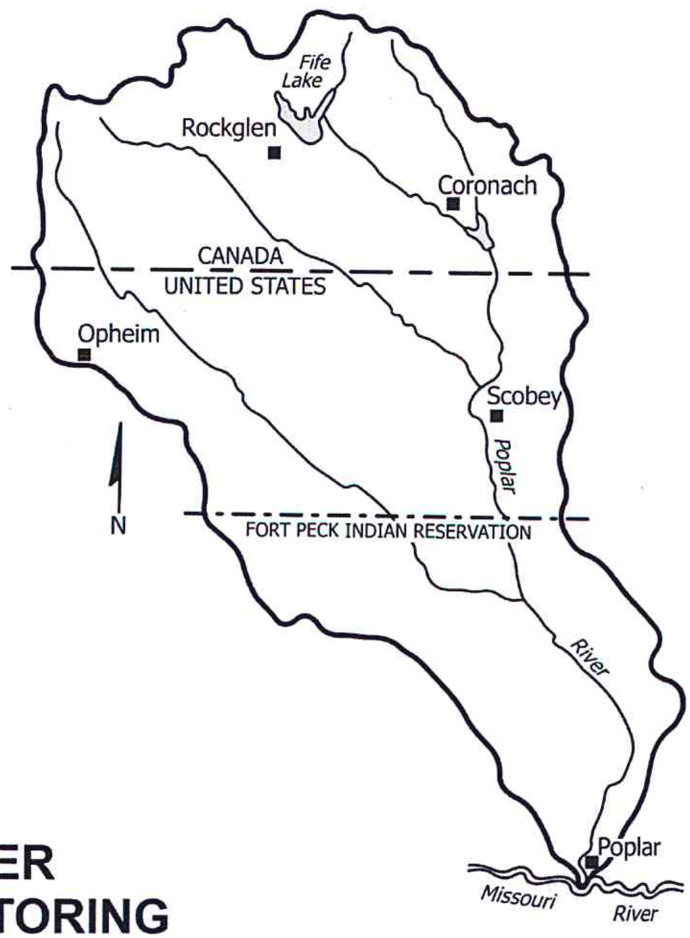
# 2017 ANNUAL REPORT

## to the

## GOVERNMENTS OF CANADA, UNITED STATES, SASKATCHEWAN AND MONTANA




by the

## POPLAR RIVER BILATERAL MONITORING COMMITTEE

**COVERING CALENDAR YEAR 2017**

**June 2018**

**Poplar River Bilateral Monitoring Committee**

Department of State
Washington, D.C., United States

Global Affairs Canada,
Ottawa, Ontario, Canada

Governor's Office
State of Montana
Helena, Montana, United States

Water Security Agency
Moose Jaw, Saskatchewan, Canada

Ladies and Gentlemen:

Herein is the 36th Annual Report of the Poplar River Bilateral Monitoring Committee. This report discusses the Committee activities of 2017 and presents the Technical Monitoring Schedules for the year 2018.

During 2017, the Poplar River Bilateral Monitoring Committee continued to fulfill the responsibilities assigned by the governments under the Poplar River Cooperative Monitoring Agreement dated September 23, 1980. Through exchange of Diplomatic Notes, the Arrangement was extended in March 1987, July 1992, July 1997, March 2002, April 2007, March 2012, and March 2017. The Monitoring Committee is currently extended to March 2022.

The enclosed report summarizes observed water-quality conditions and compares them to guidelines for specific parameter values that were developed by the International Joint Commission (IJC) under the 1977 Reference from Canada and the United States. After evaluation of the monitoring information for 2017, the Committee finds that the measured conditions meet the recommended objectives.

Based on the March 1 to May 31, 2016 runoff volume of 6,440 $dam^3$ (5,220 acre-feet) recorded at the Poplar River at International Boundary gauging station, Montana was entitled to an additional release of 617 $dam^3$ (500 acre-feet) from Cookson Reservoir during the succeeding twelve-month period commencing June 1, 2016. Montana requested this release to be made between May 1 and May 31, 2017. A volume of 623 $dam^3$ (505 acre-feet), in addition to the minimum flow, was delivered during this period.

During 2017, monitoring continued in accordance with Technical Monitoring Schedules outlined in the 2016 Annual Report of the Poplar River Bilateral Monitoring Committee.

Yours sincerely,

John M. Kilpatrick
Chairman, United States Section

Jan Langel
Member, United States Section

Mike Renouf
Chairman, Canadian Section

Kei Lo
Member, Canadian Section

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Poplar River Power Station was operated as base load plant supplying the maximum production except when system constraint and outages dictated otherwise. There was a scheduled maintenance outage for PR1 & PR2 in the spring so as not to coincide with system peak demand period that occur over the summer and winter periods.

Between January 1 and December 31, Poplar River Power Station generated 4,184,036 MW hours. During this time approximately 3,186,116 tonnes of coal and 3,268 $m^3$ of fuel oil were consumed. The average capacity factors for Unit No. 1 and Unit No. 2 were 76.6% and 75.1% respectively.

Monitoring information collected in both Canada and the United States during 2017 was exchanged in the spring of 2018.

The recorded volume of the Poplar River at International Boundary from March 1 to May 31, 2017 was 20,100 $dam^3$ (16,300 acre-feet). Based on IJC recommendations and the assumption that the recorded flow is the natural flow, the United States was entitled to a minimum discharge on the East Poplar River of 0.085 cubic metres per second ($m^3/s$) (3.0 cubic feet per second ($ft^3/s$) for the period June 1, 2017 to August 31, 2017, and 0.057 $m^3/s$ (2.0 $ft^3/s$) for the period September 1, 2017 to May 31, 2018. The minimum entitled flow for the period January 1 to May 31, 2017 was 0.057 $m^3/s$ (2.0 $ft^3/s$), determined on the basis of the Poplar River flow volume for March 1 to May 31, 2016.

Daily flows during 2017 met or exceeded the minimum flow recommended by the IJC during the year except for several periods during June 4-5, 8-17, 19-21, 25-30, July 1-31, and August 1-31.

In addition to the minimum flow, the IJC apportionment recommendation entitles Montana to an on-demand release to be delivered in the East Poplar River during the twelve-month period commencing June 1. Based on the March 1 to May 31, 2016 runoff volume of 6,440 $dam^3$ (5,220 acre-feet) recorded at the Poplar River at International Boundary gauging station, Montana was entitled to an additional release of 617 $dam^3$ (500 acre-feet) from Cookson Reservoir during the succeeding twelve-month period commencing June 1, 2016. Montana requested this release to be made between May 1 and May 31, 2017. A volume of 545 $dam^3$ (442 acre-feet), in addition to the minimum flow, was delivered during this period.

The 2017 five-year estimated flow-weighted TDS concentrations were below the long-term objective of 1,000 milligrams per litre (mg/L). The maximum monthly five-year estimated flow-weighted concentration value in 2017 was about 760 mg/L. The 2017 five-year estimated flow-weighted boron concentrations remained well below the long-term objective of 2.5 mg/L.

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## 1.0 INTRODUCTION

The Poplar River Bilateral Monitoring Committee was authorized for an initial period of five years by the Governments of Canada and the United States under the Poplar River Cooperative Monitoring Arrangement dated September 23, 1980. A copy of the Arrangement is attached to this report as Annex 1. Through exchange of Diplomatic Notes, the Arrangement was extended in March 1987, July 1992, July 1997, March 2002, April 2007, March 2012, and April 2017. The Monitoring Committee is currently extended to March 2022. A more detailed account of the historical background of the Monitoring Arrangement is contained in the 1990 Annual Report of the Poplar River Bilateral Monitoring Committee.

The Committee oversees monitoring programs designed to evaluate the potential for transboundary impacts from SaskPower's (formerly Saskatchewan Power Corporation) coal-fired thermal generating station and ancillary operations near Coronach, Saskatchewan. Monitoring is conducted in Canada and the United States at or near the International Boundary for quantity and quality of surface and ground water and for air quality. Participants from both countries, including Federal, State and Provincial agencies, are involved in monitoring.

The Committee submits an annual report to Governments which summarizes the monitoring results, evaluates apparent trends, and compares the data to objectives or standards recommended by the International Joint Commission (IJC) to Governments, or relevant State, Provincial, or Federal standards. The Committee reports to Governments on a calendar year basis. The Committee is also responsible for drawing to the attention of Governments definitive changes in monitored parameters which may require immediate attention.

A responsibility of the Committee is to review the adequacy of the monitoring programs in both countries and make recommendations to Governments on the Technical Monitoring Schedules. The Schedules are updated annually for new and discontinued programs and for modifications in sampling frequencies, parameter lists, and analytical techniques of ongoing programs. The Technical Monitoring Schedules listed in the annual report (Annex 2) are given for the year 2017. The Committee will continue to review and propose changes to the Technical Monitoring Schedules as information requirements change.

## 2.0 COMMITTEE ACTIVITIES

### 2.1 Membership

The Committee is composed of representatives of the Governments of the United States of America and Canada, the State Government of Montana, and the Provincial Government of Saskatchewan. In addition to the representatives of Governments, two ex-officio members serve as local representatives for the State of Montana and Province of Saskatchewan.

During 2017, the members of the Committee included: Mr. J. Kilpatrick, U.S. Geological Survey, United States representative and Co-chair; Mr. M. Renouf, Environment and Climate Change Canada, Canadian representative and Co-chair; Mr. T. Davis, Montana Department of Natural Resources and Conservation, Montana representative; Mr. K. Lo, Saskatchewan Water Security Agency, Saskatchewan representative; and Mr. D. Kirby, Reeve R.M., of Hart Butte, Saskatchewan local ex-officio representative; and Mr. L. Humbert, Daniels County Commissioner of Scobey, Montana local ex-officio representative.

### 2.2 Meetings

The Committee met via a conference call on June 15, 2017. Delegated representatives of Governments, with the exception of the ex-officio member from Saskatchewan, participated in the meeting. In addition to Committee members, several technical advisors representing Federal, State, and Provincial agencies also participated. Committee members reviewed the operational status of the Poplar River Power Station and associated coal-mining activities; examined data collected in 2016 including surface-water quality and quantity, ground-water quality and quantity, and air quality; discussed proposed changes in the water-quality sampling program; and established the Technical Monitoring Schedules for the year 2018.

## 2.3 Review of Water-Quality Objectives

The International Joint Commission in its Report to Governments, titled "Water Quality in the Poplar River Basin," recommended that the Committee periodically review the water-quality objectives within the overall Basin context and recommend new and revised objectives as appropriate. In 1991, an action item from the annual Committee meeting set in motion the review and revision of the water-quality objectives.

In 1993, the Committee approved changes in water-quality objectives recommended by the subcommittee that was formed in 1992 to review the objectives. The Committee also discussed the water-quality objectives for 5-year and 3-month flow-weighted concentrations for total dissolved solids and boron. Although the Committee agreed that calculation procedures to determine flow-weighted concentrations are time consuming and probably scientifically questionable, no consensus was reached on alternative objectives or procedures.

In 1997, the Committee agreed to suspend the monitoring and reporting of several parameters. The parameters affected were: dissolved aluminum, un-ionized ammonia, total chromium, dissolved copper, mercury in fish tissues, fecal coliform, and total coliform. The Committee also agreed to other minor revisions for clarification purposes; for example, changing the designation for pH from "natural" to "ambient".

In 1999, the Committee replaced the term "discontinued" with "suspended" in Table 2.1.

In 2001, the Committee suspended the monitoring of dissolved mercury and total copper. This decision was based on data indicating concentrations or levels well below or within the objectives. Current objectives approved by the Committee are listed in Table 2.1.

The Committee also agreed to periodically review all parameters for which monitoring has been suspended.

Another responsibility of the Committee has included an ongoing exchange of data acquired through the monitoring programs. Exchanged data and reports are available for public viewing at the agencies of the participating governments or from Committee members.

## 2.4 Data Exchange

The Committee is responsible for assuring exchange of data between governments. The exchange of monitoring information was initiated in the first quarter of 1981 and was an expansion of the informal quarterly exchange program initiated between the United States and Canada in 1976. Until 1991, data were exchanged quarterly. At the request of the Committee, the United States and Canada agreed to replace the quarterly exchange of data with an annual exchange effective at the beginning of the 1992 calendar year. Henceforth, data will be exchanged once each year as soon after the end of the calendar year as possible. However, unusual conditions or anomalous data will be reported and exchanged whenever warranted. No unusual conditions occurred during 2017 which warranted special reporting.

## 2.5 Water-Quality Monitoring Responsibilities

The United States Geological Survey has agreed to take responsibility for repairing the continuous water-quality monitor installed at the East Poplar station at the International Boundary. The continuous water-quality monitor records daily specific conductance values which are used in the computation of TDS and boron values to monitor water quality in the East Poplar River. In the absence of regular monthly water-quality samples, the Committee has agreed to utilize the data collected by the continuous water-quality monitor for its surface-water-quality monitoring program.

## Table 2.1 Water-Quality Objectives

| Parameter | Original Objective | Recommendation | Current Objective |
|---|---|---|---|
| Boron, total | 3.5/2.5[3] | Continue as is | 3.5/2.5[1] |
| TDS[1] | 1,500/1,000[3] | Continue as is | 1,500/1,000[1] |
| Aluminum, dissolved | 0.1 | Suspended* | --- |
| Ammonia, un-ionized | 0.02 | Suspended* | --- |
| Cadmium, total | 0.0012 | Continue as is | 0.0012 |
| Chromium, total | 0.05 | Suspended* | --- |
| Copper, dissolved | 0.005 | Suspended* | --- |
| Copper, total | 1 | Suspended* | --- |
| Fluoride, dissolved | 1.5 | Continue as is | 1.5 |
| Lead, total | 0.03 | Continue as is | 0.03 |
| Mercury, dissolved | 0.0002 | Suspended* | --- |
| Mercury, fish (mg/kg) | 0.5 | Suspended* | --- |
| Nitrate, dissolved (as N) | 10 | Continue as is | 10 |
| Oxygen, dissolved | 4.0/5.0[4] | Objective applies only during open water | 4.0/5.0[2] |
| SAR[2] (units) | 10 | Continue as is | 10 |
| Sulfate, dissolved | 800 | Continue as is | 800 |
| Zinc, total | 0.03 | Continue as is | 0.03 |
| Water temperature (C) | 30.0[5] | Continue as is | 30.0[3] |
| pH (units) | 6.5[6] | Continue as is | 6.5[4] |
| Coliform (no./100 mL) | | | |
| Fecal | 2,000 | Suspended* | --- |
| Total | 20,000 | Suspended* | --- |

Units in mg/L except as noted.

1. Total Dissolved Solids.
2. Sodium Adsorption Ratio.
3. Five-year average of flow-weighted concentrations (March to October) should be <2.5 boron, <1,000 TDS. Three-month average of flow-weighted concentration should be <3.5 boron and <1,500 TDS.
4. 5.0 (minimum April 10 to May 15), 4.0 (minimum remainder of year - Fish Spawning).
5. Natural temperature (April 10 to May 15), <30 degree Celsius (remainder of year).
6. Less than 0.5 pH units above ambient, minimum pH=6.5.

