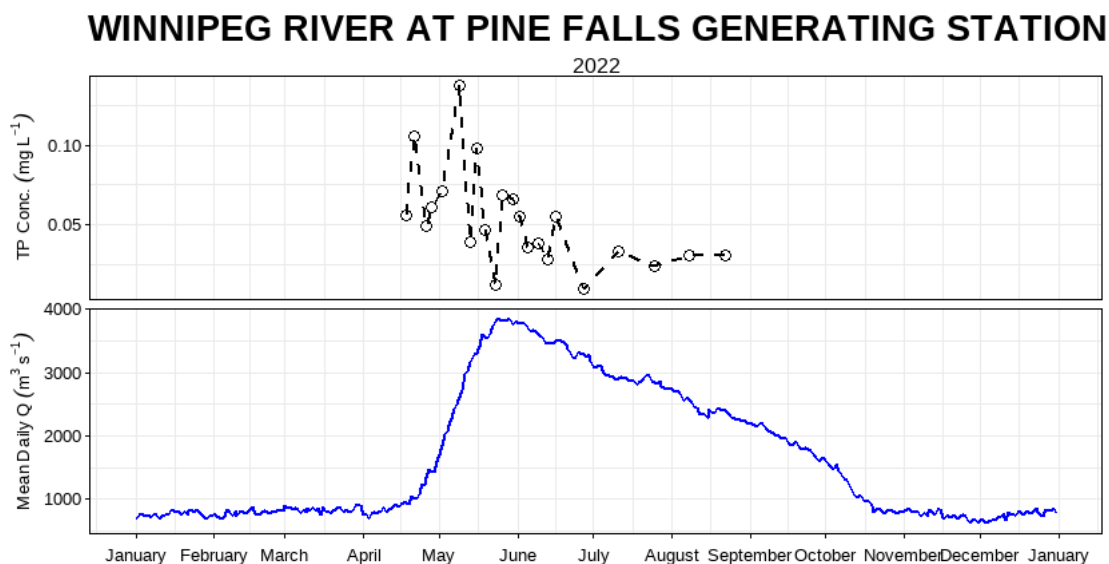


Figure 4: Mean daily discharge (m<sup>3</sup> s<sup>-1</sup>) and total phosphorus concentration (mg L<sup>-1</sup>) over the 2022 sampling season at Winnipeg River at Pine Falls Generating Station.

<sup>1</sup> Incremental loads are calculated by subtracting gross “Winnipeg River at McArthur Generating Station” values from gross “Winnipeg River at Pine Falls Generating Station” values.

<sup>2</sup> Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

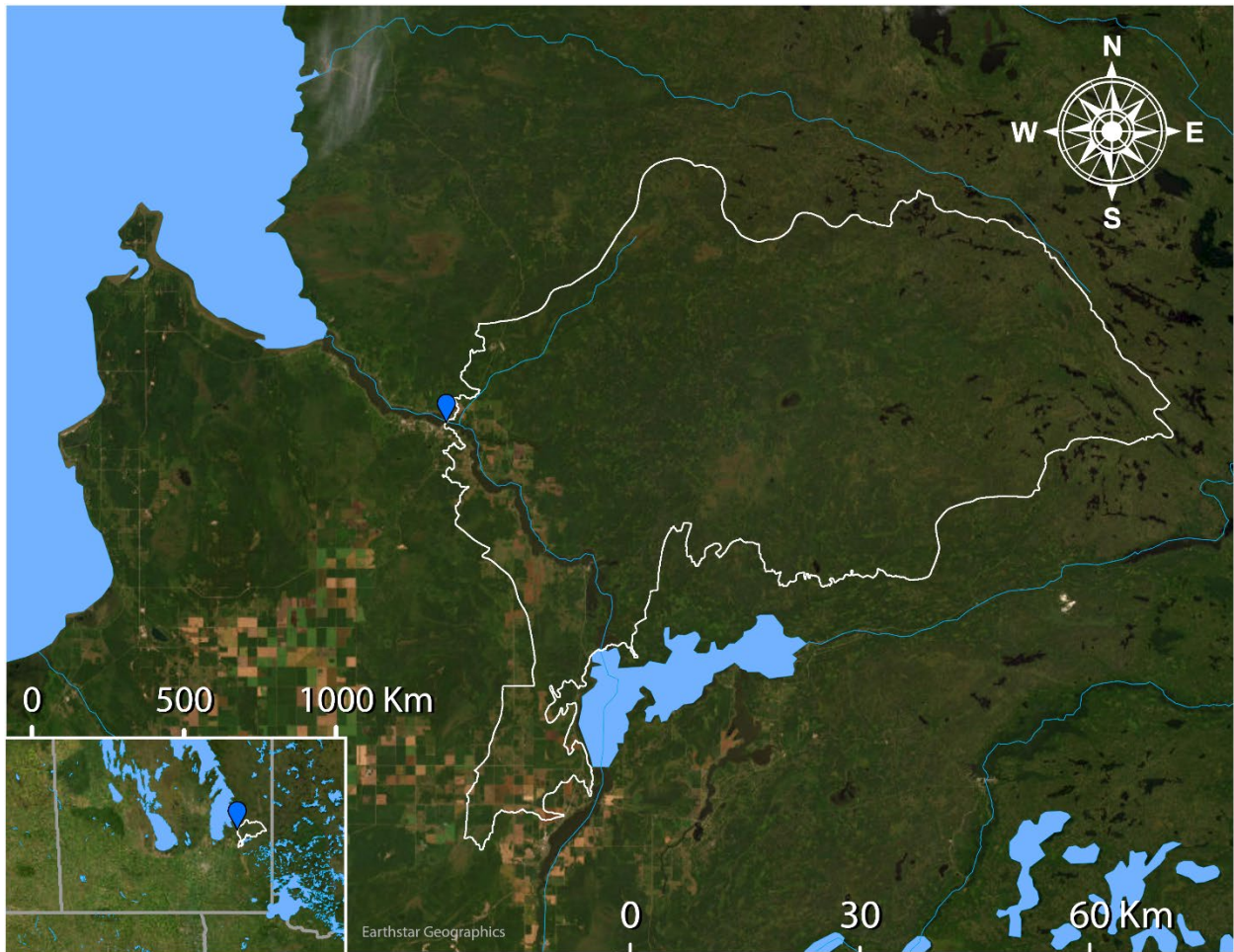


Figure 5: Winnipeg River at Pine Falls Generating Station sampling site (blue), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 1 for upstream drainage areas used to calculate incremental area.

# Winnipeg River at McArthur Generating Station

McArthur Falls Generating Station is located on the Winnipeg River at the conjunction with Lac du Bonnet. It is situated approximately 42 km upstream of Lake Winnipeg. Flow data was collected by Manitoba Hydro and provided to LWCBMN. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 4: Indices of discharge and phosphorus from the incremental drainage area of Winnipeg River at McArthur Generating Station. See Supplemental Table 2 for gross calculations.

<b>Incremental drainage area:</b>	5591.28 km <sup>2</sup>
<b>Peak discharge:</b>	3791.45 m <sup>3</sup> s <sup>-1</sup> (2022-05-28)
<b>Peak TP concentration:</b>	0.090 mg/L (2022-09-20)
<b>% of water load in spring:</b>	25.04%
<b>% of TP load in spring:</b>	27.33%
<b><sup>1</sup>Incremental water load:</b>	4.29 km <sup>3</sup> y <sup>-1</sup>
<b><sup>1</sup>Incremental TP load:</b>	1397.50 tonnes P y <sup>-1</sup>
<b><sup>2</sup>Incremental water export:</b>	767.23 mm y <sup>-1</sup>
<b><sup>2</sup>Incremental TP export:</b>	2.50 kg P ha <sup>-1</sup> y <sup>-1</sup>

## WINNIPEG RIVER AT MCARTHUR GENERATING STATION

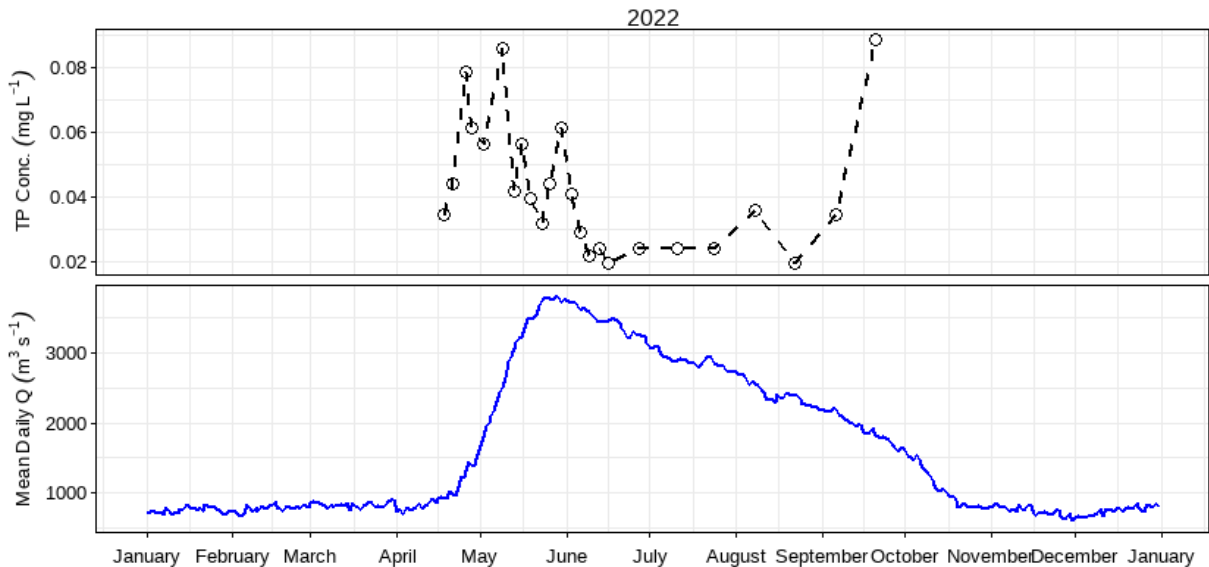


Figure 6: Mean daily discharge (m<sup>3</sup> s<sup>-1</sup>) and total phosphorus concentration (mg L<sup>-1</sup>) over the 2022 sampling season at Winnipeg River at McArthur Generating Station.

<sup>1</sup> Incremental loads are calculated by subtracting gross “Bird River outlet of Bird Lake”, “Caribou Falls”, “Whitemouth River near Whitemouth”, “Whitedog Falls”, and “Whiteshell River at outlet of Jessica Lake” from “Winnipeg River at McArthur Generating Station” values.

<sup>2</sup> Incremental exports are calculated by dividing incremental loads by incremental drainage areas.



Figure 7: Winnipeg River at McArthur Generating Station sampling site (blue), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 2 for upstream drainage areas used to calculate incremental area.

## Bird River outlet of Bird Lake

The Bird River flows west out of Bird Lake and discharges into Lac du Bonnet. This sampling site is located at Water Survey of Canada station 05PJ001. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 5: Indices of discharge and phosphorus from the gross drainage area of Bird River outlet of Bird Lake (05PJ001) in 2022.