*Suspended after review of historic data found sample concentrations consistently below the objective. The Committee will periodically review status of suspended objectives.

## 3.0 WATER AND AIR: MONITORING AND INTERPRETATIONS

### 3.1 Poplar River Power Station Operation

Saskatchewan Power Corporation operates the Poplar River Power Station near the town on Coronach, Saskatchewan. The Poplar River Power Station is comprised of two lignite-burning power generating units designated Unit No. 1 and Unit No. 2. Unit No. 1 is rated as a 315 MW generating unit and Unit No. 2 is rated as a 315 MW generating unit. Both units share a common 122 meter stack.

In 2017 both units were operated as base load units supplying the maximum production except when system constraint and outages dictated otherwise. There was a scheduled maintenance outage for PR1 & PR2 in the spring so as not to coincide with system peak demand period that occur over the summer and winter periods.

Poplar River has changed the scheduling of Unit No. 1 and Unit No. 2 outages. In the past, the spring/fall outages have consisted of a three week outage on one unit and a one-week outage on the other. Starting in 2014, we have moved to a four-week outage on one unit, approximately every 18 months.

Between January 1 and December 31, 2017 Poplar River Power Station generated 4,184,036 MW hours. During this time approximately 3,186,116 tonnes of coal and 3,268 $m^3$ of fuel oil were consumed. The average capacity factors for Unit No. 1 and Unit No. 2 were 76.6% and 75.1% respectively.

### 3.2 Surface Water

#### 3.2.1 Streamflow

Streamflow in the Poplar River basin was above normal in 2017. The March to October recorded flow of the Poplar River at International Boundary, an indicator of natural flow in the basin, was 20,530 cubic decameters ($dam^3$) (16,640 acre-feet), which was 200 percent of the 1931-2016 median seasonal flow of 10,290 $dam^3$ (8,340 acre-feet). A comparison of 2017 monthly mean discharge with the 1931-2016 median monthly mean discharge is shown in Figure 3.1.

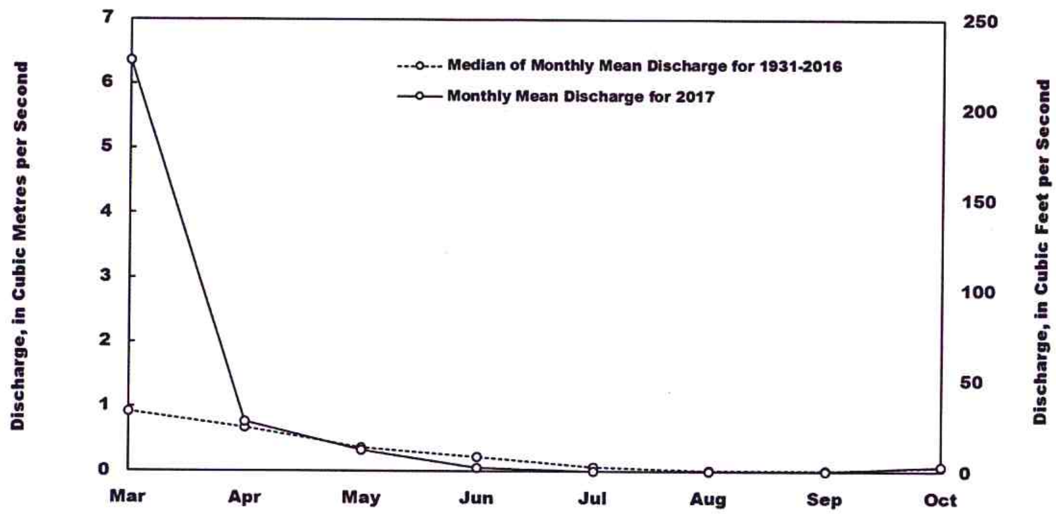



**Figure 3.1 Monthly Mean Discharge During 2017 as Compared with the Median Monthly Mean Discharge from 1931-2016 for the Poplar River at International Boundary.**

The 2017 recorded flow volume of the East Poplar River at International Boundary was 3,130 $dam^3$ (2,540 acre-feet). This volume is 105 percent of the median annual flow of 2,980 $dam^3$ (2,420 acre-feet) for 1976-2016 (since the completion of Morrison Dam).

### 3.2.2 Apportionment

In 1976 the International Souris-Red Rivers Engineering Board, through its Poplar River Task Force, completed an investigation and made a recommendation to the Governments of Canada and the United States regarding the apportionment of waters of the Poplar River basin. Although the recommendations have not been officially adopted, the Province of Saskatchewan has adhered to the apportionment recommendations. Annex 3 contains the apportionment recommendation.

### 3.2.3 Minimum Flows

The recorded volume of the Poplar River at International Boundary from March 1 to May 31, 2017 was 20,100 $dam^3$ (16,300 acre-feet). Based on IJC recommendations and the assumption that the recorded flow is the natural flow, the United States was entitled to a minimum discharge on the East Poplar River of 0.085 cubic metres per second ($m^3/s$) (3.0 cubic feet per second ($ft^3/s$) for the period June 1, 2017 to August 31, 2017, and 0.057 $m^3/s$ (2.0 $ft^3/s$) for the period September 1, 2017 to May 31, 2018. The minimum entitled flow for the period January 1 to May 31, 2017 was 0.028 $m^3/s$ (1.0 $ft^3/s$), determined on the basis of the Poplar River flow volume for March 1 to May 31, 2016. A hydrograph for the East Poplar River at International Boundary and the minimum flow as recommended by the IJC are shown in Figure 3.2.

Daily flows during 2017 met or exceeded the minimum flow recommended by the IJC during the year except for several periods during June 4-5, 8-17, 19-21, 25-30, July 1-31, and August 1-31.

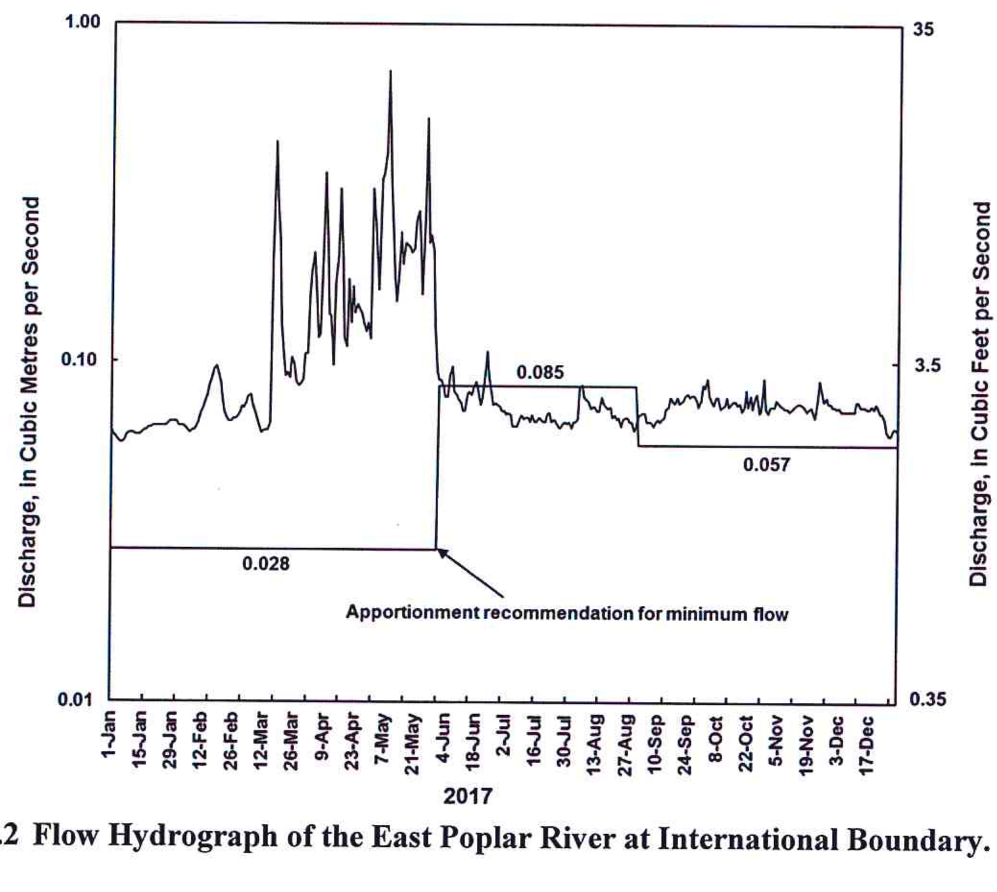



**Figure 3.2 Flow Hydrograph of the East Poplar River at International Boundary.**

### 3.2.4 On-Demand Release

Based on the March 1 to May 31, 2016 runoff volume of 6,440 dam³ (5,220 acre-feet) recorded at the Poplar River at International Boundary gauging station, Montana was entitled to an additional release of 617 dam³ (500 acre-feet) from Cookson Reservoir during the succeeding twelve-month period commencing June 1, 2016. Montana requested this release to be made between May 1 and May 31, 2017. A volume of 545 dam³ (442 acre-feet), in addition to the minimum flow, was delivered during this period. A hydrograph showing cumulative volume of the on-demand release request and on-demand release delivery made at the East Poplar River at International Boundary is shown in Figure 3.3.

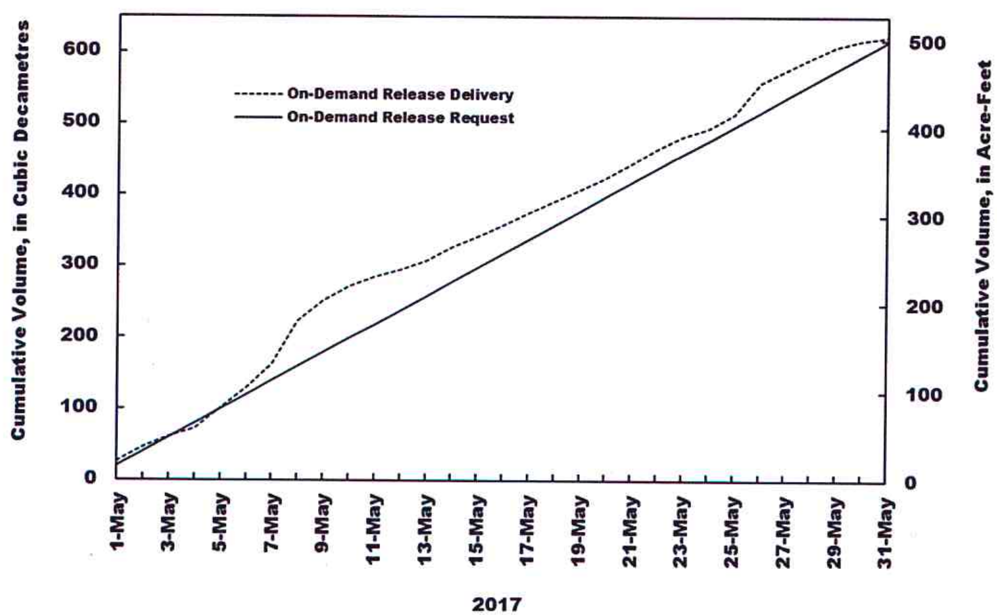



**Figure 3.3 Cumulative Volume Hydrograph of On-Demand Release.**

### 3.2.5 Surface-Water Quality

The 1981 report by the IJC to Governments recommended:

*For the March to October period, the maximum flow-weighted concentrations should not exceed 3.5 milligrams per litre (mg/L) for boron and 1,500 mg/L for TDS for any three consecutive months in the East Poplar River at the International Boundary. For the March to October period, the long-term average of flow-weighted concentrations should be 2.5 mg/L or less for boron, and 1,000 mg/L or less for TDS in the East Poplar River at the International Boundary.*

For the period prior to 1982, the three-month moving flow-weighted concentration (FWC) for boron and total dissolved solids (TDS) was calculated solely from monthly water-quality monitoring results.

Since the beginning of 1982, the USGS has monitored specific conductance daily in the East Poplar River at the International Boundary, making it possible to estimate boron and TDS concentrations using a linear regression relationship with specific conductance. Thus, the three-month FWC for boron and TDS for the period 1982 to 2002 was calculated from the results of monthly monitoring (discrete water-quality samples collected by both Canada and the United States) or from estimated monthly water-quality data based upon daily specific conductance data collected by the USGS during months when a discrete water-quality sample was not available.

In 2003, the Poplar River Bilateral Monitoring Committee decided to suspend much of the water-quality sampling program until it is warranted again. All surface-water-quality sample collection by Environment Canada has been suspended at the East Poplar River boundary station. After the monthly discrete sampling program was suspended in 2003, the USGS continued to collect four discrete samples per year until 2010, when due to a lack of funding no samples were obtained.

Since 2003, the Committee has agreed to use the continuous data collected by the specific-conductance monitor as a surrogate for the monthly water-quality sampling program. Hence, the three-month FWC for TDS and boron in 2017 were calculated using the two equations (shown later in text) and the continuous specific-conductance data collected at the East Poplar River at the International Boundary.

The Bilateral Monitoring Committee adopted the approach that, for the purpose of comparison with the proposed IJC long-term objectives, the boron and TDS data are best plotted as a five-year moving FWC which is advanced one month at a time.

Prior to 1988, long-term averages were calculated for a five-year period in which 2.5 years preceded and 2.5 years followed each plotted point. Beginning in 1988, the FWC was calculated from the 5-year period preceding each plotted point. For example, the FWC for December 2017 is calculated from data generated over the period December 2013 to December 2017. The calculations are based on the results of samples collected throughout the year, and are not restricted to only those collected during the months bracketing the period of irrigation (March to October) each year.

#### 3.2.5.1 Total Dissolved Solids

TDS is inversely related to streamflow at the East Poplar River at the International Boundary station. During periods of high runoff such as spring freshet, TDS decreases as the proportion of streamflow contributed by ground water decreases. Conversely, during times of low streamflow (late summer, winter) the contribution of ground water to streamflow is proportionally greater. Because the ground water entering the river has a higher ionic strength than the surface water, the TDS of the stream increases markedly during low-flow conditions.

The March to October estimated monthly TDS concentrations during 2017 for East Poplar River at the International Boundary are shown in Figure 3.4. The estimated monthly TDS concentrations during this period ranged from 695 mg/L (March) to 951 mg/L (April). Estimated daily TDS concentrations during the 2017 calendar year ranged from 300 mg/L (March 17) to 1,214 mg/L (December 28).

The three-month moving FWC for TDS for the period of 1998-2017 is presented in Figure 3.5. The short-term TDS objective has not been exceeded during the period of record.

The five-year moving estimated FWC for TDS (Figure 3.6) did not exceed the long-term objective of 1,000 mg/L in 2017. The maximum monthly five-year estimated FWC in 2017 was about 760 mg/L, down significantly from values prior to May 2012.

The daily TDS values, as estimated by linear regression from the daily specific-conductance readings, for the period January 1998 through December 2017 are shown in Figure 3.7. The figure shows an abrupt drop in estimated TDS corresponding to the snowmelt runoff occurring during the spring of each year.

The relationship between TDS and specific conductance based upon data collected during the March to October period from 1974 to 2009 is as follows:

$$\mathbf{TDS = (0.6205645 \times specific\ conductance) + 34.843914}$$
$$\mathbf{(R^2 = 0.89,\ n = 363)}$$

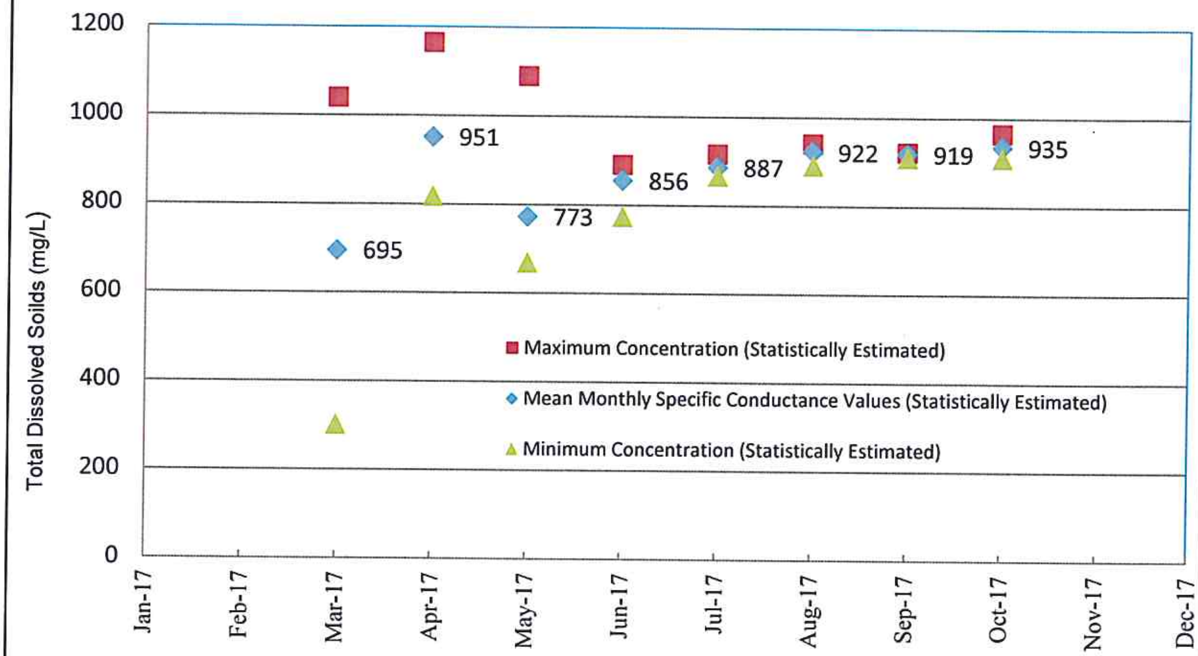



Figure 3.4: Estimated March to October Monthly TDS Concentrations During 2017 for East Poplar River at International Boundary

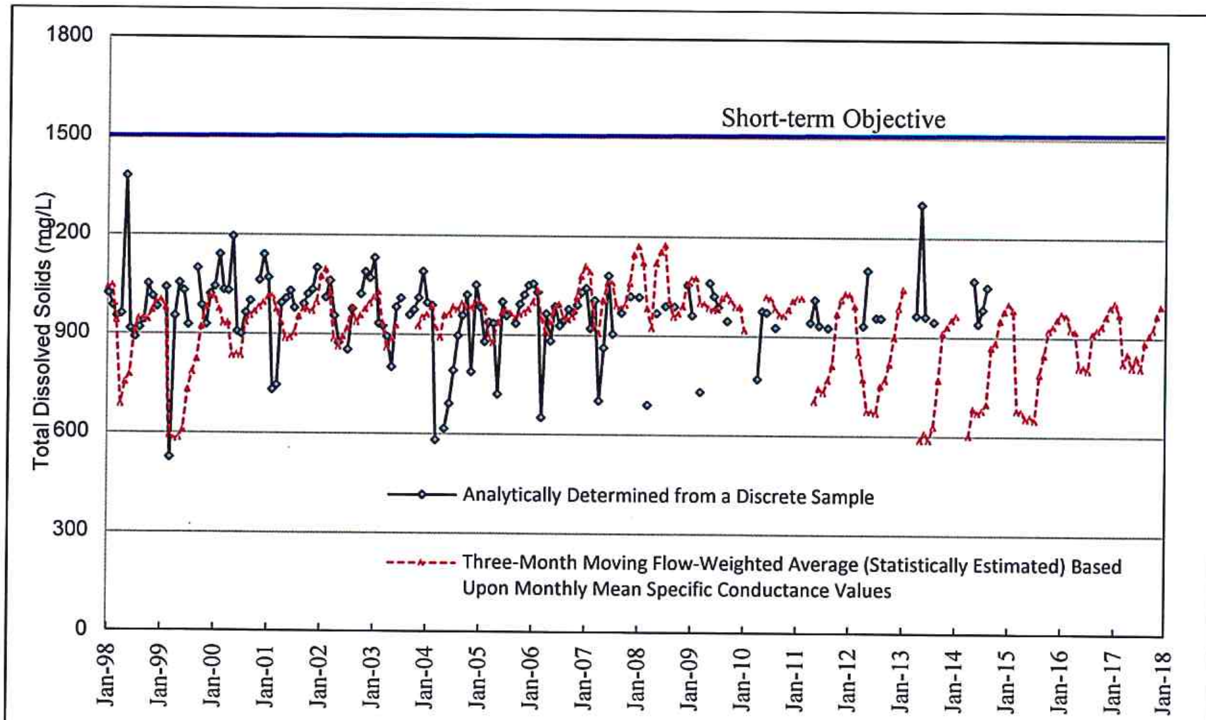



Figure 3.5: Discrete Sample and Three-Month Moving Flow-Weighted Average Estimated TDS Concentrations for East Poplar River at the International Boundary

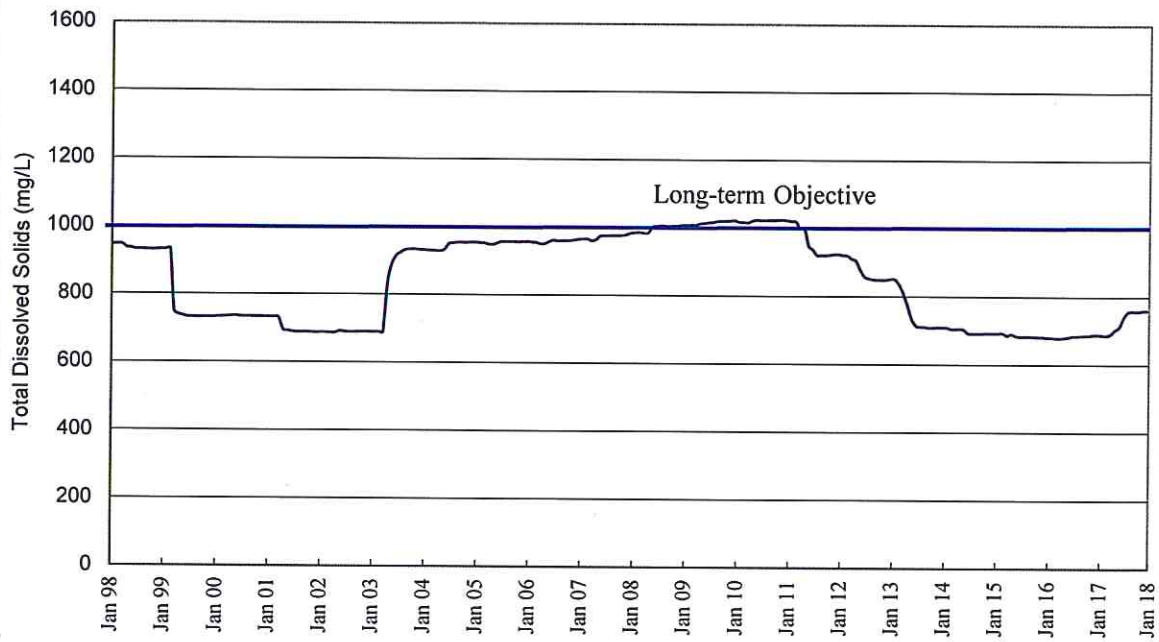



Figure 3.6: Five-Year Moving Flow-Weighted Average Estimated TDS Concentration for East Poplar River at the International Boundary

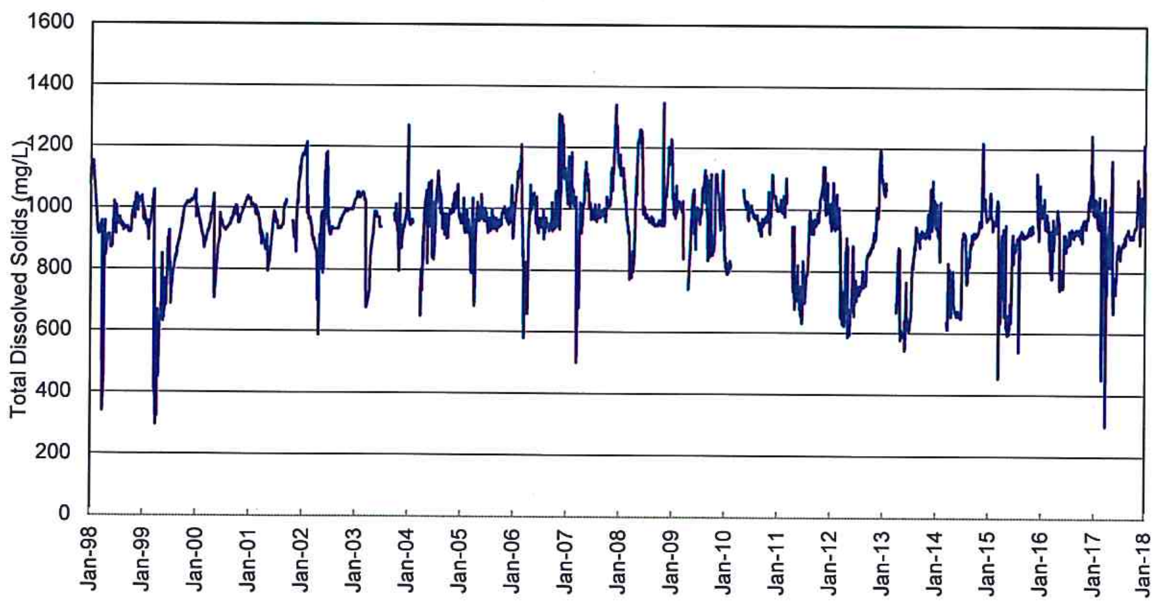



Figure 3.7: Daily TDS Concentration (Statistically Estimated), Calendar Years 1998 to 2017 for East Poplar River at the International Boundary

#### 3.2.5.2 Boron

All the boron concentrations presented below were estimated using the boron equation that was developed from water-quality samples collected during the months March through October from 1974-2009 and the daily specific conductance data collected by the specific-conductance monitor.

The March to October estimated monthly boron concentrations during 2017 for East Poplar River at the International Boundary are shown in Figure 3.8. The estimated mean-monthly boron concentrations during this period ranged from 0.49 mg/L (March) to 2.31 mg/L (April). Estimated daily boron concentrations during the 2017 calendar year ranged from 0.49 mg/L (March 17) to 2.42 mg/L (December 28).

The 3-month flow-weighted concentration (FWC) for boron for the period of 2000-2017 is shown in Figure 3.9. The short-term objective of 3.5 mg/L has not been exceeded during the period of record.

The 5-year moving FWC for boron (Figure 3.10) remained well below the long-term objective of 2.5 mg/L during 2016.

Boron concentrations are not as well-correlated with specific conductance as TDS. Boron is a relatively minor ion, and does not in itself contribute to a large degree to the total load of dissolved constituents in the water. Accordingly, it appears likely that the standard deviation of dissolved boron (relative to the long-term mean boron concentration) may be greater than that of the major cations (sodium, potassium, and magnesium) and anions (sulphate, bicarbonate, and chloride) around their respective long-term mean concentrations.

The daily boron values, as estimated by linear regression from the daily specific-conductance readings, for the period January 1997 through December 2017 are shown in Figure 3.11.

The relationship between boron and specific conductance based upon March to October data collected from 1974 to 2009 is as follows:

$$\textbf{Boron} = (0.0013081 \times \textbf{specific conductance}) - 0.0677588$$
$$(R^2 = 0.66, n = 363)$$

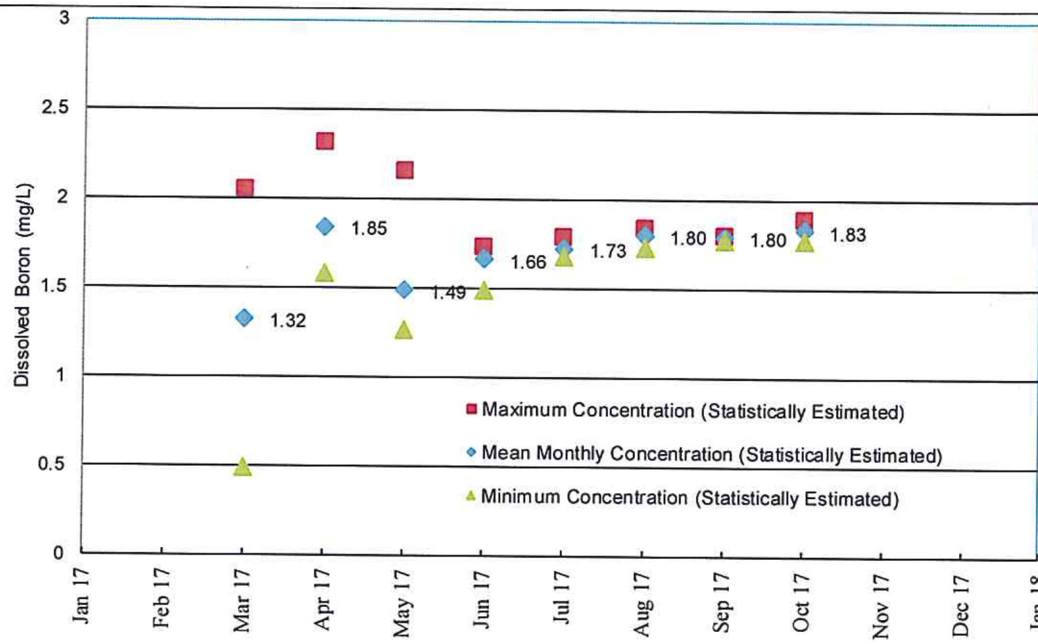



Figure 3.8: Estimated March to October Monthly Boron Concentrations During 2017 for East Poplar River at the International Boundary