<b>Gross drainage area:</b>	1040.13 km <sup>2</sup>
<b>Peak discharge:</b>	79.24 m <sup>3</sup> s <sup>-1</sup> (2022-05-07)
<b>Peak TP concentration:</b>	0.16 mg/L (2022-08-03)
<b>% of water load in spring:</b>	50.14%
<b>% of TP load in spring:</b>	42.33%
<b>Water load:</b>	0.43 km <sup>3</sup> y <sup>-1</sup>
<b>TP load:</b>	20.51 tonnes P y <sup>-1</sup>
<b>Water export:</b>	412.37 mm y <sup>-1</sup>
<b>TP export:</b>	0.20 kg P ha <sup>-1</sup> y <sup>-1</sup>

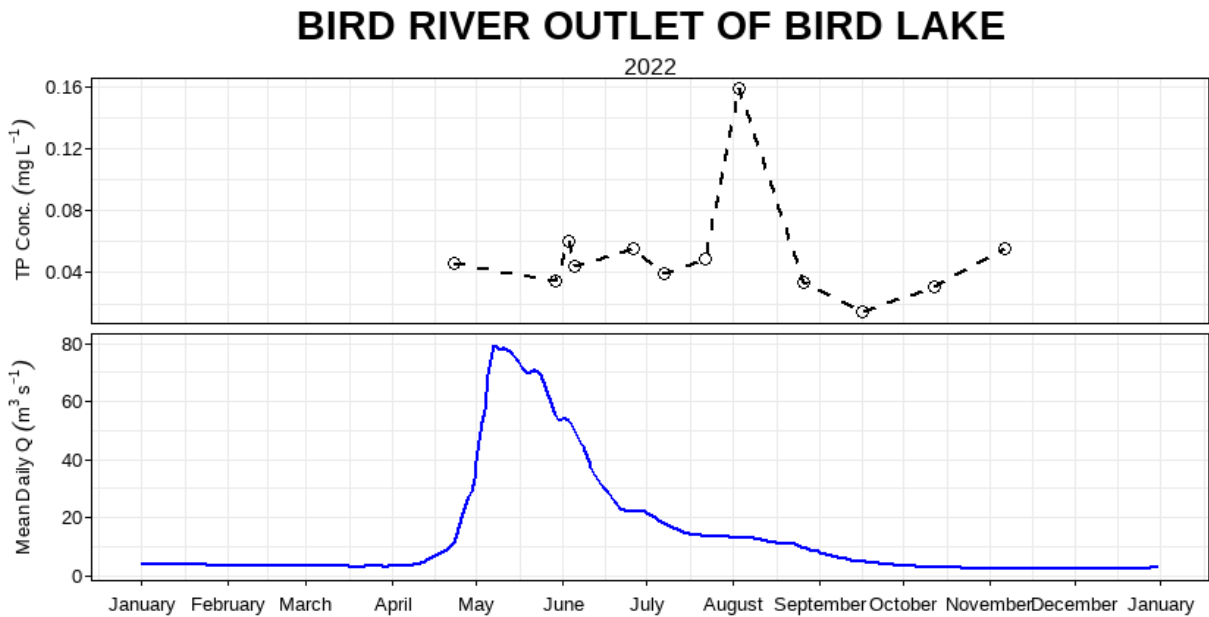


Figure 8: Mean daily discharge (m<sup>3</sup> s<sup>-1</sup>) and total phosphorus concentration (mg L<sup>-1</sup>) over the 2022 sampling season at Bird River outlet of Bird Lake (05PJ001).

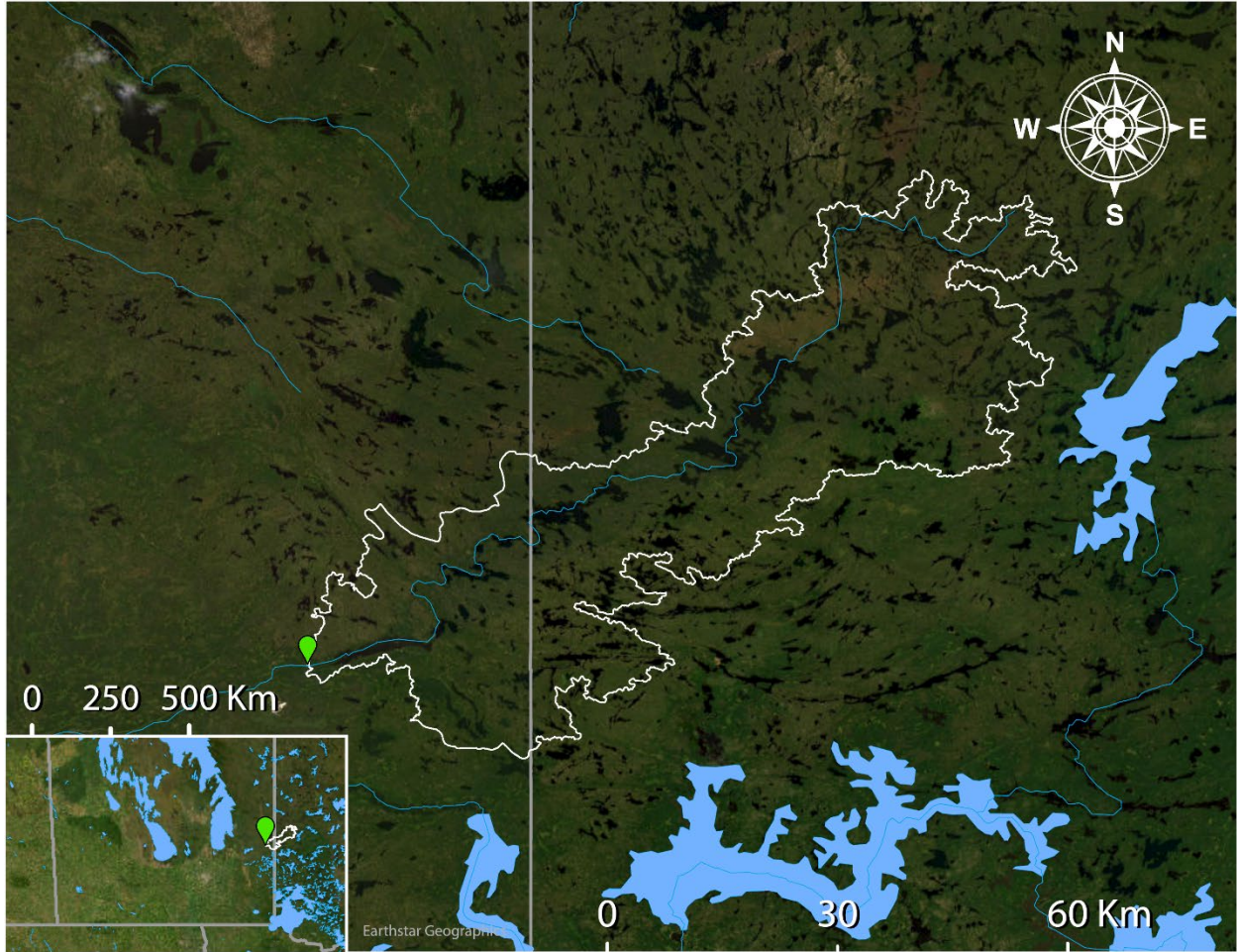


Figure 9: WSC station 05PJ001 (green) and drainage area polygon (white - source: WSC). LWCBMN samples directly at the WSC station.

## Whiteshell River at outlet of Jessica Lake

The Whiteshell River is located in Whiteshell Provincial Park, near the Ontario border. It is one of the major rivers in the park, connecting many lakes, and eventually flows into the Winnipeg River. This sampling site is located at Water Survey of Canada flow meter 05PG001. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 6: Indices of discharge and phosphorus from the gross drainage area of Whiteshell River at outlet of Jessica Lake (05PG001) in 2022.

<b>Gross drainage area:</b>	904.12 km <sup>2</sup>
<b>Peak discharge:</b>	56.88 m <sup>3</sup> s <sup>-1</sup> (2022-05-21)
<b>Peak TP concentration:</b>	0.0096 mg/L (2022-09-04)
<b>% of water load in spring:</b>	38.34%
<b>% of TP load in spring:</b>	40.12%
<b>Water load:</b>	0.36 km <sup>3</sup> y <sup>-1</sup>
<b>TP load:</b>	14.94 tonnes P y <sup>-1</sup>
<b>Water export:</b>	401.96 mm y <sup>-1</sup>
<b>TP export:</b>	0.17 kg P ha <sup>-1</sup> y <sup>-1</sup>

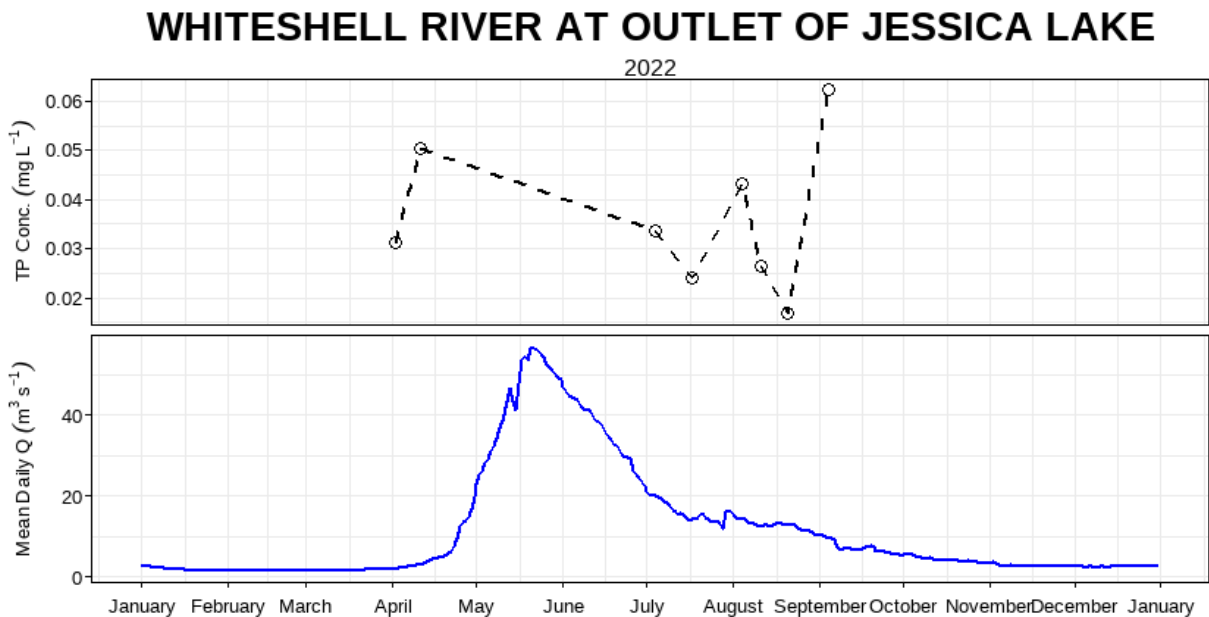


Figure 10: Mean daily discharge (m<sup>3</sup> s<sup>-1</sup>) and total phosphorus concentration (mg L<sup>-1</sup>) over the 2022 sampling season at Whiteshell River at outlet of Jessica Lake (05PG001).