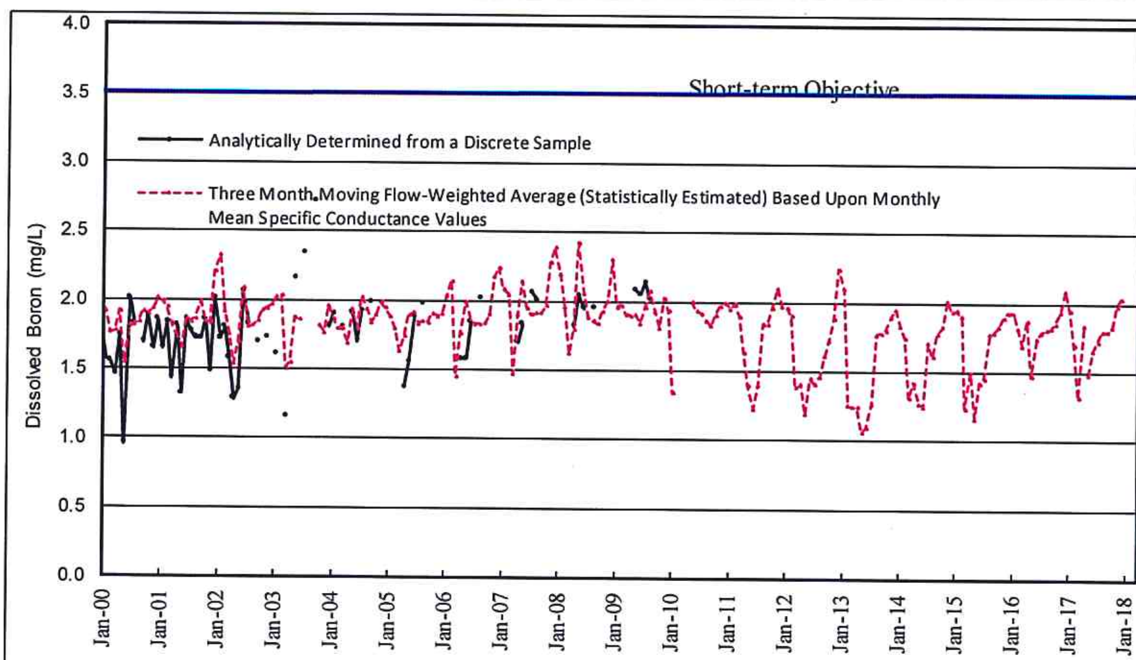



Figure 3.9: Discrete Sample and Three-Month Moving Flow-Weighted Average Estimated Boron Concentrations for East Poplar River at the International Boundary

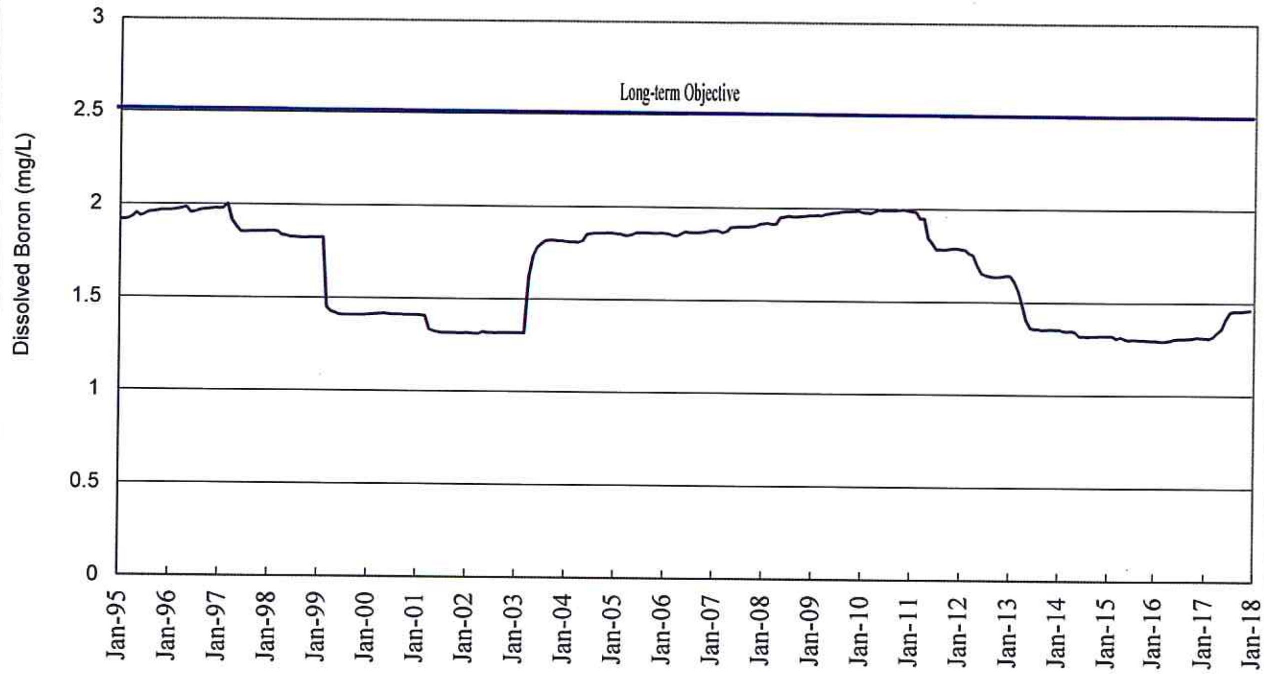



Figure 3.10: Five-Year Moving Flow-Weighted Average Estimated Boron Concentrationfor East Poplar River at the International Boundary (Statistically Estimated)

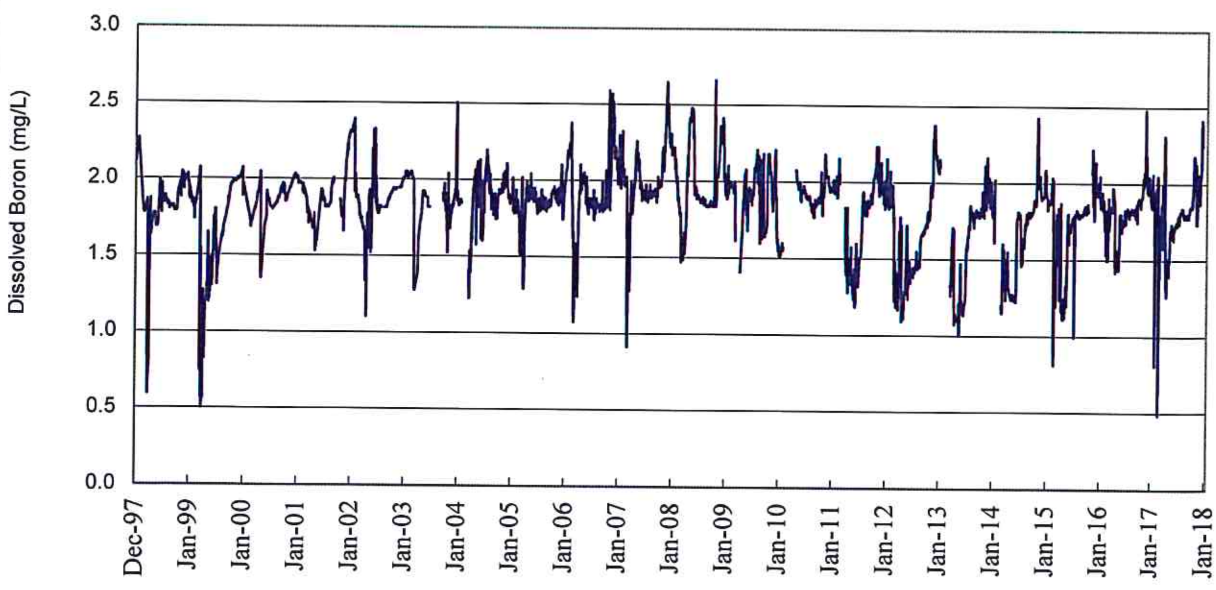



Figure 3.11: Daily Boron Concentration (Statistically Estimated), Calendar Years 1997 - 2017, for East Poplar River at the International Boundary

### 3.2.5.3 Other Water-Quality Objectives

Table 3.1 contains the multipurpose water-quality objectives for the East Poplar River at International Boundary, recommended by the International Poplar River Water Quality Board in 1979 to the IJC. Please note that no samples were obtained during the 2017 season so the number of samples collected for each parameter and excursions from the recommended objectives are shown as not applicable (N/A) in the table.

For years when samples are obtained, the table shows the number of samples collected for each parameter and the number of times over the course of the year that the objectives were exceeded. Multiple replicate samples collected during the annual quality control exercise are treated as a single sample in the table, but where an objective was exceeded in a replicate sample, this is charged against the single sample noted.

**Table 3.1 Recommended Water-Quality Objectives and Excursions, 2017 Sampling Program, East Poplar River at International Boundary (units in mg/L, except as otherwise noted)**

| Parameter | Objective | No. of Samples | | Excursions |
|---|---|---|---|---|
| | | USA | Canada | |
| **Objectives recommended by IJC to Governments** | | | | |
| Boron, dissolved | 3.5/2.5 (1) | N/A | N/A | N/A |
| Total Dissolved Solids | 1,500/1,000 (1) | N/A | N/A | N/A |
| **Objectives recommended by Poplar River Bilateral Monitoring Committee to Governments** | | | | |
| Cadmium, total | 0.0012 | N/A | N/A | N/A |
| Fluoride, dissolved | 1.5 | N/A | N/A | N/A |
| Lead, total | 0.03 | N/A | N/A | N/A |
| Nitrate | 10.0 | N/A | N/A | N/A |
| Oxygen, dissolved | 4.0/5.0 (2) | N/A | N/A | N/A |
| Sodium adsorption ratio | 10.0 | N/A | N/A | N/A |
| Sulphate, dissolved | 800.0 | N/A | N/A | N/A |
| Zinc, total | 0.03 | N/A | N/A | N/A |
| Water temperature (Celsius) | 30.0 (3) | N/A | N/A | N/A |
| pH (pH units) | 6.5 (4) | N/A | N/A | N/A |

(1) Three-month average of flow-weighted concentrations should be <3.5 mg/L boron and <1,500 mg/L TDS. Five-year average of flow-weighted concentrations (March to October) should be <2.5 mg/L boron and <1,000 mg/L TDS.
(2) 5.0 (minimum April 10 to May 15), 4.0 (minimum, remainder of the year).
(3) Natural temperature (April 10 to May 15), <30 degrees Celsius (remainder of the year).
(4) Less than 0.5 pH units above natural, minimum pH = 6.5.

N/A – Not applicable

*NOTE: No samples were obtained in 2017.*

## 3.3 Ground Water

### 3.3.1 Operations – Saskatchewan

SaskPower's supplementary supply continues to operate, with an annual withdrawal of 1,775 cubic decametres ($dam^3$) in 2017. The production rate was greater than 1,716 $dam^3$ in 2016. Figure 1 illustrates the annual withdrawal by the Poplar River Power Station. The average production rate from 1991 to 2017 was 3,947 $dam^3$ per year. Prior to 1991, the well network was part of a dewatering network for coal mining operations, which resulted in the high production levels experienced in the early to mid 1980's. With the drought of the late 1980's and early 1990's it was evident that there was a continued need for groundwater to supplement water levels in Cookson Reservoir. As a result, the wells were taken over by SaskPower for use as a supplementary supply (Figure 3.12).

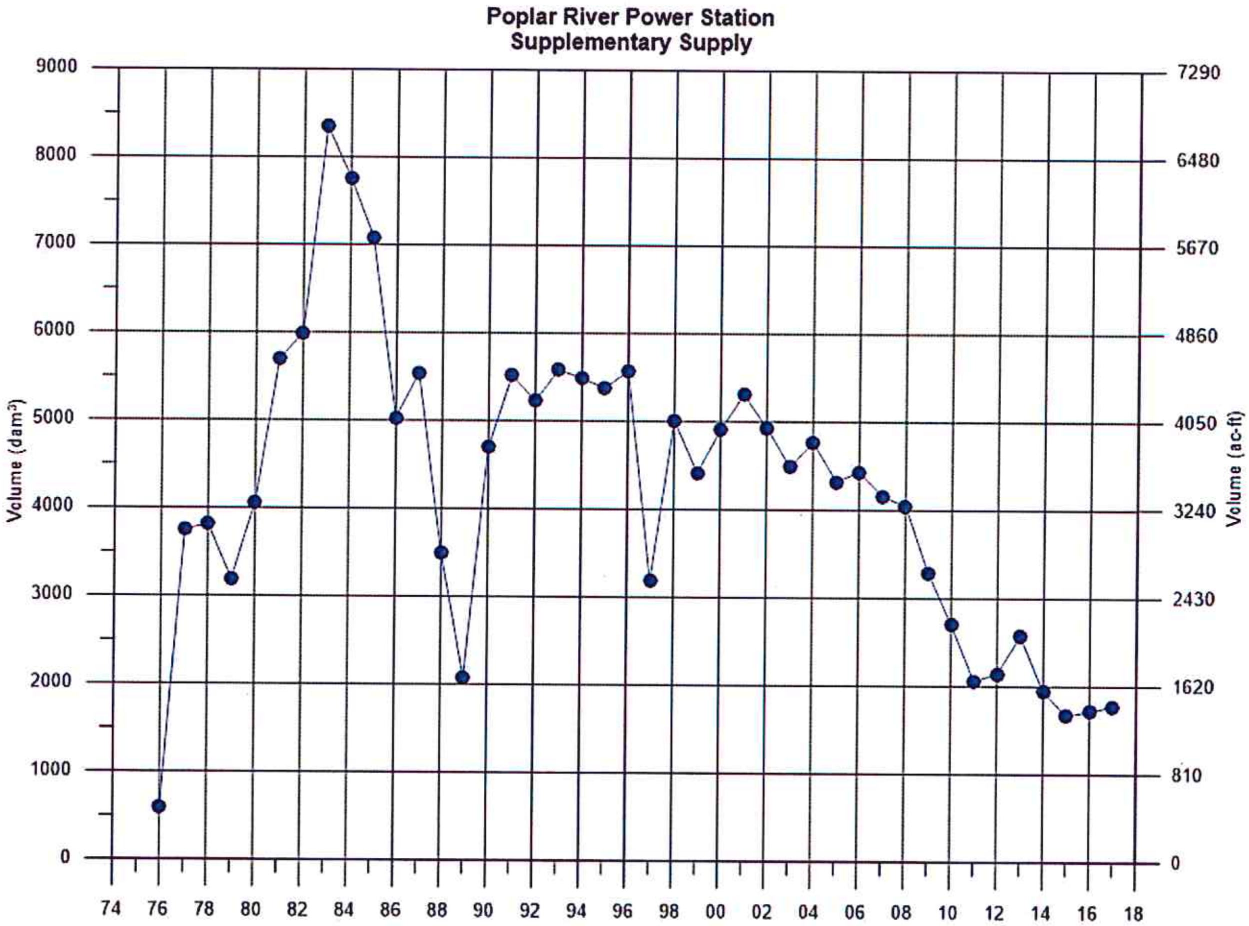



Figure 3.12. Annual Pumping from the Poplar River Power Station Supplementary Supply.