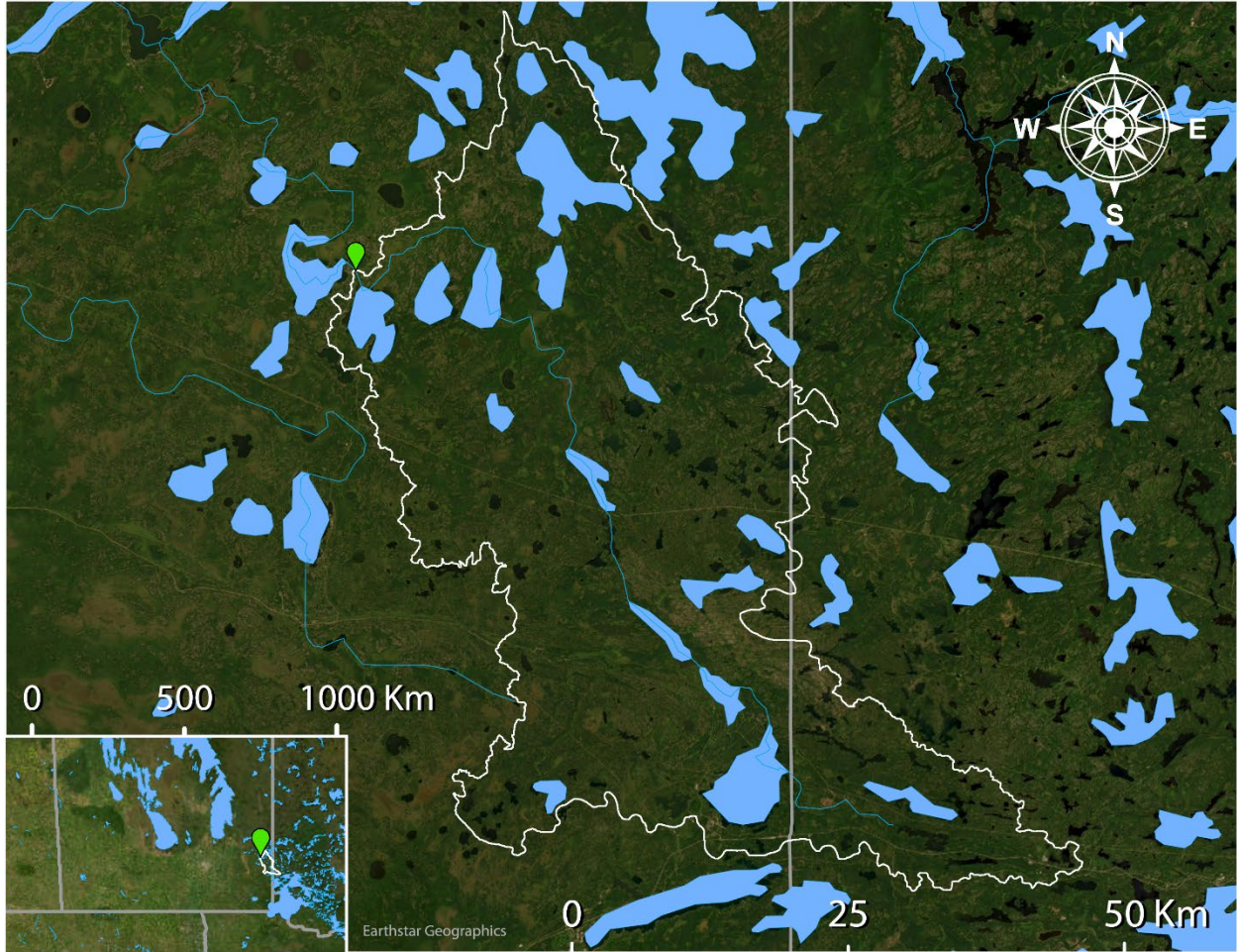


Figure 11: WSC station 05PG001 (green) and drainage area polygon (white – source: WSC). LWCBMN samples directly at the WSC station.

# Whitemouth River near Whitemouth

The Whitemouth River originates from Whitemouth Lake in southeastern Manitoba. It flows through sandy land deposits from Lake Agassiz, agricultural lands and the Canadian Shield to empty into the Winnipeg River near the Seven Sisters Falls Generating Station. This sampling site is located at Water Survey of Canada station 05PH003. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 7: Indices of discharge and phosphorus from the incremental drainage area of Whitemouth River near Whitemouth (05PH003). See Supplemental Table 3 for gross calculations.

<b>Incremental drainage area:</b>	2685.36 km <sup>2</sup>
<b>Peak discharge:</b>	161.43 m <sup>3</sup> s <sup>-1</sup> (2022-05-07)
<b>Peak TP concentration:</b>	0.11 mg/L (2022-07-09 & 2022-09-19)
<b>% of water load in spring:</b>	55.97%
<b>% of TP load in spring:</b>	47.11%
<b><sup>1</sup>Incremental water load:</b>	0.60 km <sup>3</sup> y <sup>-1</sup>
<b><sup>1</sup>Incremental TP load:</b>	37.23 tonnes P y <sup>-1</sup>
<b><sup>2</sup>Incremental water export:</b>	221.83 mm y <sup>-1</sup>
<b><sup>2</sup>Incremental TP export:</b>	0.14 kg P ha <sup>-1</sup> y <sup>-1</sup>

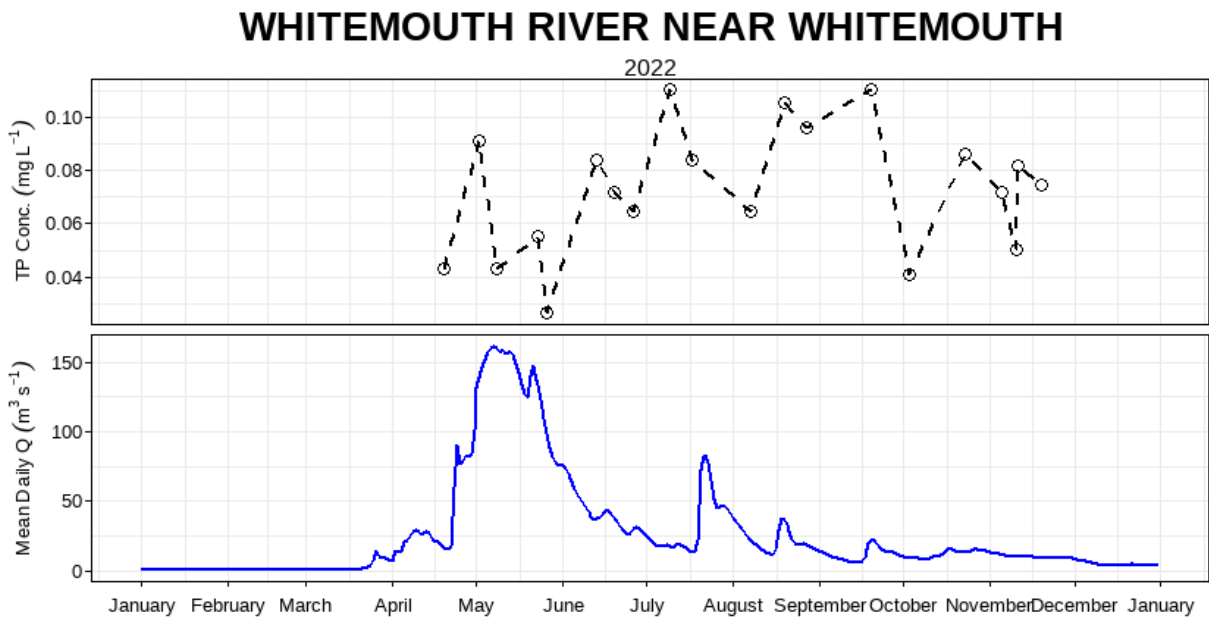


Figure 12: Mean daily discharge (m<sup>3</sup> s<sup>-1</sup>) and total phosphorus concentration (mg L<sup>-1</sup>) over the 2022 sampling season at Whitemouth River near Whitemouth (05PH003).

<sup>1</sup> Incremental loads are calculated by subtracting gross “Birch River near Prawda” from “Whitemouth River near Whitemouth” values.

<sup>2</sup> Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

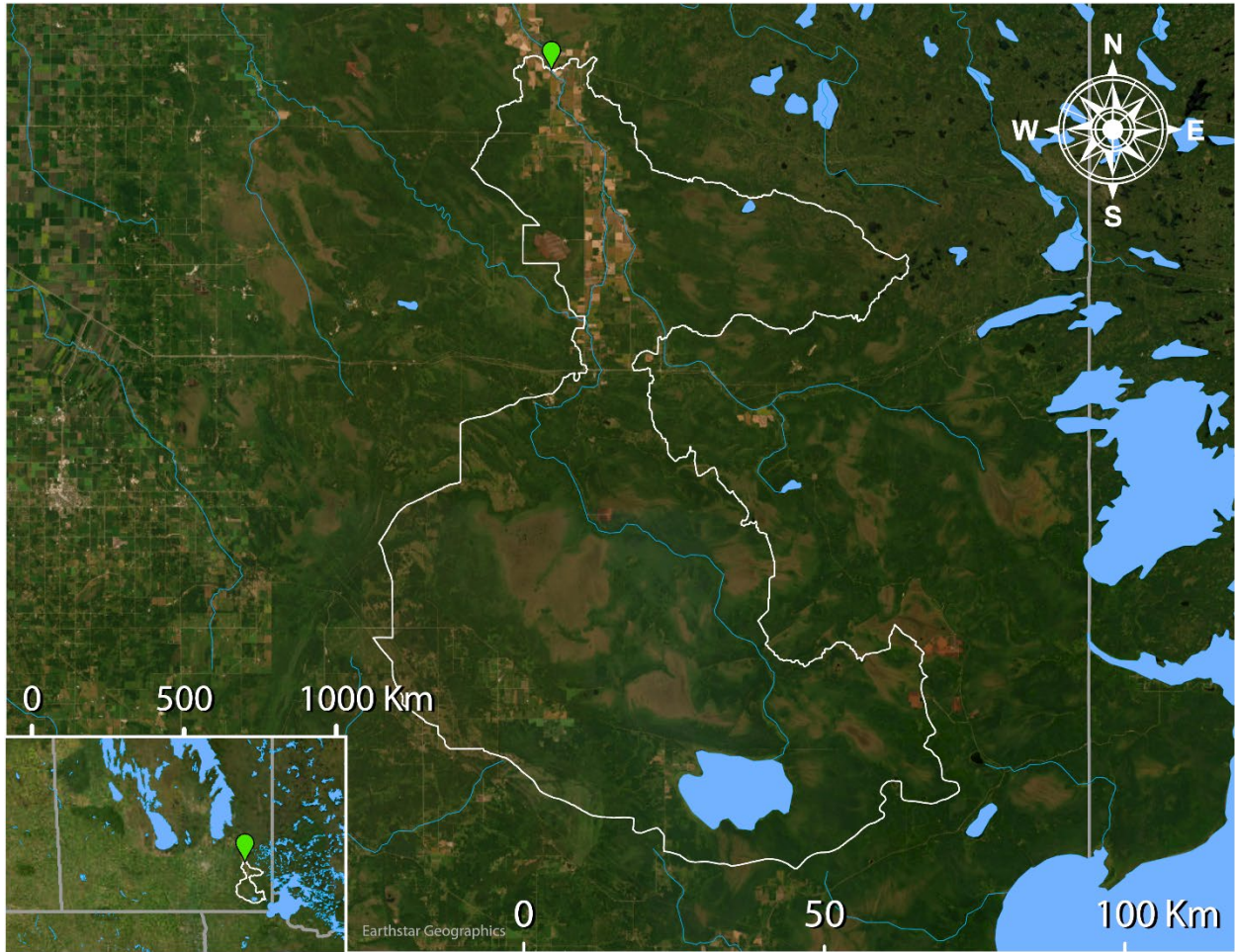


Figure 13: WSC station 05PH003 (green), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 3 for upstream drainage areas used to calculate incremental area. LWCBMN samples directly at the WSC station.

## Birch River near Prawda

The Birch River is located north of Prawda, Man. situated along the Trans-Canada Highway. The sampling site is located at Water Survey of Canada station 05PH007. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 8: Indices of discharge and phosphorus from the gross drainage area of Birch River near Prawda (05PH007) in 2022.

<b>Gross drainage area:</b>	1054.26 km <sup>2</sup>
<b>Peak discharge:</b>	54.95 m <sup>3</sup> s <sup>-1</sup> (2022-05-13)
<b>Peak TP concentration:</b>	0.090 mg/L (2022-04-21)
<b>% of water load in spring:</b>	59.40%
<b>% of TP load in spring:</b>	60.32%
<b>Water load:</b>	0.23 km <sup>3</sup> y <sup>-1</sup>
<b>TP load:</b>	15.50 tonnes P y <sup>-1</sup>
<b>Water export:</b>	213.47 mm y <sup>-1</sup>
<b>TP export:</b>	0.15 kg P ha <sup>-1</sup> y <sup>-1</sup>

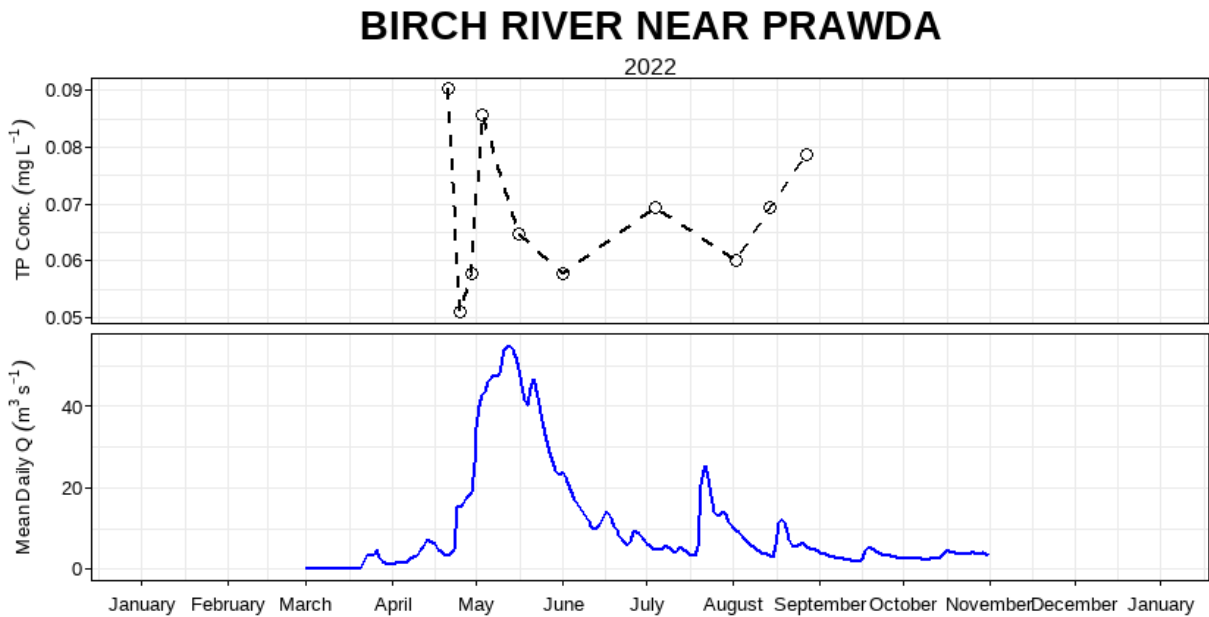


Figure 14: Mean daily discharge (m<sup>3</sup> s<sup>-1</sup>) and total phosphorus concentration (mg L<sup>-1</sup>) over the 2022 sampling season at Birch River near Prawda (05PH007).

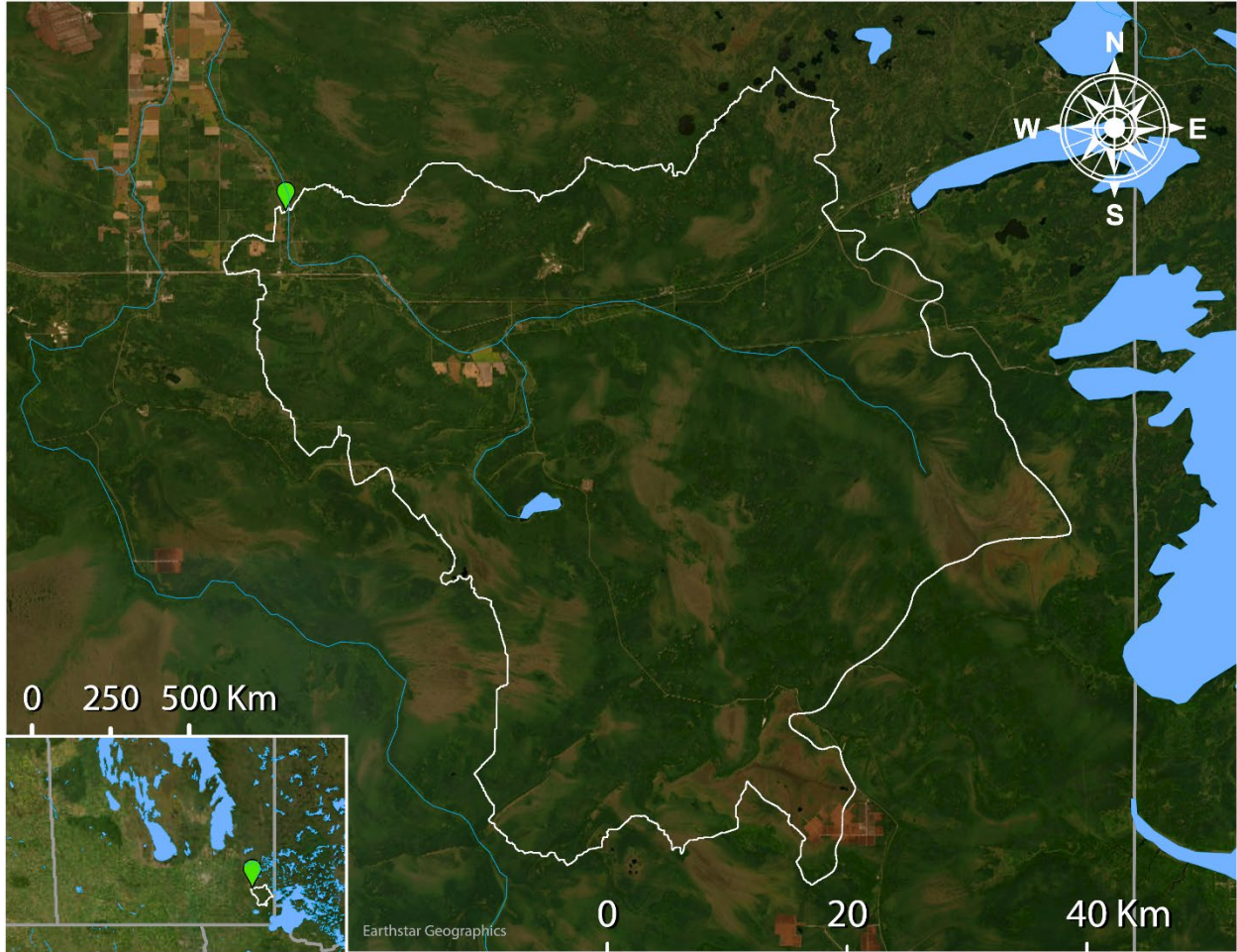


Figure 15: WSC station 05PH007 (green) and drainage area polygon (white – source: WSC). LWCBMN samples directly at the WSC station.

# Whitedog Falls

Whitedog Falls is a hydro-electric generating station powered by Ontario Power Generation Inc. (OPG). It is located on the Winnipeg River near the Manitoba and Ontario border and drains an area which includes the Rainy-Lake of the Woods watershed. Flow data was collected by OPG and provided to LWCBMN. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 9: Indices of discharge and phosphorus from the gross drainage area of Whitedog Falls in 2022.

<b>Gross drainage area:</b>	71670 km <sup>2</sup>
<b>Peak discharge:</b>	1404.2 m <sup>3</sup> s <sup>-1</sup> (2022-07-19)
<b>Peak TP concentration:</b>	0.056 mg/L (2022-06-02)
<b>% of water load in spring:</b>	23.62%
<b>% of TP load in spring:</b>	30.26%
<b>Water load:</b>	23.39 km <sup>3</sup> y <sup>-1</sup>
<b>TP load:</b>	558.79 tonnes P y <sup>-1</sup>
<b>Water export:</b>	326.30 mm y <sup>-1</sup>
<b>TP export:</b>	0.078 kg P ha <sup>-1</sup> y <sup>-1</sup>

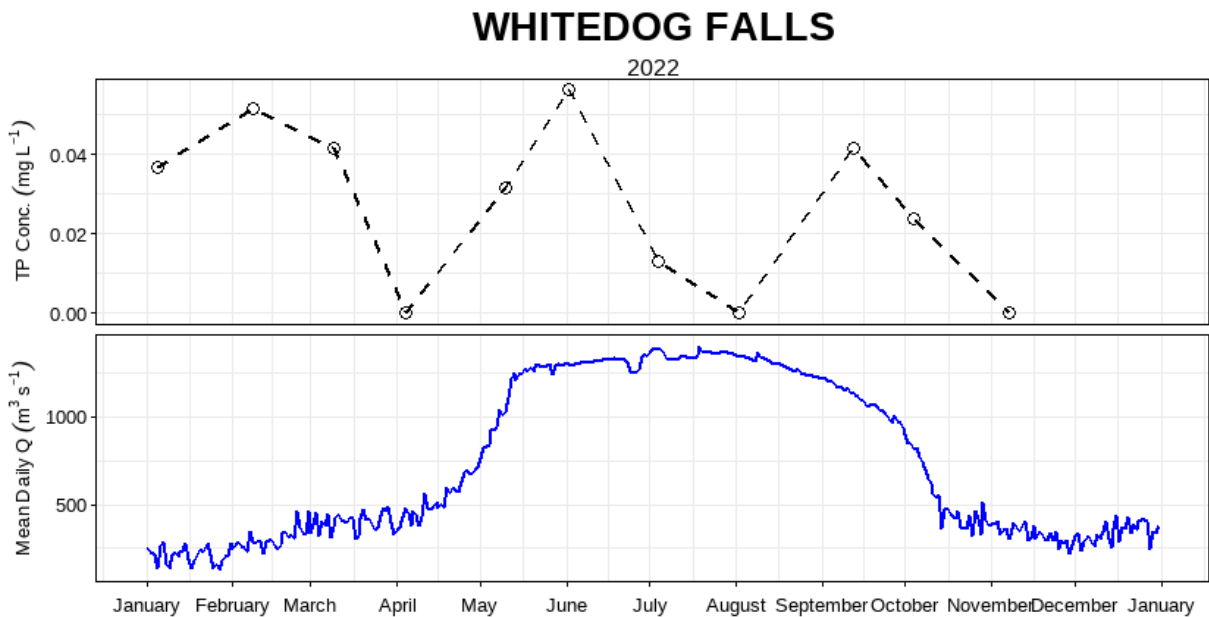


Figure 16: Mean daily discharge (m<sup>3</sup> s<sup>-1</sup>) and total phosphorus concentration (mg L<sup>-1</sup>) over the 2022 sampling season at Whitedog Falls.