SaskPower has an approval for the supplementary supply project to produce an annual volume of 5,500 $dam^3$/year. The supplementary supply well network consisted of 21 wells with 10 discharge points. However, one production well, PW11A, was converted to a farm well to supply groundwater to a local resident in 2014 and three production wells (38, 48, and 58) were decommissioned in fall 2016. To date, there are 17 production wells in operation.

In addition to the supplementary supply, SaskPower also operates the Soil Salinity Project south of Morrison Dam. The impoundment of water behind Morrison Dam caused a 2 to 3 metre rise in groundwater levels. The increase in the groundwater levels raised in salinity of the soil and reduced crop yield. To reduce the groundwater levels south of Morrison Dam, 8 production wells were constructed in 1989 and 1990. Of the 8 production wells, 4 are located on the east side of the East Poplar River and 4 on the west side of the river. Water from the production wells is discharged into the cooling water canal, which is in turn discharged directly to Cookson Reservoir. Withdrawals from the production wells varied from a maximum of 1,100 $dam^3$ in 1994 to a minimum of 359.86 $dam^3$ in 2017.

The total water produced from the Soil Salinity Project in 2017 was 359.86 $dam^3$, which was lower than 2016 of 375.59 $dam^3$. The 2017 production rate was from two production wells, PW87104 (282.216 $dam^3$) and well PW87105 (77.64 $dam^3$), both of which are on the east side of the Poplar River. Production since operation of this network began in 1990 has averaged 672.85 $dam^3$/year (Figure 3.13).

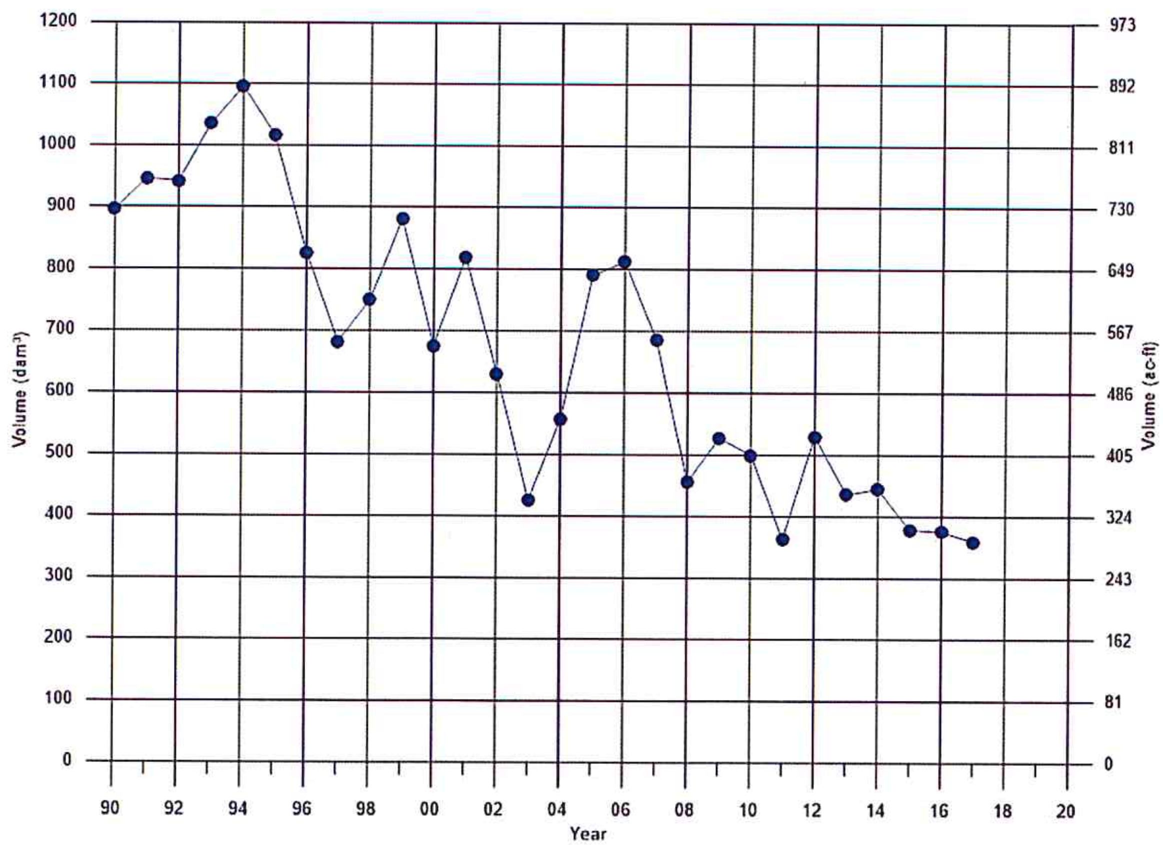



Figure 3.13 Annual Pumping from SaskPower's Soil Salinity Project.

### 3.3.2 Groundwater Monitoring

Equivalent geologic formations present in Saskatchewan and Montana have different names. A list of the corresponding formation names is provided in Table 3.2.

**Table 3.2 Geologic Formation Name Equivalence between Saskatchewan and Montana**

| System | Series | Group | Lithostratigraphic Units – United States – Montana | Lithostratigraphic Units – Canada – Saskatchewan | Hydrogeologic unit | Principal aquifer system |
|---|---|---|---|---|---|---|
| Quaternary | Pleistocene | | Glacial deposits | Saskatoon<br>Sutherland<br>Empress | Till / Glacial aquifers | Glacial aquifer system |
| Tertiary | Paleocene | Fort Union Formation* | Tongue River Member | Ravenscrag Formation | Upper Fort Union aquifer | Lower Tertiary aquifer system |
| | | | Lebo Shale Member | Ravenscrag Formation | Middle Fort Union hydrogeologic unit | |
| | | | Ludow and Tullock Members | Ravenscrag Formation | Lower Fort Union aquifer | |
| Cretaceous | Upper Cretaceous | | Hell Creek Formation (upper part) | Frenchman Formation | Upper Hell Creek hydrogeologic unit | Upper Cretaceous aquifer system |
| | | | Hell Creek Formation (lower part) | Frenchman Formation | Lower Hell Creek aquifer | |
| | | Montana Group | Fox Hills Sandstone | Whitemud Formation<br>Eastend Formation | Fox Hills aquifer | |
| | | | Bearpaw Shale | Bearpaw Formation | Basal confining unit | |

#### 3.3.2.1 Saskatchewan

In 2003, SaskPower reduced its monitoring network from 180 to about 85 piezometers. The Water Security Agency approved this reduction based on modelling studies undertaken by SaskPower.

Figures 3.3 illustrate selected piezometers completed in the Coal Hart Seam near the International Boundary. The hydrograph illustrate that there have been no significant changes in water levels in the Hart Coal Seam near the boundary in the past 29 years.

The goal of the Soil Salinity Project is to lower groundwater levels in the Empress Sands below Morrison Dam to pre-reservoir levels of approximately two to three metres. Groundwater pumping from 1990 to 1995 ranged between 900 and 1,100 dam$^3$/year and consequently the drawdown objectives were achieved in 1995 and 1996. Due to the decline in well production, high reservoir levels and increased precipitation, the drawdown in the Empress Sands has been reduced and is well below the two to three metre drawdown objective.

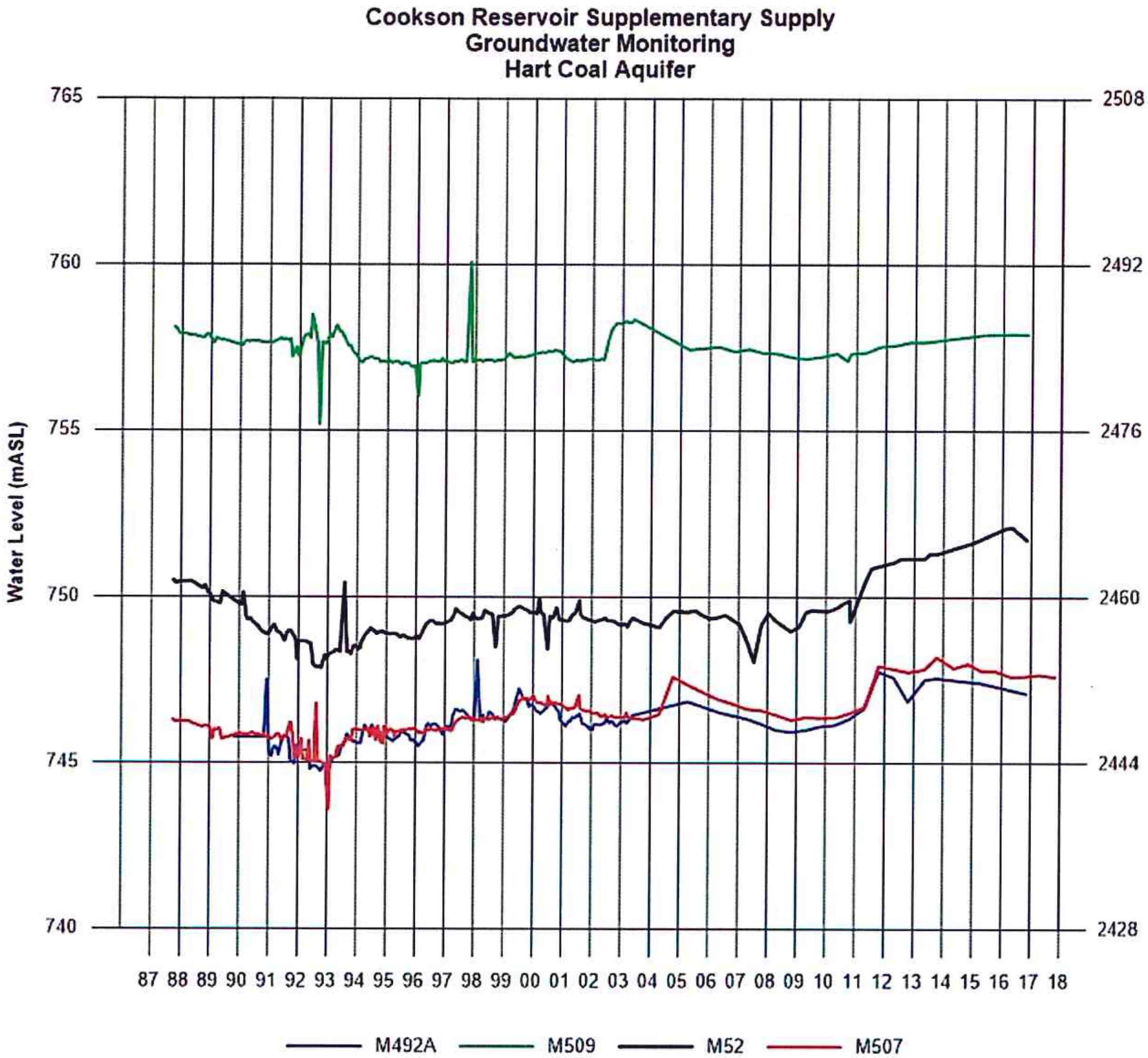



Figure 3.14. Hydrograph of Selected Wells completed in the Hart Coal Seam.

#### 3.3.2.2 Montana

Hydrographs from wells completed in the Fort Union Formation and/or the Hart Coal Seam (wells 6, 7, 9, 13, 16, 17, and 19) exhibit two general patterns. Water levels in wells 9, 13, 17, and 19 have changed less than 5 ft (1.5 m) since monitoring began in 1979 (well 9) and 1984 (wells 13, 17, and 19). Water levels generally declined between 1985 and 1992-1994; between 1994 and 2010, water-level trends are flat or slowly rising. Between 2011 and 2014, water levels rose; in wells 13, 17 and 19 water levels increased by about 3 ft. (1 m). Water-level hydrographs from wells 17 and 19 are shown on Figure 3.15. Offsets noted in the legend for Figure 3.15 have been applied to make the hydrographs more readable. Water-level data used to construct the hydrographs in Figure 3.15 can be accessed through the Montana Ground Water Information Center (GWIC) database at http://mbmggwic.mtech.edu.

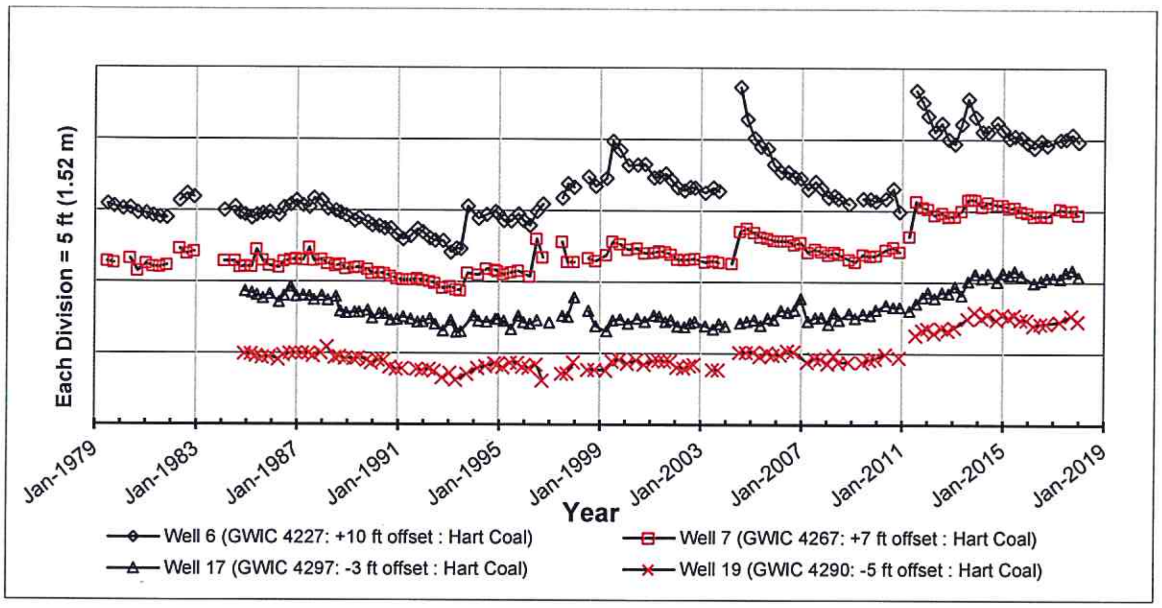



Figure 3.15 Hydrographs of Selected Wells - Fort Union-Hart Coal Aquifer

During their period of record, water levels in wells 6, 7, and 16 have changed as much as 18 ft (5.5 m) but generally declined from the beginning of monitoring in 1979 (wells 6 and 7) and 1985 (well 16) until the mid-1990s. Since then, water levels have generally risen, peaking in 2014. The elevated water levels are related to heavy winter snow accumulation, associated melt, and positive departures from average annual precipitation in 2010, 2011, and 2013 (National Oceanic and Atmospheric Administration's northeast Montana climate division). Since 2014, water levels in all the Fort Union Formation and/or the Hart Coal Seam wells have declined slightly. Water-level hydrographs for wells 6 and 7 are shown on Figure 3.15.

Water levels in monitoring wells 5, 8, 10, 23, and 24, completed in alluvium and/or outwash, show seasonal changes caused by climate and/or precipitation. Heavy snow accumulation and melt in 2004 and 2011 caused upward water-level response during the remainder of those years. Since the 2011 peaks, water levels have declined slightly. Water levels in wells 5, 8, 10, and 24 have been at period of record highs in response to wet climate since 2011. Hydrographs for alluvial and outwash (wells 10, 23, and 24) and the Fox Hills/Hell Creek aquifer (well 11) are shown in figure 3.16. Offsets noted in the legend have been applied to the data to make the hydrographs more readable. Measurements from wells 11 and 24 where the wellhead was noted as being frozen or when a well was flowing are not included. Water-level data used to construct the hydrographs in Figure 3.16 can be accessed through the Montana Ground Water Information Center (GWIC) database at http://mbmggwic.mtech.edu.

The potentiometric surface in the Fox Hills/Hell Creek artesian aquifer (well 11-fig, 3.16) has shown little fluctuation during the 1979-2017 monitoring period.

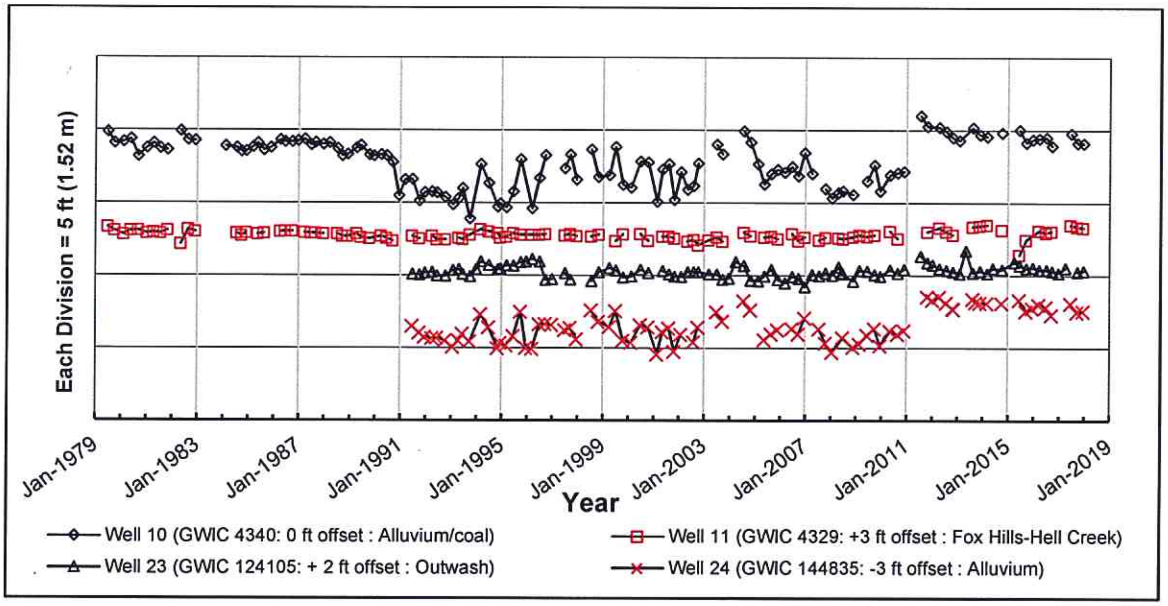



Figure 3.16 Hydrographs of Selected Wells - Alluvium and Fox Hills/Hell Creek Aquifers

Above average precipitation, including heavy snow accumulation and subsequent melting, caused water levels to rise to near-record highs in wells 5, 6, 7, 8, 9, 10, 13, 16, 17, 19, 22, 23, and 24 between 2010 and 2013. Flowing artesian conditions were noted in well 24 between August 3013 and June of 2015, but the well has not flowed since then.

### 3.3.3 Ground-Water Quality

#### 3.3.3.1 Saskatchewan

The water quality from the Supplementary Supply Project discharge points has been consistent with no trends indicated. A summary of the more frequently tested parameters during 2017 is provided in Table 3.3. Result averages for the 1992-2015 periods are also included in this table for comparison.

**TABLE 3.3 Water-Quality Statistics for Water Pumped from Supplementary Water Supply Project Wells***

| Parameters | 2017 | 1992 to 2016 | |
|---|---|---|---|
| | Average | Average | Std. Dev |
| | | | |
| pH (units) | 8.0 | 8.0 | 0.3 |
| Conductivity (µs/cm) | 1073 | 1263 | 342 |
| Total Dissolved Solids | 747 | 868 | 250 |
| Total Suspended Solids | 7 | 11 | 16 |
| Boron | 0.9 | 1.1 | 0.7 |
| Sodium | 149 | 165 | 62 |
| Cyanide (µg/L) | 2.20 | 2.03 | 1.07 |
| Iron | 0.5 | 0.3 | 0.4 |
| Manganese | 0.0 | 0.1 | 0.1 |
| Mercury (µg/L) | 0.10 | 0.07 | 0.04 |
| Calcium | 79.35 | 65 | 15 |
| Magnesium | 45.17 | 51 | 13 |
| Sulfate | 212.30 | 277 | 91 |
| Nitrate | 0.05 | 0.15 | 0.25 |

All units mg/L unless otherwise noted. *Sampled at Site "C3" on Girard Creek.

Average results from the common discharge point for the Salinity Control Project for 2017, plus an average of the 1992-2016 results are provided in Table 3.4. Results have remained relatively consistent since 1992.

**TABLE 3.4 Water-Quality Statistics for Water Pumped from Salinity Control Project Wells Sampled at the Discharge Pipe***

| Parameters | 2017 Average | 1992 - 2016 Average |
|---|---|---|
| | | |
| pH (units) | 7.6 | 7.6 |
| Conductivity (µs/cm) | 1571 | 1493 |
| Total Dissolved Solids | 1182 | 1039 |
| Boron | 2.0 | 1.6 |
| Calcium | 141 | 106 |
| Magnesium | 76 | 60 |
| Sodium | 241 | 169 |
| Potassium | 11.8 | 7.6 |
| Arsenic (µg/L) | 13.9 | 12.3 |
| Aluminum | 0.011 | 0.04 |
| Barium | 0.018 | 0.031 |
| Cadmium | 0.00010 | 0.010 |
| Iron | 4.7 | 4.1 |
| Manganese | 0.129 | 0.127 |
| Molybdenum | 0.001 | 0.010 |
| Strontium | 1.998 | 1.752 |
| Vanadium | 0.0010 | 0.010 |
| Uranium (µg/L) | 1.075 | 0.794 |
| Mercury (µg/L) | 0.10 | 0.07 |
| Sulfate | 416 | 349 |
| Chloride | 12.2 | 6.9 |
| Nitrate | 0.050 | 0.069 |

*All concentrations are mg/L unless otherwise noted.

Leachate movement through the ash lagoon liner systems can potentially affect ground-water quality in the vicinity of the ash lagoons. The piezometers listed in the Technical Monitoring Schedules are used to assess leachate movement and calculate seepage rates. Piezometric water level, boron, and chloride are the chosen indicator parameters to assess leachate movement.

The chemistry of water immediately above the liner systems is expected to differ from the surface water of the lagoons. Meaningful information is only available from piezometers installed within Ash Lagoon # 1 where ash had been deposited for many years. Future monitoring of all piezometers completed above the lagoon liner systems will continue with the purpose of confirming the boron trend noted above and to improve the understanding of leachate quality and flow from the ash lagoons.

The piezometric surface measurements for the oxidized till continue to show the presence of a ground-water mound beneath the ash lagoons. The mound extends from the center of the Ash Lagoon # 1 to the southeast side of Ash Lagoon # 2. Isolated ground-water mounds have developed within the area of the oxidized ground-water mound. Piezometers located in the oxidized till suggest limited leachate activity. No seepage activity is evident in the unoxidized till.

The greatest changes in chloride and boron concentrations within the oxidized till have occurred where piezometric levels have changed the most. Although increasing water levels do not automatically suggest that the water affecting the piezometers is leachate, changing piezometric levels do suggest ground-water movement. On the west side of the Polishing Pond, the boron levels have changed only slightly in the oxidized till piezometers C728A and C728D, where the chloride levels have changed more significantly. The chloride level for C728A had decreased from 403 mg/L in 1983 to 305 mg/L in 2016. The chloride level for C728D has increased from 185 mg/L in 1983 to 366 mg/L in 2016. Although these piezometers are close in proximity and installed at the same level, they are being influenced by different water. Chloride results for C728A suggest initial seepage and it is to be expected that over time the same observation will be seen in C728D. This piezometer series was replaced in 2017 to address safety concerns and will be sampled again in 2018.

The piezometric surface of the Empress Gravel indicates a regional flow from northwest to southeast below Morrison Dam. As a general observation, Empress piezometers respond to changing reservoir levels. Results for the Empress layer do not indicate seepage activity with the majority of the analyses showing little real change in boron or chloride results.

Piezometer C712B has been monitored for several years. Historically, boron levels were below 1 mg/L. From 1992 to 2017, boron levels have remained relatively steady around between 12 and 20 mg/L.

### 3.3.3.2 Montana

Samples were collected from monitoring wells 7, 16, and 24 during 2017. Well 7 is completed in the Hart Coal, well 16 is completed in the Fort Union Formation, and well 24 is completed in alluvium. Total dissolved solids (TDS) concentrations in wells 7 and 24 show slight increases over the past seven years, but overall the concentrations have been stable. The TDS concentration in well 16 was anomalously low in 2017. This anomaly is attributed to flooding in the well area in the spring of 2017. Flood waters likely entered the well bore directly and significantly impacted the water quality sample collected in 2017. Excluding the 2017 sample from well 16, samples from all three wells have remained well above the anomalously low values observed in 2009. Changes in TDS with time for wells 7, 16, and 24 are shown in Figure 3.17. Water-chemistry data used to construct the graphs in Figure 3.17 can be accessed through the Montana Ground Water Information Center (GWIC) database at http://mbmggwic.mtech.edu.

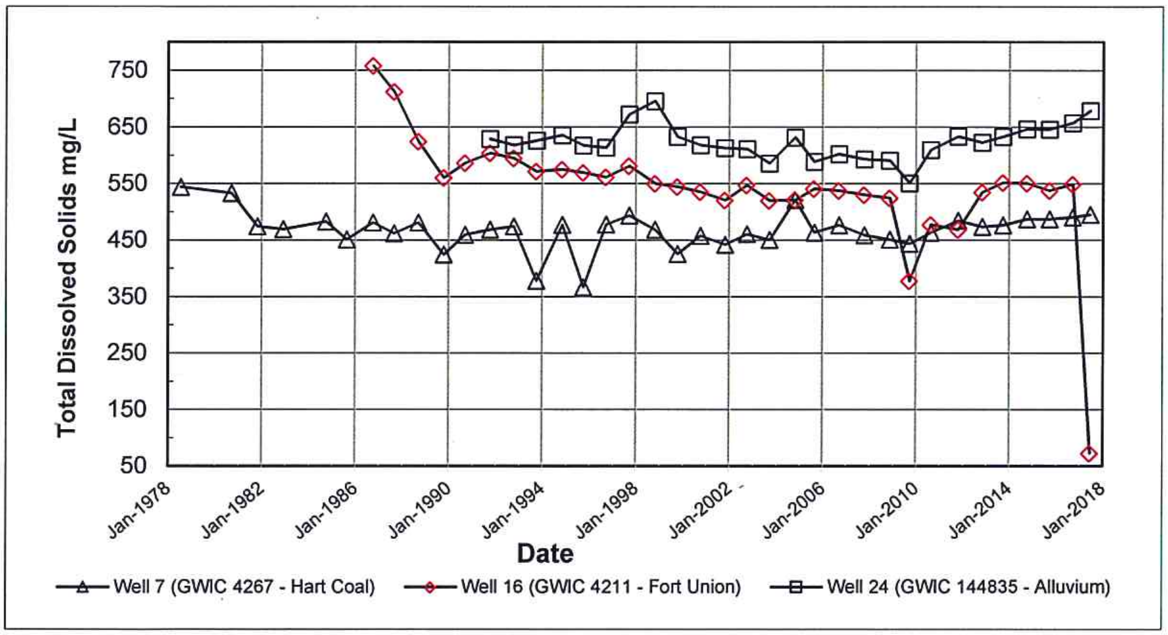



Figure 3.17 Total Dissolved Solids in Samples from Montana Wells.

## 3.4 Cookson Reservoir

### 3.4.1 Storage

On January 1, 2017, Cookson Reservoir storage was about 29,710 $dam^3$ (24,086 acre-feet) or 68 % of the full supply volume. The 2017 maximum, minimum, and period elevations and volumes are indicated in Table 3.5.

Spring inflows into the reservoir were well above average, increasing water levels by 1.96 m, which resulted in a peak water level of 753.01 m (2,470.50 ft) on May 3, 2017. Due to limited inflows, evaporation, and water releases, after the peak, water levels started to decrease gradually until the end of the year. On December 31st of 2017, the reservoir was at 751.55 m (2,465.69 ft), or approximately 1.46 m (4.77 ft) below full supply.

**Table 3.5 Cookson Reservoir Storage Statistics for 2017**

| Date | Elevation (m) | Elevation (ft) | Contents ($dam^3$) | Contents (acre-feet) |
|---|---|---|---|---|
| January 1 | 751.05 | 2,464.05 | 29,710 | 24,086 |
| May 3 (Maximum) | 753.01 | 2,470.50 | 43,479 | 35,249 |
| January 17 (Minimum) | 751.02 | 2,463.96 | 29,542 | 23,950 |
| December 31 | 751.55 | 2,465.69 | 32,833 | 26,618 |
| Full Supply Level | 753.00 | 2,470.47 | 43,410 | 35,193 |

The Poplar River Power Station is dependent on water from Cookson Reservoir for cooling. The power plant operation is adversely affected once the reservoir levels drop below 749.0 m (2,457.3 ft). The dead storage level for cooling water used in the generation process is 745.0 m (2,444.2 ft). The 2017 recorded levels and associated operating levels are illustrated in Figure 3.18 along with the 10-year median levels. Likewise, the 2017 storage and associated operating levels are shown in Figure 3.19 along with the 10-year median levels.