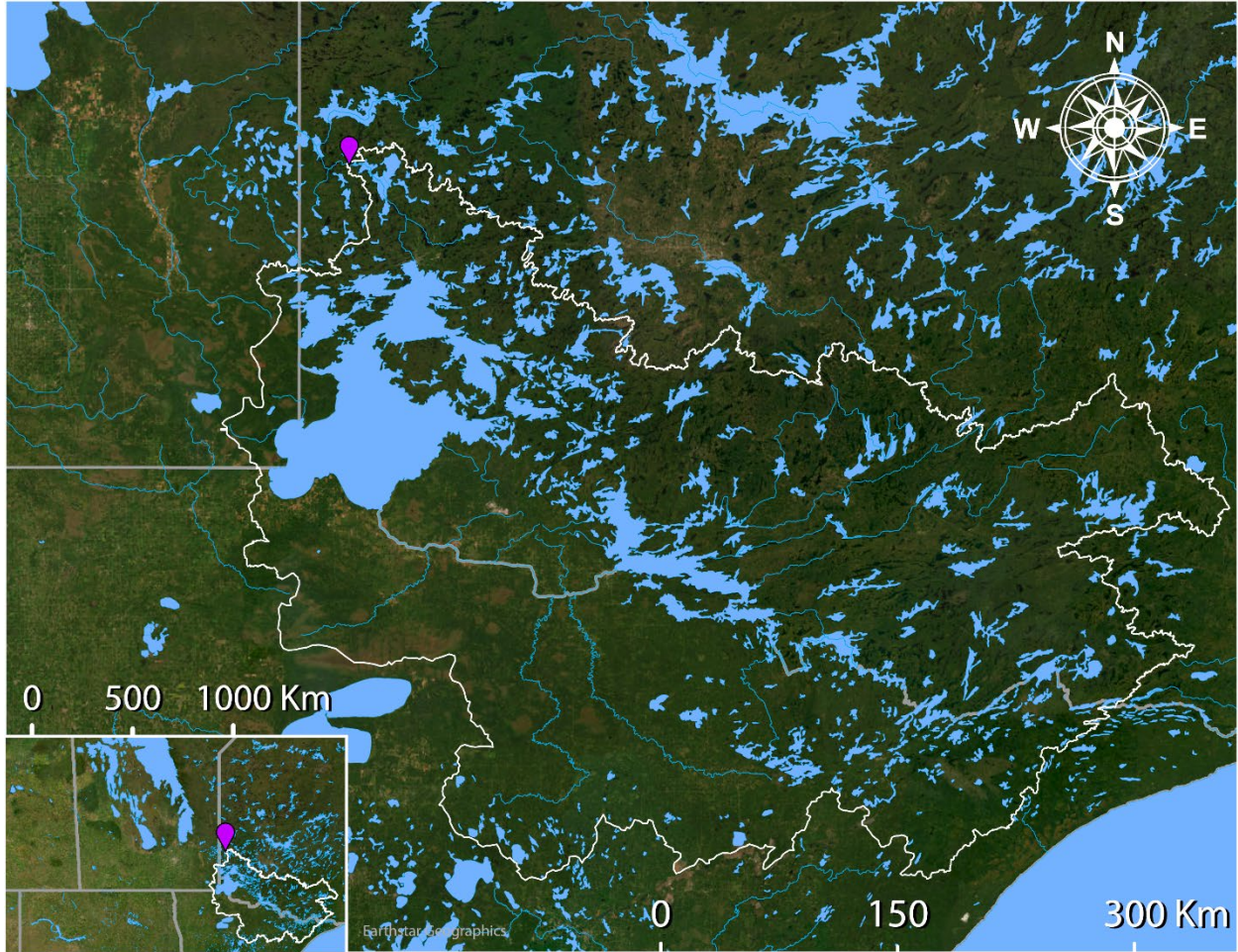


Figure 17: Whitedog Falls sample site (purple) and drainage area polygon (white – source: OPG).

# Caribou Falls

Caribou Falls is a hydro-electric generating station powered by Ontario Power Generation Inc. (OPG). It is situated on the English River 13 km east of the Manitoba border, at the outlet of Umfreville Lake in Ontario. The English River flows west into the Winnipeg River and eventually enters Manitoba. Flow data was collected by OPG and provided to LWCBMN. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 10: Indices of discharge and phosphorus from the incremental drainage area of Caribou Falls. See Supplemental Table 4 for gross calculations.

<b>Incremental drainage area:</b>	15646.39 km <sup>2</sup>
<b>Peak discharge</b>	1807.6 m <sup>3</sup> s <sup>-1</sup> (2022-05-31)
<b>Peak TP concentration</b>	0.064 mg/L (2022-03-03)
<b>% of water load in spring:</b>	24.36%
<b>% of TP load in spring:</b>	22.33%
<b><sup>1</sup>Incremental water load:</b>	6.87 km <sup>3</sup> y <sup>-1</sup>
<b><sup>1</sup>Incremental TP load:</b>	-217.35 tonnes P y <sup>-1</sup>
<b><sup>2</sup>Incremental water export:</b>	439.07 mm y <sup>-1</sup>
<b><sup>2</sup>Incremental TP export:</b>	-0.14 kg P ha <sup>-1</sup> y <sup>-1</sup>

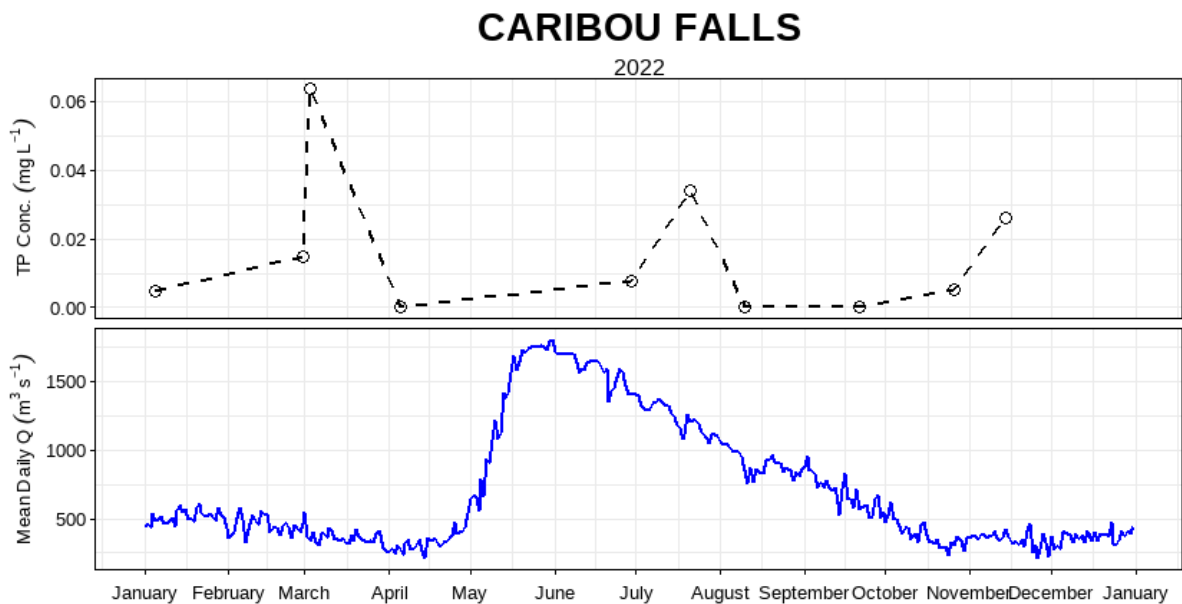


Figure 18: Mean daily discharge (m<sup>3</sup> s<sup>-1</sup>) and total phosphorus concentration (mg L<sup>-1</sup>) over the 2022 sampling season at Caribou Falls.

<sup>1</sup> Incremental loads are calculated by subtracting gross “Manitou Falls Generating Station” values from gross “Caribou Falls” values.

<sup>2</sup> Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

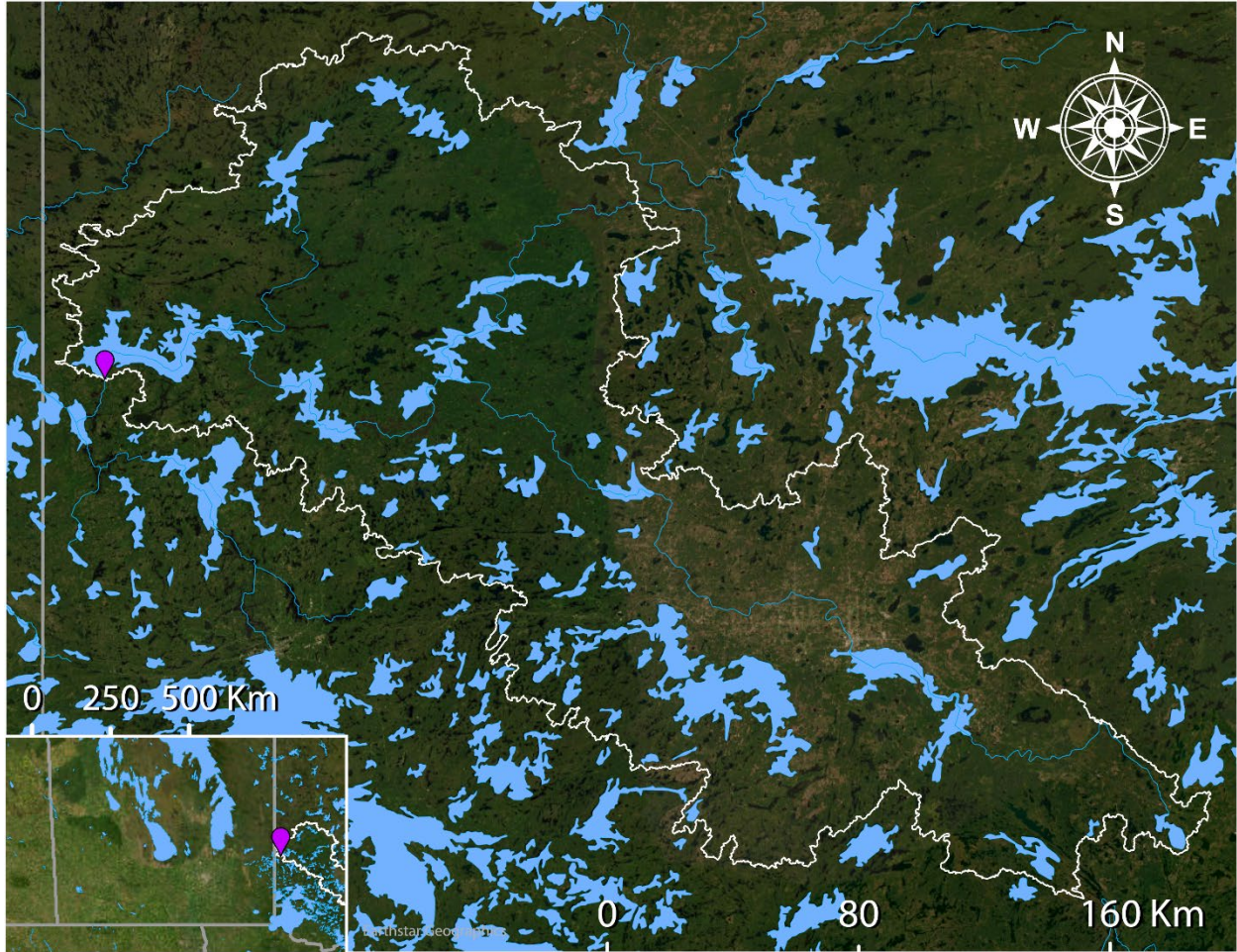


Figure 19: Caribou Falls sampling site (purple) and incremental drainage area polygon (white - source: OPG). See Supplemental Figure 5 for upstream drainage areas used to calculate incremental area.