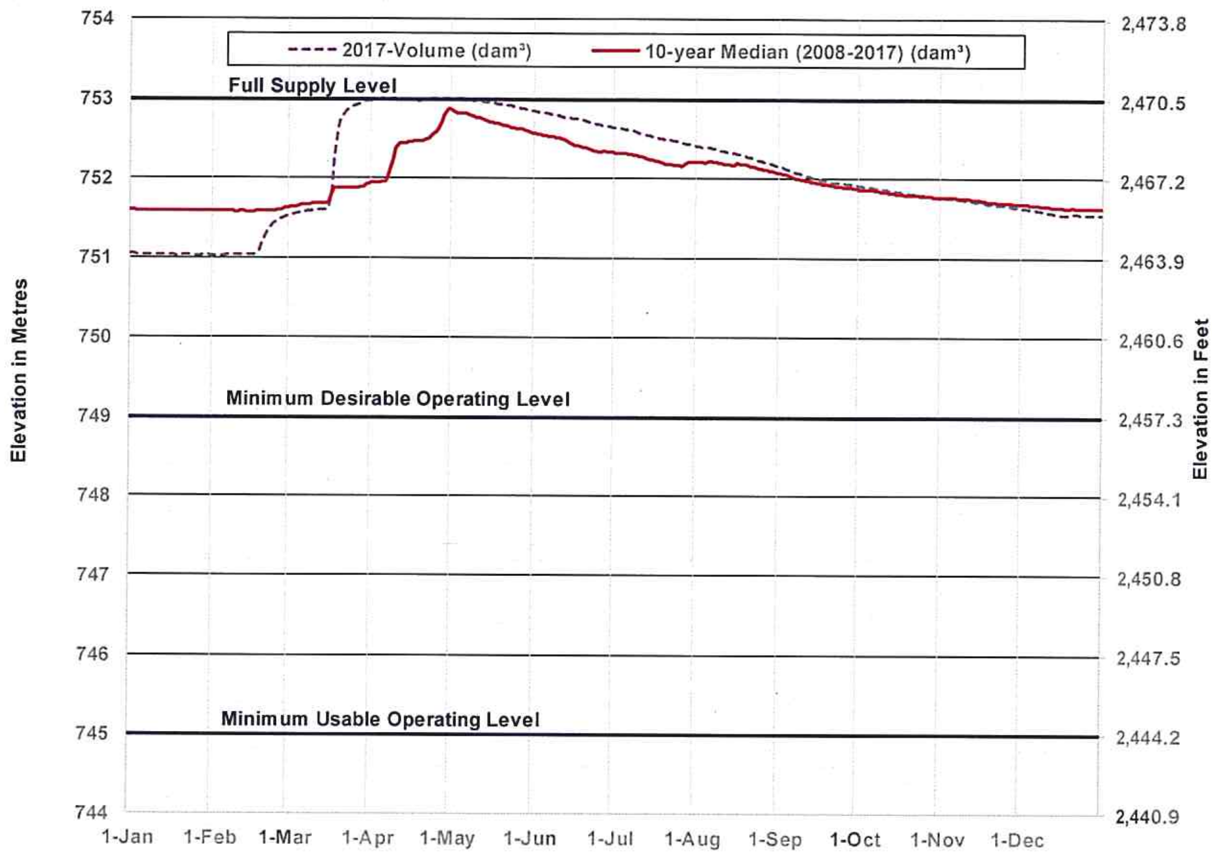



Figure 3.18 Cookson Reservoir Daily Mean Water Levels for 2017 and Median Daily Water Levels, 2008-2017

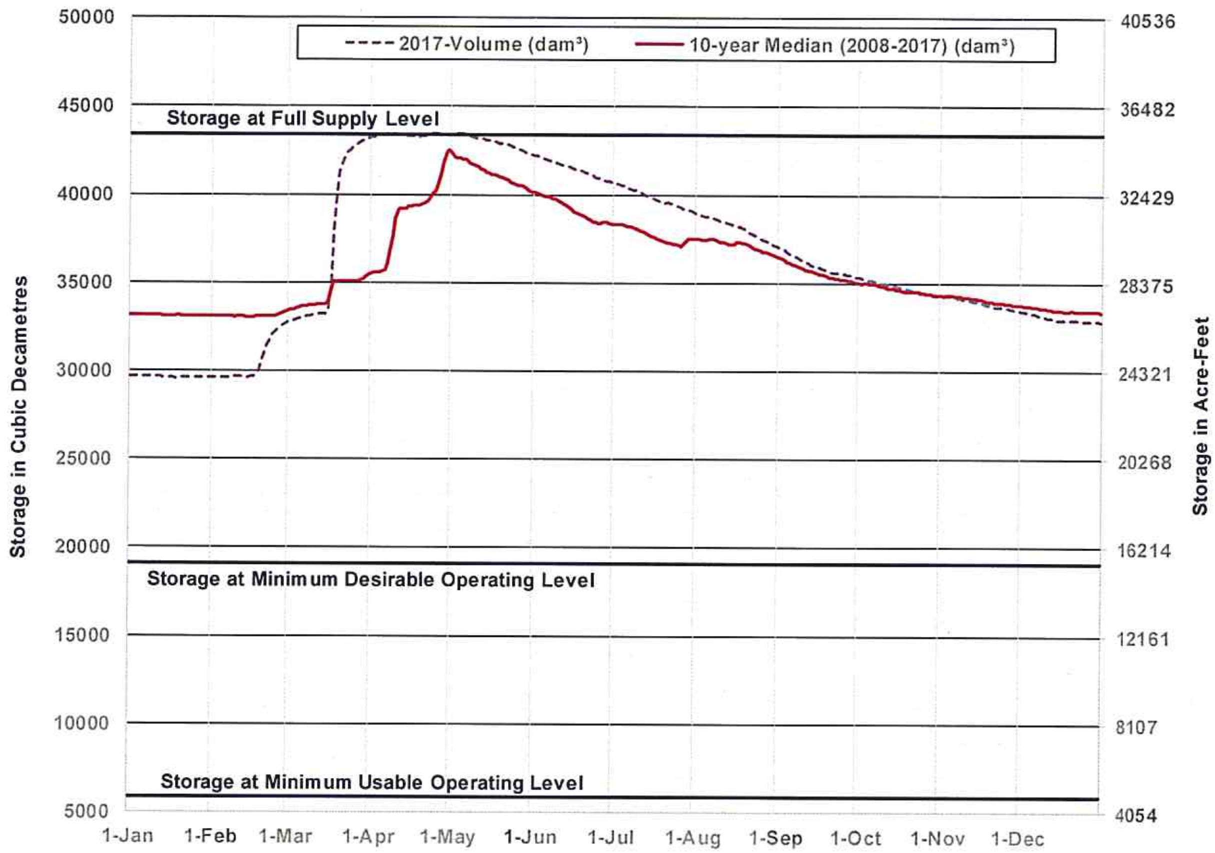



Figure 3.19 Cookson Reservoir Daily Mean Water Storage for 2017 and Median Daily Storage, 2008-2017

### 3.4.2 Water Quality

One major factor affecting the water quality of Cookson Reservoir is volume. Low reservoir volumes will decrease the water quality while high volumes will improve the water quality. The reservoir volume is controlled by two factors: inflow, which consists of spring runoff, precipitation and supplementary water supply, which increases reservoir volumes and losses, which consist of evaporation, water uses and apportionment releases, which decreases volume.

By 2008, the concentration of total dissolved solids had reached 1,540 mg/L. Significant runoff in 2009 reduced the total dissolved solids to 1,160 mg/L but they have increased throughout the year as the reservoir volume decreased. 2010 saw a slight decrease in Total Dissolved Solids for the runoff period and again increasing as the reservoir level decreased. The spilling that occurred during the 2011 runoff period significantly reduced the total dissolved solids to 391 mg/L. The December 2017 TDS of 864 mg/L was slightly lower than the 2016 TDS of 890 mg/L.

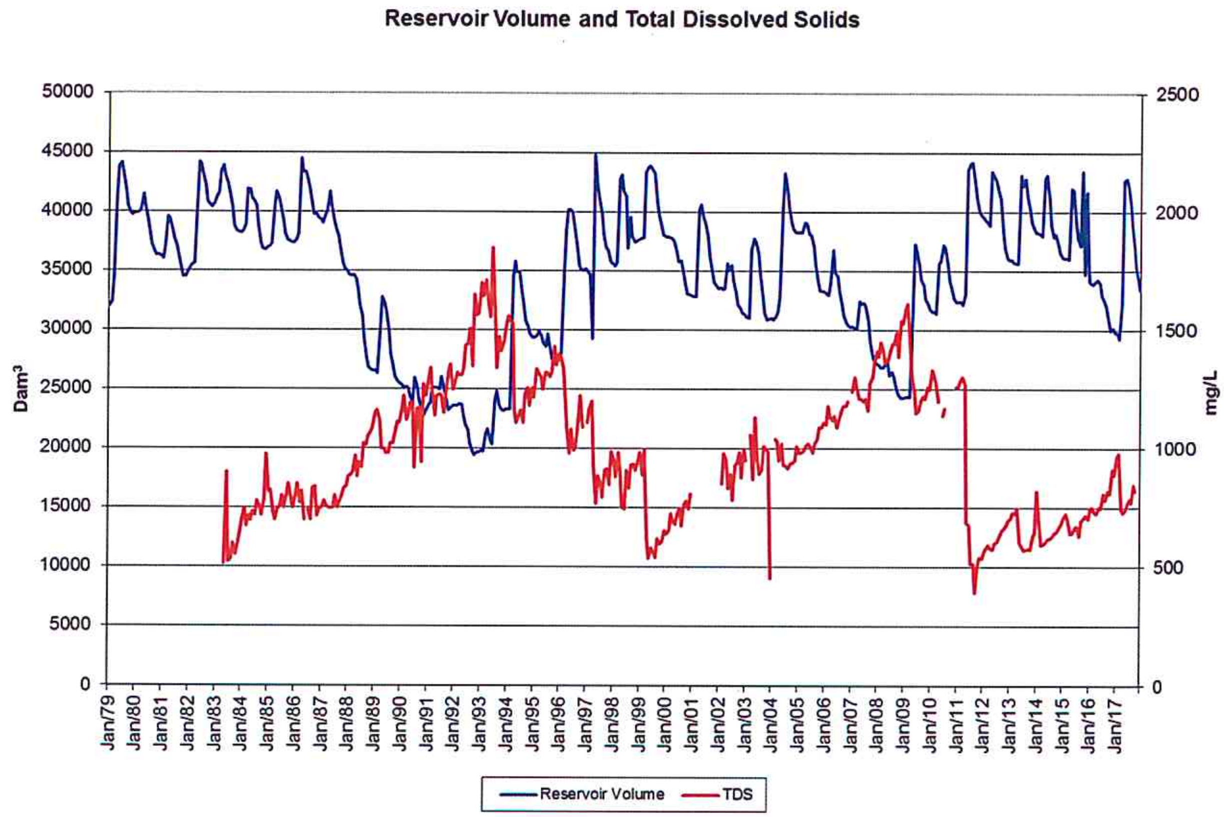



Figure 3.20 Reservoir Volume and Total Dissolved Solids Concentrations from 1979 – 2017 for Cookson Reservoir

## 3.5 Air Quality

SaskPower's ambient $SO_2$ monitoring for 2017 recorded no values greater than Saskatchewan Environment's one-hour average standard of 0.17 ppm and the 24-hour average standard of 0.06 ppm. The 2017 geometric mean for the high-volume suspended-particulate sampler was 12.0 µg/m$^3$ and 2017 was the twenty fifth consecutive year of below-average standard particulate readings.

## 3.6 Quality Control

### Streamflow

No comparative current-meter discharge measurements were made in 2017 at the East Poplar River at International Boundary site between personnel from the U.S. Geological Survey (USGS) and Environment and Climate Change Canada (ECCC) to confirm streamflow measurement comparability.

### 3.6.2 Water Quality

No joint sampling was performed in 2017 at the East Poplar River at International Boundary due to continued suspension in the surface-water-quality sampling program by the USGS and ECCC.

**ANNEX 1**

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

CANADA-UNITED STATES

September 23, 1980

# POPLAR RIVER COOPERATIVE MONITORING ARRANGEMENT

## I. PURPOSE

This Arrangement will provide for the exchange of data collected as described in the attached Technical Monitoring Schedules in water-quality, water quantity and air quality monitoring programs being conducted in Canada and the United States at or near the International Boundary in response to SaskPower development. This Arrangement will also provide for the dissemination of the data in each country and will assure its comparability and assist in its technical interpretation.

The Arrangement will replace and expand upon the quarterly information exchange program instituted between Canada and the United States in 1976.

## II. PARTICIPATING GOVERNMENTS

Governments and government agencies participating in the Arrangement are:

Government of Canada: Environment Canada
Government of the Province of Saskatchewan:
Saskatchewan Environment and Resource Management
Government of the United States of America: United States Geological Survey
Government of the State of Montana: Executive Office

## III. POPLAR RIVER MONITORING COMMITTEE: TERMS OF REFERENCE

A binational committee called the Poplar River Bilateral Monitoring Committee will be established to carry out responsibilities assigned to it under this Arrangement. The Committee will operate in accordance with the following terms of reference:

## A. Membership

The Committee will be composed of four representatives, one from each of the participating Governments. It will be jointly chaired by the Government of Canada and the Government of the United States. There will be a Canadian Section and a United States Section. The participating Governments will notify each other of any changes in membership on the Committee. Co-chairpersons may by mutual agreement invite agency technical experts to participate in the work of the Committee.

The Governor of the State of Montana may also appoint a chief elective official of local government to participate as an ex-officio member of the Committee in its technical deliberations. The Saskatchewan Minister of the Environment may also appoint a similar local representative.

## B. Functions of the Committee

The role of the Committee will be to fulfil the purpose of the Arrangement by ensuring the exchange of monitored data in accordance with the attached Technical Monitoring Schedules, and its collation and technical interpretation in reports to Governments on implementation of the Arrangement. In addition, the Committee will review the existing monitoring systems to ensure their adequacy and may recommend to the Canadian and United States Governments any modifications to improve the Technical Monitoring Schedules.

### 1. Information Exchange

Each Co-chairperson will be responsible for transmitting to his counterpart Co-chairperson on a regular annual basis, the data provided by the cooperative monitoring agencies in accordance with the Technical Monitoring Schedules.

2. Reports

(a) The Committee will prepare a joint Annual Report to the participating governments, and may at any time prepare joint Special Reports.

(b) Annual Reports will

i) summarize the main activities of the Committee in the year under Report and the data which has been exchanged under the Arrangement;

ii) draw to the attention of the participating governments any definitive changes in the monitored parameters, based on collation and technical interpretation of exchanged data (i.e. the utilization of summary, statistical and other appropriate techniques);

iii) draw to the attention of the participating governments any recommendations regarding the adequacy or redundancy of any scheduled monitoring operations and any proposals regarding modifications to the Technical Monitoring Schedules, based on a continuing review of the monitoring programs including analytical methods to ensure their comparability.

(c) Special Reports may, at any time, draw to the attention of participating governments definitive changes in monitored parameters which may require immediate attention.

(d) Preparation of Reports

Reports will be prepared following consultation with all committee members and will be signed by all Committee members. Reports will be separately forwarded by the Committee Co-chairmen to the participating governments. All annual and special reports will be so distributed.

3. Activities of Canadian and United States Sections

The Canadian and United States section will be separately responsible for:

(a) dissemination of information within their respective countries, and the arrangement of any discussion required with local elected officials;

(b) verification that monitoring operations are being carried out in accordance with the Technical Monitoring Schedules by cooperating monitoring agencies;

(c) receipt and collation of monitored data generated by the cooperating monitoring agencies in their respective countries as specified in the Technical Monitoring Schedules;

(d) if necessary, drawing to the attention of the appropriate government in their respective countries any failure to comply with a scheduled monitoring function on the part of any cooperating agency under the jurisdiction of that government, and requesting that appropriate corrective action be taken.