## Ear Falls Generating Station

Ear Falls is a hydro-electric generating station powered by Ontario Power Generation Inc. (OPG). It is situated on the English River 136 km east of the Manitoba border, at the outlet of Lac Seul. The English River flows west from Lac Seul through Manitou Falls, Caribou Falls and eventually into the Winnipeg River and eventually enters Manitoba. Flow data was collected by OPG and provided to LWCBMN. The sampling effort provided excellent coverage to calculate TP loads and exports.

Table 11: Indices of discharge and phosphorus from the gross drainage area of Ear Falls Generating Station in 2022.

<b>Gross drainage area:</b>	41825 km <sup>2</sup>
<b>Peak discharge:</b>	847.4 m <sup>3</sup> s <sup>-1</sup> (2022-05-31)
<b>Peak TP concentration:</b>	0.11 mg/L (2022-05-24)
<b>% of water load in spring:</b>	19.59%
<b>% of TP load in spring:</b>	29.79%
<b>Water load:</b>	11.36 km <sup>3</sup> y <sup>-1</sup>
<b>TP load:</b>	353.27 tonnes P y <sup>-1</sup>
<b>Water export:</b>	271.52 mm y <sup>-1</sup>
<b>TP export:</b>	0.084 kg P ha <sup>-1</sup> y <sup>-1</sup>

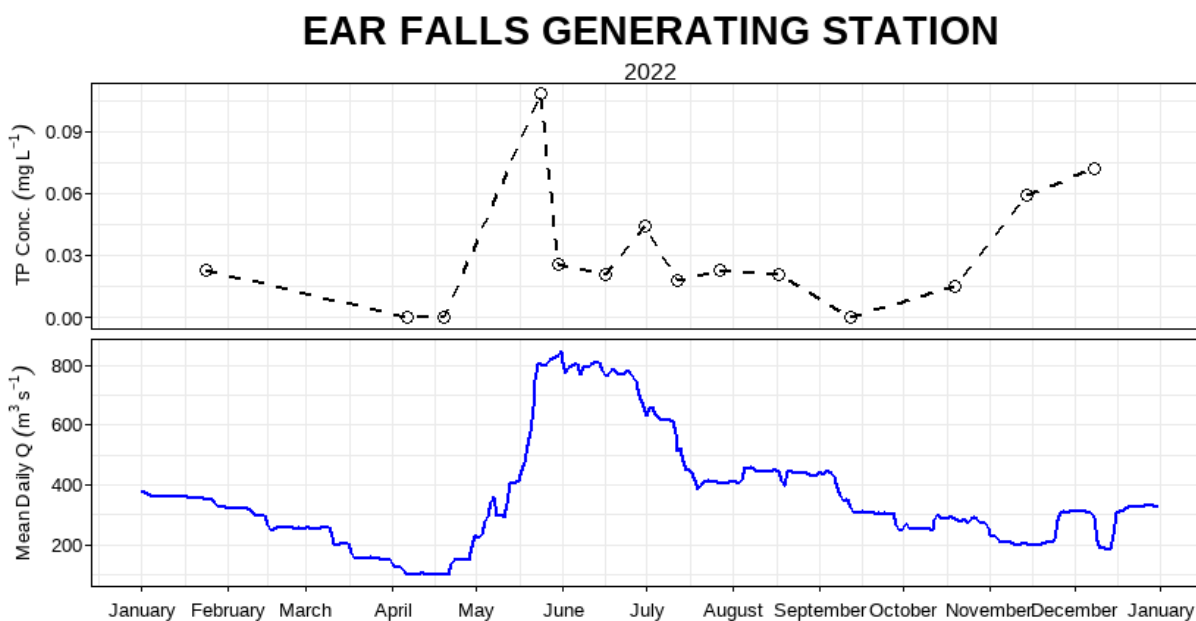


Figure 20: Mean daily discharge (m<sup>3</sup> s<sup>-1</sup>) and total phosphorus concentration (mg L<sup>-1</sup>) over the 2022 sampling season at Ear Falls Generating Station.

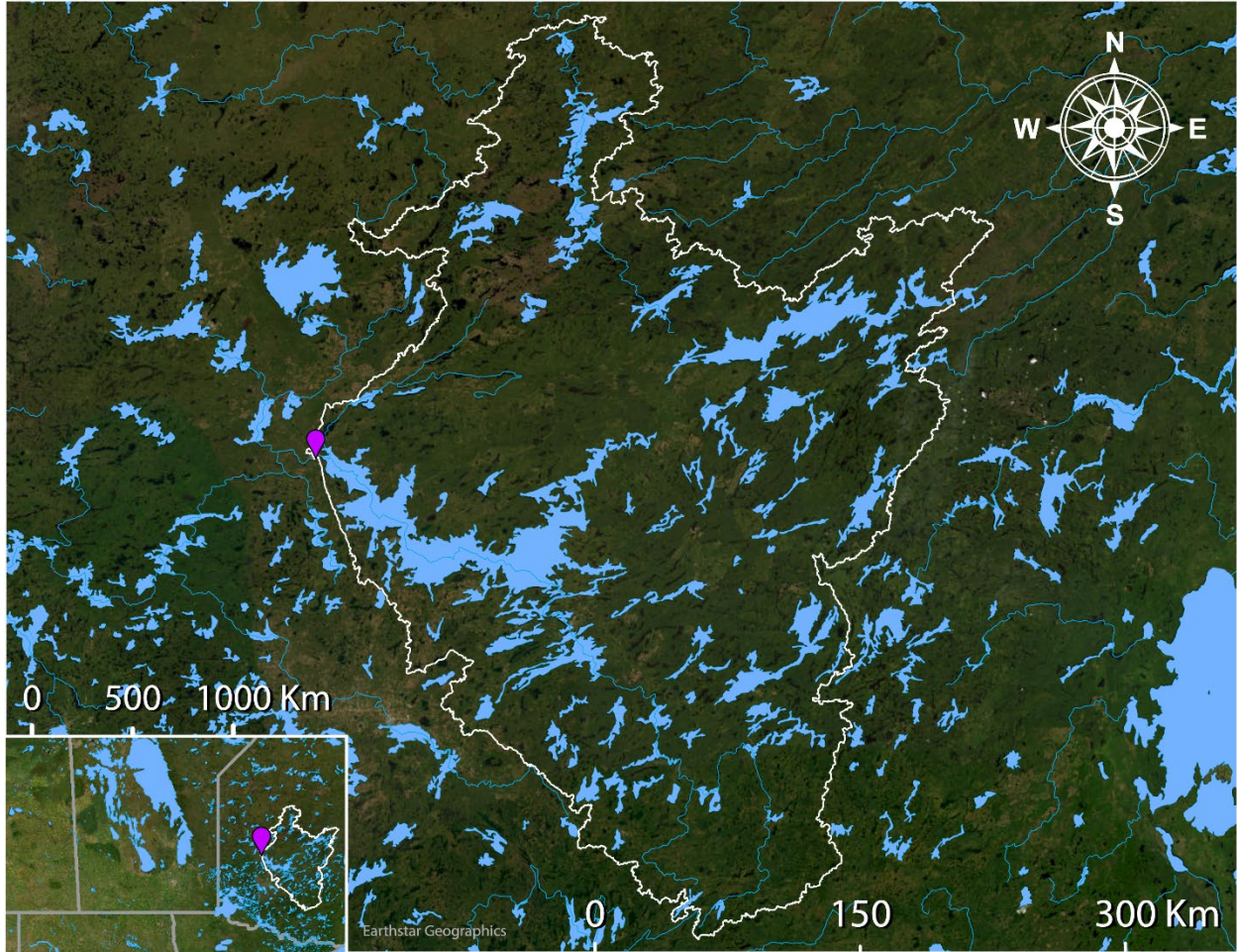


Figure 21: Ear Falls Generating Station sampling site (purple) and drainage area polygon (white - source: OPG).

# Manitou Falls Generating Station

Manitou Falls is a hydro-electric generating station powered by Ontario Power Generation Inc. (OPG). It is situated on the English River 120 km east of the Manitoba border, at the northeastern border of the West English River Provincial Park. The English River flows west through Caribou Falls and into the Winnipeg River and eventually enters Manitoba. Flow data was collected by OPG and provided to LWCBMN. The sampling effort provided adequate coverage to calculate TP loads and exports.

Table 12: Indices of discharge and phosphorus from the incremental drainage area of Manitou Falls Generating Station. See Supplemental Table 5 for gross calculations.

<b>Incremental drainage area:</b>	10092.08 km <sup>2</sup>
<b>Peak discharge</b>	1166.6 m <sup>3</sup> s <sup>-1</sup> (2022-06-02)
<b>Peak TP concentration</b>	0.083 mg/L (2022-06-02)
<b>% of water load in spring:</b>	22.37%
<b>% of TP load in spring:</b>	24.37%
<b><sup>1</sup>Incremental water load:</b>	4.26 km <sup>3</sup> y <sup>-1</sup>
<b><sup>1</sup>Incremental TP load:</b>	98.53 tonnes P y <sup>-1</sup>
<b><sup>2</sup>Incremental water export:</b>	422.15 mm y <sup>-1</sup>
<b><sup>2</sup>Incremental TP export:</b>	0.098 kg P ha <sup>-1</sup> y <sup>-1</sup>

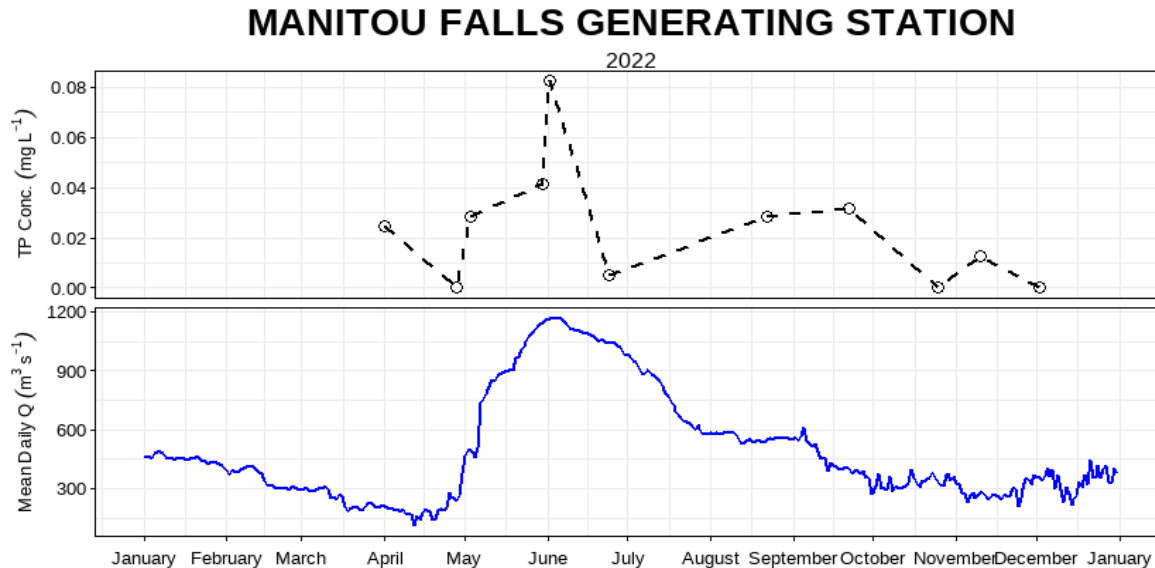


Figure 22: Mean daily discharge (m<sup>3</sup> s<sup>-1</sup>) and total phosphorus concentration (mg L<sup>-1</sup>) over the 2022 sampling season at Manitou Falls Generating Station.

<sup>1</sup> Incremental loads are calculated by subtracting gross “Ear Falls Generating Station” values from gross “Manitou Falls Generating Station” values.

<sup>2</sup> Incremental exports are calculated by dividing incremental loads by incremental drainage areas.

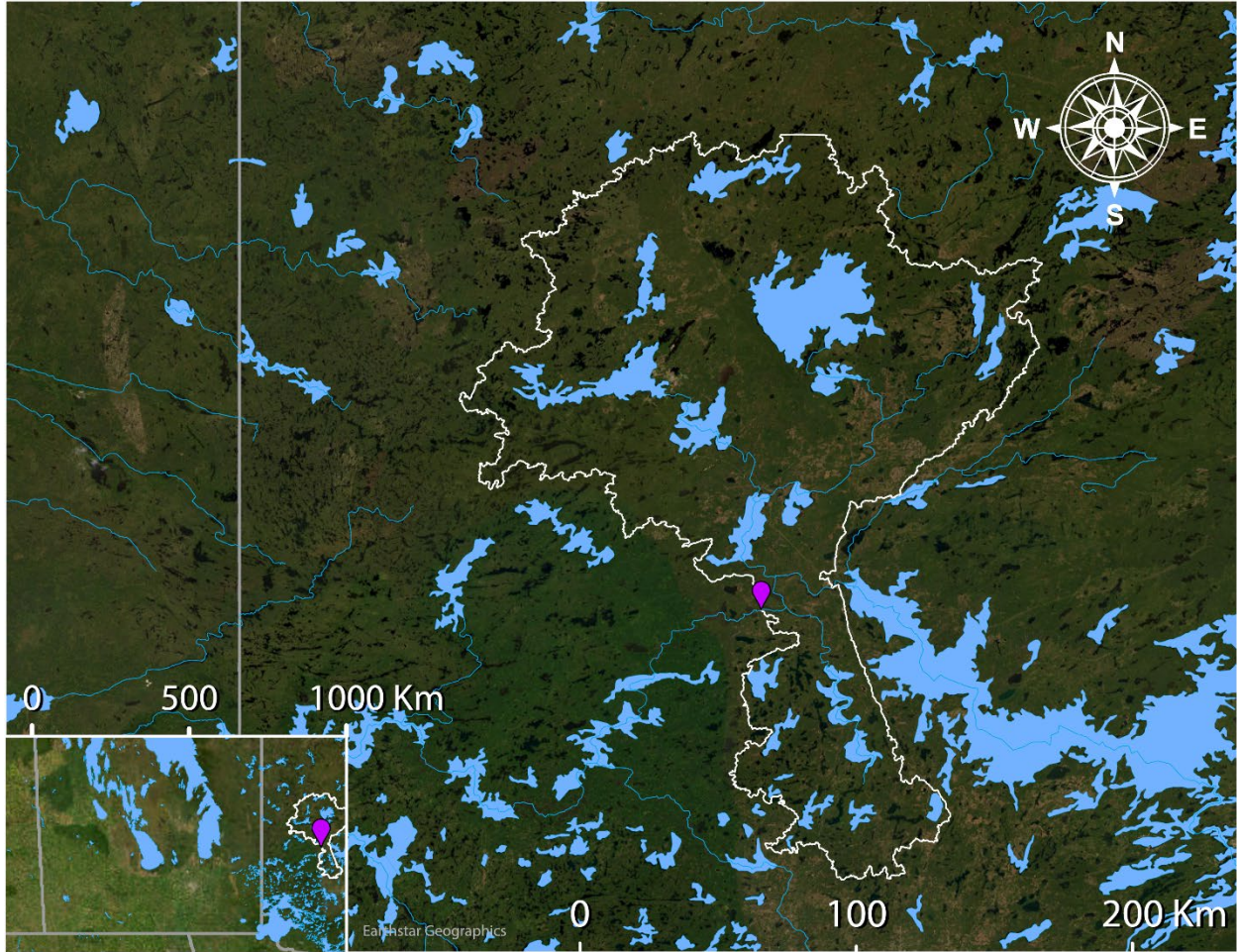


Figure 23: Manitou Falls Generating Station sampling site (purple), and incremental drainage area polygon (white - source: WSC). See Supplemental Figure 5 for upstream drainage areas used to calculate incremental area.

# Incremental Calculations

## Winnipeg River at Pine Falls Generating Station

Supplemental Table 1: Indices of discharge and phosphorus from the gross drainage area of Winnipeg River at Pine Falls Generating Station in 2022.

<b>Gross drainage area:</b>	151879.9 km <sup>2</sup>
<b>Water load:</b>	52.23 km <sup>3</sup> y <sup>-1</sup>
<b>TP load:</b>	2165.64 tonnes P y <sup>-1</sup>
<b>Water export:</b>	343.89 mm y <sup>-1</sup>
<b>TP export:</b>	0.14 kg P ha <sup>-1</sup> y <sup>-1</sup>

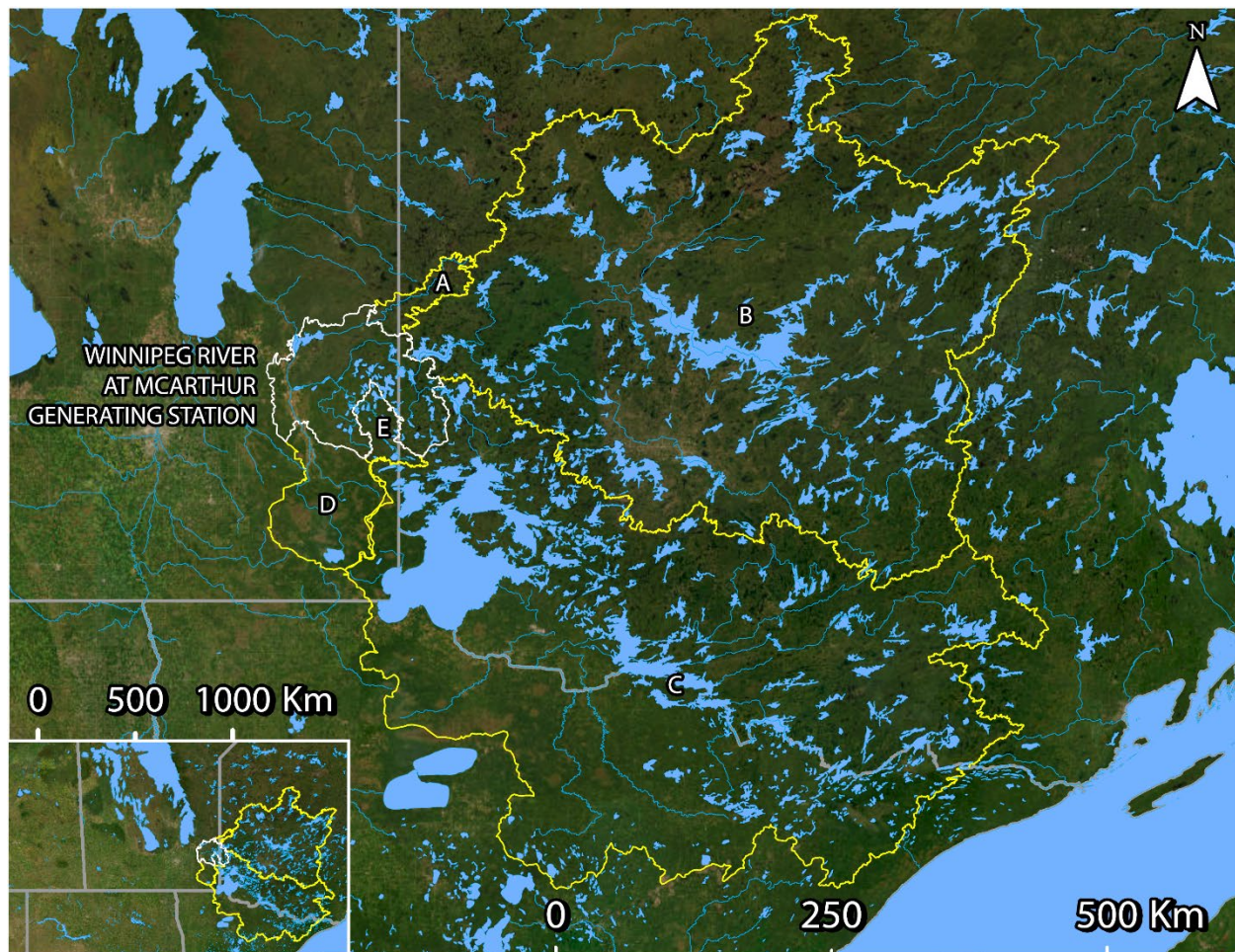


Supplemental Figure 1: Incremental drainage area in white and upstream drainage area in yellow. Incremental loads are calculated by subtracting gross “Winnipeg River at McArthur Generating Station” values from gross “Winnipeg River at Pine Falls Generating Station” values.

# Winnipeg River at McArthur Generating Station

Supplemental Table 2: Indices of discharge and phosphorus from the gross drainage area of Winnipeg River at McArthur Generating Station in 2022.

Gross drainage area:	150343.9 km <sup>2</sup>
Water load:	51.78 km <sup>3</sup> y <sup>-1</sup>
TP load:	2278.92 tonnes P y <sup>-1</sup>
Water export:	344.38 mm y <sup>-1</sup>
TP export:	0.15 kg P ha <sup>-1</sup> y <sup>-1</sup>



Supplemental Figure 2: Incremental drainage area in white and upstream drainage areas in yellow. Incremental loads are calculated by subtracting gross “Bird River outlet of Bird Lake” (A), “Caribou Falls” (B), “Whitedog Falls” (C), “Whitemouth River near Whitemouth” (D), and “Whiteshell River at outlet of Jessica Lake” (E) from “Winnipeg River at McArthur Generating Station” values.

# Whitemouth River near Whitemouth

Supplemental Table 3: Indices of discharge and phosphorus from the gross drainage area of Whitemouth River near Whitemouth (05PH003) in 2022.

<b>Gross drainage area:</b>	3739.61 km <sup>2</sup>
<b>Water load:</b>	0.82 km <sup>3</sup> y <sup>-1</sup>
<b>TP load:</b>	52.73 tonnes P y <sup>-1</sup>
<b>Water export:</b>	219.47 mm y <sup>-1</sup>
<b>TP export:</b>	0.14 kg P ha <sup>-1</sup> y <sup>-1</sup>

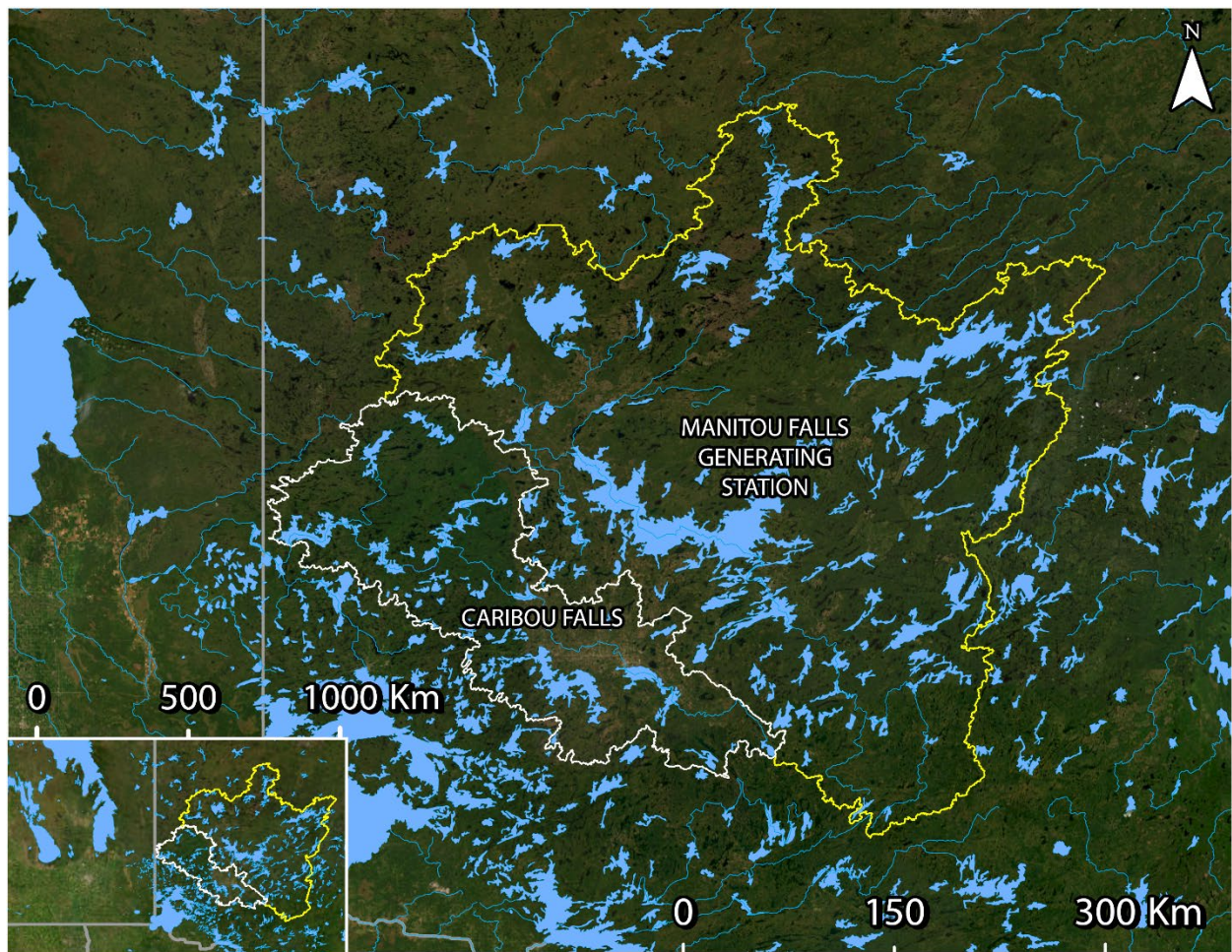


Supplemental Figure 3: Incremental drainage area in white and upstream drainage area in yellow. Incremental loads are calculated by subtracting gross “Birch River near Prawda” from “Whitemouth River near Whitemouth” values.

# Caribou Falls

Supplemental Table 4: Indices of discharge and phosphorus from the gross drainage area of Caribou Falls in 2022.

<b>Gross drainage area:</b>	67546 km <sup>2</sup>
<b>Water load:</b>	22.49 km <sup>3</sup> y <sup>-1</sup>
<b>TP load:</b>	234.45 tonnes P y <sup>-1</sup>
<b>Water export:</b>	332.91 mm y <sup>-1</sup>
<b>TP export:</b>	0.035 kg P ha <sup>-1</sup> y <sup>-1</sup>

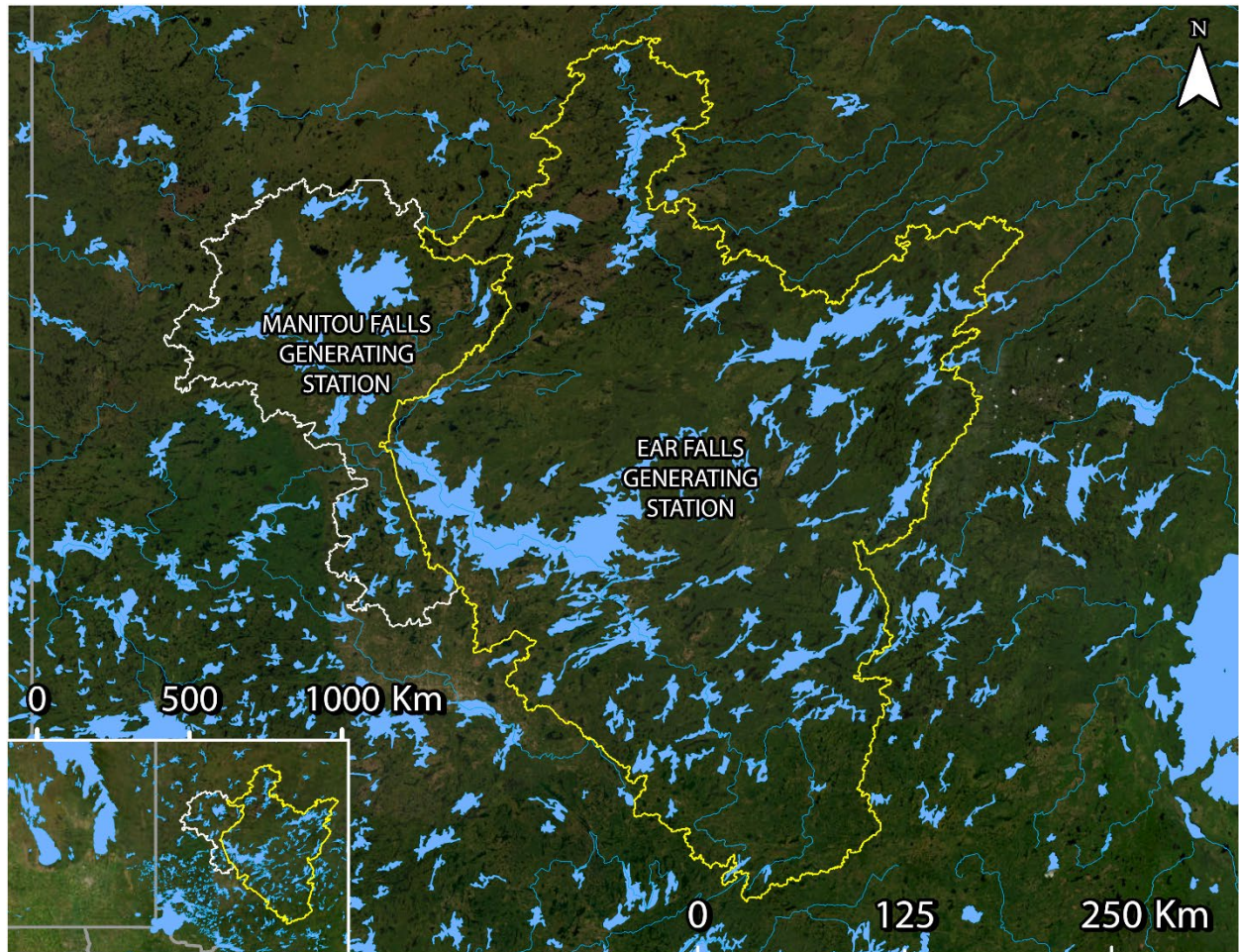


Supplemental Figure 4: Incremental drainage area in white and upstream drainage areas in yellow. Incremental loads are calculated by subtracting gross “Manitou Falls Generating Station” values from gross “Caribou Falls” values.

# Manitou Falls Generating Station

Supplemental Table 5: Indices of discharge and phosphorus from the combined gross drainage area and stream discharge of Manitou Falls Generating Station.

<b>Gross drainage area:</b>	51910 km <sup>2</sup>
<b>Water load:</b>	15.62 km <sup>3</sup> y <sup>-1</sup>
<b>TP load:</b>	451.80 tonnes P y <sup>-1</sup>
<b>Water export:</b>	300.84 mm y <sup>-1</sup>
<b>TP export:</b>	0.087 kg P ha <sup>-1</sup> y <sup>-1</sup>



Supplemental Figure 5: Incremental drainage area in white and upstream drainage areas in yellow. Incremental loads are calculated by subtracting gross “Ear Falls Generating Station” values from gross “Manitou Falls Generating Station” values.

# Map Sources

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## Drainage area polygons

Primarily, and whenever possible, drainage area polygons were taken from the Water Survey of Canada's (WSC) National Hydrometric Network Basin Polygons. Released on July 15, 2022, this prerelease version of the dataset contains drainage area polygons for over 7300 of the 7896 active and discontinued WSC stations. According to WSC, this dataset will continue to be updated as new polygons are added. For our analysis, we used drainage areas from this dataset.

Link: <https://catalogue.ec.gc.ca/geonetwork/srv/eng/catalog.search#/metadata/0c121878-ac23-46f5-95df-eb9960753375>

Secondarily, when no WSC drainage area polygons were available, or when it was necessary to enable accurate incremental calculations, we used drainage area polygons from the Total Gross Drainage Areas of the Agriculture and Agri-Food Canada (AAFC)'s Watersheds Project – 2013

Link: <https://open.canada.ca/data/en/dataset/67c8352d-d362-43dc-9255-21e2b0cf466c>

Due to the required use of drainage area polygons from two different datasets, some polygons may slightly overlap. Hotspot maps, as a result, have a few instances where a drainage area is visually cut off. However, most of these instances are very minor, and we display all watersheds in their full extent on each sampling site's individual section.

## Map layers

Satellite imagery used in all maps is from the World Imagery map layer (Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community). World Imagery provides one meter or better satellite and aerial imagery in many parts of the world and lower resolution satellite imagery worldwide.

Lake and river map data used in all maps is from North America Environmental Atlas (Lakes, Rivers). The North American Environmental Atlas – Lakes & Rivers datasets display area hydrographic features (Lakes: major lakes and reservoirs; Rivers: major rivers, streams, and canals) of North America at a reference spatial scale of 1:1,000,000. Credits: Commission for Environmental Cooperation (CEC). 2023. "North American Atlas – Lakes and Rivers". Natural Resources Canada (NRCan), Instituto Nacional de Estadística y Geografía (INEGI), Comisión Nacional del Agua (CONAGUA), U.S. Geological Survey (USGS). Ed. 3.0, Vector digital data [1:1,000,000].

The **Lake Winnipeg Community-Based Monitoring Network** (LWCBMN) is a collaborative, long-term phosphorus monitoring program designed to identify localized phosphorus hotspots where action is required to improve Lake Winnipeg water quality. LWCBMN mobilizes citizen volunteers and watershed partners to collect water samples across Manitoba, generating robust water-quality data that is useful to community practitioners, academic researchers, government scientists and policy-makers alike. Focusing research, resources and action in phosphorus hotspots is necessary to reduce phosphorus loading to Lake Winnipeg.

LWCBMN is delivered in partnership with Manitoba's watershed districts, LWF's science advisors, volunteer citizen scientists and Dr. Nora Casson's laboratory at the University of Winnipeg. Thank you to all who make this network possible!

The **Lake Winnipeg Foundation** (LWF) advocates for change and coordinates action to improve the health of Lake Winnipeg. Combining the commitment of our grassroots membership and the expertise of our science advisors, LWF is nationally recognized for our unique capacity to link science and action. Our goal is to ensure policy and practices informed by evidence are implemented and enforced.

### LWF proudly acknowledges the following funders

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**Lake Winnipeg Foundation**    

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