## IV. PROVISION OF DATA

In order to ensure that the Committee is able to carry out the terms of this Arrangement, the participating governments will use their best efforts to have cooperating monitoring agencies, in their respective jurisdictions provide on an ongoing basis all scheduled monitored data for which they are responsible.

## V. TERMS OF THE ARRANGEMENT

The Arrangement will be effective for an initial term of five years and may be amended by agreement of the participating governments. It will be subject to review at the end of the initial term and will be renewed thereafter for as long as it is required by the participating governments.

**ANNEX 2**

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

2018

CANADA-UNITED STATES

# TABLE OF CONTENTS

## PREAMBLE

The Technical Monitoring Schedule lists those water quantity, water-quality and air quality monitoring locations and parameters which form the basis for information exchange and reporting to Governments. The structure of the Committee responsible for ensuring the exchange takes place is described in the Poplar River Cooperative Monitoring Arrangement.

The monitoring locations and parameters listed herein have been reviewed by the Poplar River Bilateral Monitoring Committee and represent the basic technical information needed to identify any definitive changes in water quantity, water quality and air quality at the International Boundary. The Schedule was initially submitted to Governments for approval as an attachment to the 1981 report to Governments. Changes in the sampling locations and parameters may be made by Governments based on the recommendations of the Committee.

Additional information has been or is being collected by agencies on both sides of the International Boundary, primarily for project management or basin-wide baseline data purposes. This additional information is usually available upon request from the collecting agency and forms part of the pool of technical information which may be drawn upon by Governments for specific study purposes. Examples of additional information are water-quantity, water-quality, ground-water and air-quality data collected at points in the Poplar River basin not of direct concern to the Committee. In addition, supplemental information on parameters such as vegetation, soils, fish and waterfowl populations and aquatic vegetation has been collected on either a routine or specific-studies basis by various agencies.

# POPLAR RIVER

# COOPERATIVE MONITORING ARRANGEMENT

## TECHNICAL MONITORING SCHEDULES

2018

CANADA

## STREAMFLOW MONITORING

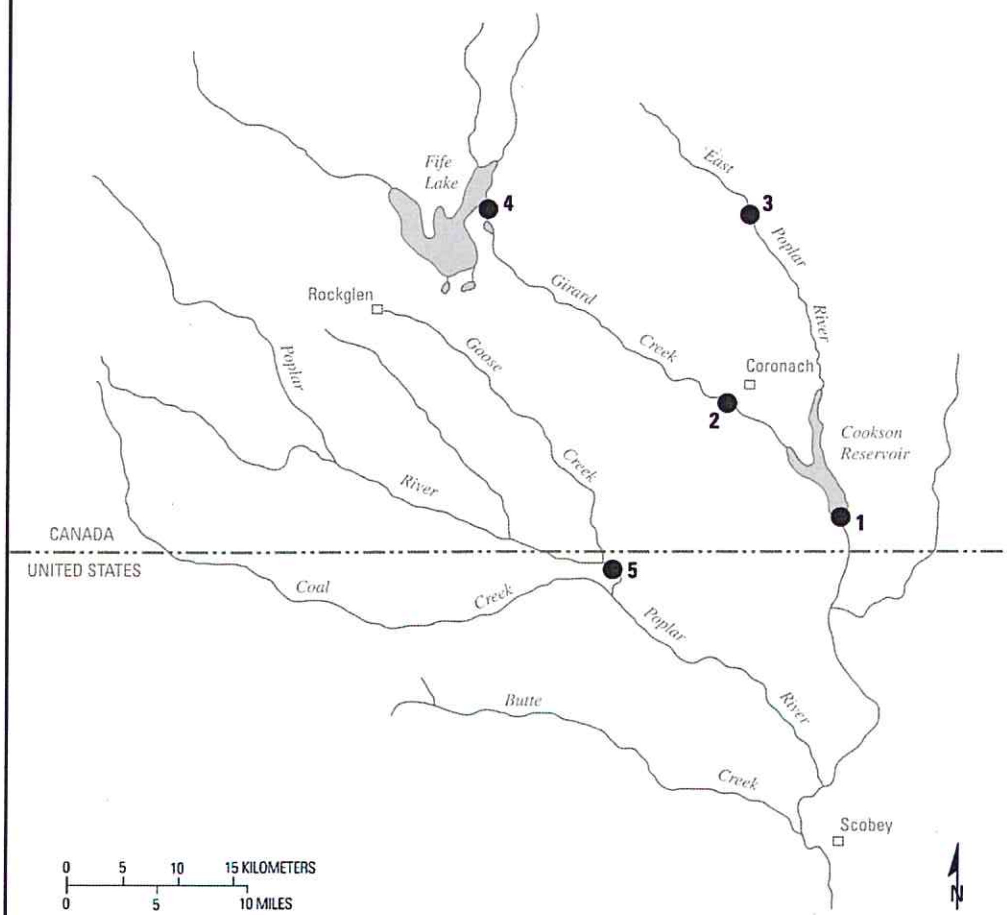
Daily mean discharge or levels and instantaneous monthly extremes as normally published in surface-water-data publications.

| Responsible Agencies: Environment Canada, Water Security Agency | | |
|---|---|---|
| **No. on Map** | **Station No.** | **Station Name** |
| 1 | 11AE013** | Cookson Reservoir near Coronach |
| 2 | 11AE015** | Girard Creek near Coronach Cookson Reservoir |
| 3 | 11AE014** | East Poplar River above Cookson Reservoir |
| 4 | | Fife Lake Overflow*** |
| 5* | 11AE008 (06178000) | Poplar River at International Boundary |

* International gauging station.

** Water Security Agency (WSA) took over the monitoring responsibility effective July 1, 1992.

*** Miscellaneous measurements of outflow to be made by WSA during periods of outflow only.




**HYDROMETRIC GAUGING STATIONS (CANADA)**

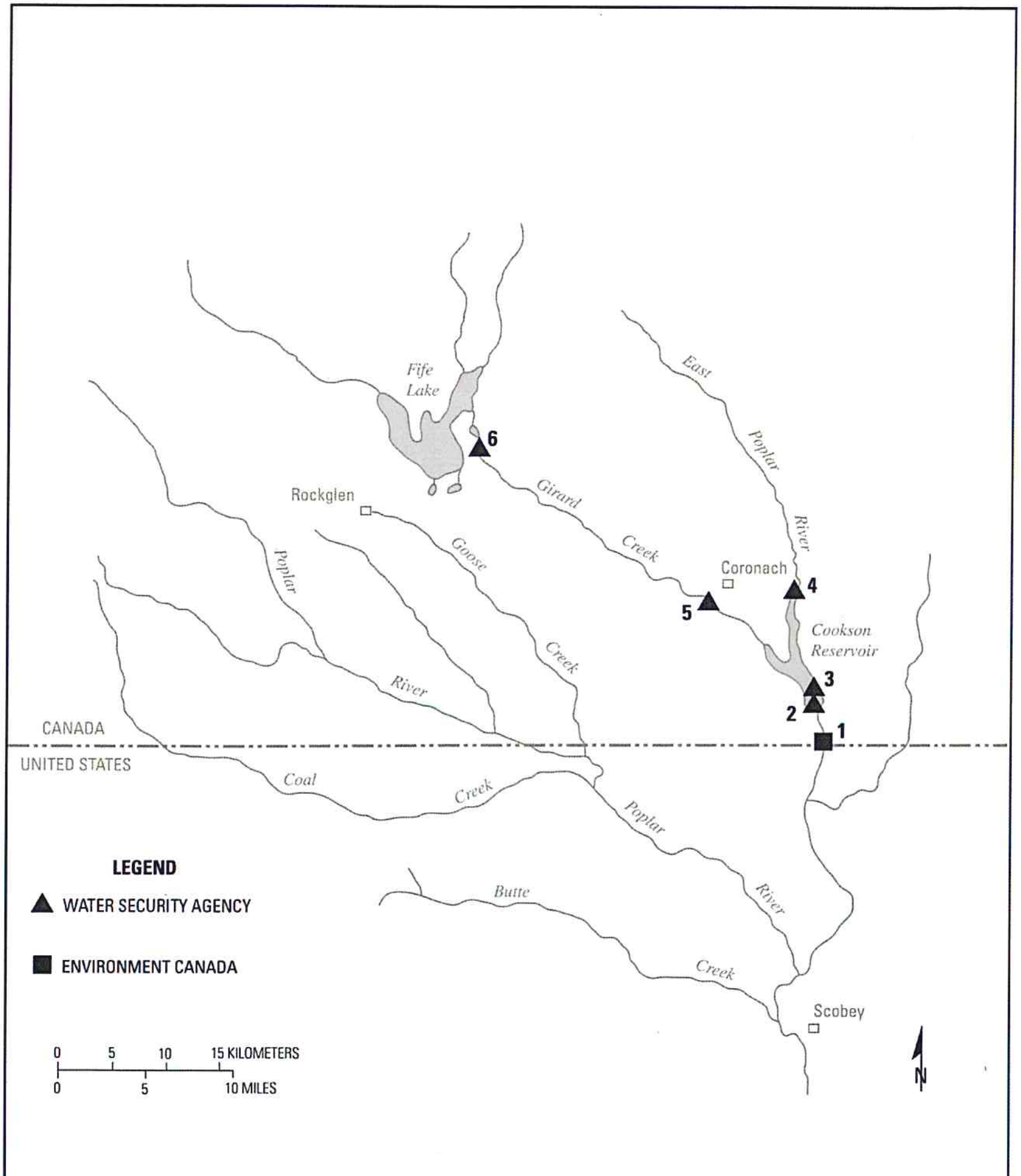
## SURFACE-WATER-QUALITY MONITORING

Sampling Locations

| Responsible Agency: Environment Canada | | |
|---|---|---|
| **No. on Map** | **Station No.** | **Station Name** |
| 1 | 00SA11AE0008<br>Suspended | East Poplar River at International Boundary |

| Responsible Agency: Water Security Agency<br>Data collected by: SaskPower | | |
|---|---|---|
| **No. on Map** | **Station No.** | **Station Name** |
| 2 | 12386<br>Discontinued | East Poplar River at Culvert immediately below Cookson Reservoir |
| 3 | 12368 | Cookson Reservoir near Dam |
| 4 | 12377<br>Discontinued | Upper End of Cookson Reservoir at Highway 36 |
| 5 | 12412<br>Discontinued | Girard Creek at Coronach, Reservoir Outflow |
| 6 | 7904 | Fife Lake Outflow* |

*Sampled only when outflow occurs for a 2-week period, which does not occur every year.




**SURFACE-WATER-QUALITY MONITORING STATIONS (CANADA)**

# PARAMETERS

| Responsible Agency: Environment Canada | | | |
|---|---|---|---|
| **ENVIRODAT* Code** | **Parameter** | **Analytical Method** | **Sampling Frequency Station No. 1** |
| 10151 | Alkalinity-phenolphthalein | Potentiometric Titration | SUS |
| 10111 | Alkalinity-total | Potentiometric Titration | SUS |
| 13102 | Aluminum-dissolved | AA-Direct | SUS |
| 13302 | Aluminum-extracted | AA-Direct | SUS |
| 07540 | Ammonia-total | Automated Colourimetric | SUS |
| 33108 | Arsenic-dissolved | ICAP-hydride | SUS |
| 56001 | Barium-total | AA-Direct | SUS |
| 06201 | Bicarbonates | Calculated | SUS |
| 05211 | Boron-dissolved | ICAP | SUS |
| 96360 | Bromoxynil | Gas Chromatography | SUS |
| 48002 | Cadmium-total | AA Solvent Extraction | SUS |
| 20113 | Calcium | AA-Direct | SUS |
| 06104 | Carbon-dissolved organic | Automated IR Detection | SUS |
| 06901 | Carbon-particulate | Elemental Analyzer | SUS |
| 06002 | Carbon-total organic | Calculated | SUS |
| 06301 | Carbonates | Calculated | SUS |
| 17206 | Chloride | Automated Colourimetric | SUS |
| 06717 | Chlorophyll a | Spectrophotometric | SUS |
| 24003 | Chromium-total | AA-Solvent Extraction | SUS |
| 27002 | Cobalt-total | AA-Solvent Extraction | SUS |
| 36012 | Coliform-fecal | Membrane Filtration | SUS |
| 36002 | Coliform-total | Membrane Filtration | SUS |
| 02021 | Colour | Comparator | SUS |
| 02041 | Conductivity | Wheatstone Bridge | SUS |
| 06610 | Cyanide | Automated UV-Colourimetric | SUS |
| 09117 | Fluoride-dissolved | Electrometric | SUS |
| 06401 | Free Carbon Dioxide | Calculated | SUS |
| 10602 | Hardness | Calculated | SUS |
| 17811 | Hexachlorobenzene | Gas Chromatography | SUS |
| 08501 | Hydroxide | Calculated | SUS |
| 26104 | Iron-dissolved | AA-Direct | SUS |
| 82002 | Lead-total | AA-Solvent Extraction | SUS |
| 12102 | Magnesium | AA-Direct | SUS |
| 25104 | Manganese-dissolved | AA-Direct | SUS |
| 07901 | N-particulate | Elemental Analyzer | SUS |
| 07651 | N-total dissolved | Automated UV Colourimetric | SUS |
| 10401 | NFR | Gravimetric | SUS |
| 28002 | Nickel-total | AA-Solvent Extraction | SUS |
| 07110 | Nitrate/Nitrite | Colourimetric | SUS |
| 07603 | Nitrogen-total | Calculated | SUS |
| 10650 | Non-Carbonate Hardness | Calculated | SUS |
| 18XXX | Organo Chlorines | Gas Chromatography | SUS |
| 08101 | Oxygen-dissolved | Winkler | SUS |
| 15901 | P-particulate | Calculated | SUS |
| 15465 | P-total dissolved | Automated Colourimetric | SUS |
| 185XX | Phenoxy Herbicides | Gas Chromatography | SUS |
| 15423 | Phosphorus-total | Colourimetric (TRAACS) | SUS |
| 19103 | Potassium | Flame Emission | SUS |
| 11250 | Percent Sodium | Calculated | SUS |
| 011201 | SAR | Calculated | SUS |
| 00210 | Saturation Index | Calculated | SUS |
| 34108 | Selenium-dissolved | ICAP-hydride | SUS |
| 14108 | Silica | Automated Colourimetric | SUS |
| 11103 | Sodium | Flame Emission | SUS |
| 00211 | Stability Index | Calculated | SUS |
| 16306 | Sulphate | Automated Colourimetric | SUS |
| 00201 | TDS | Calculated | SUS |
| 02061 | Temperature | Digital Thermometer | SUS |
| 02073 | Turbidity | Nephelometry | SUS |
| 23002 | Vanadium-total | AA-Solvent Extraction | SUS |
| 30005 | Zinc-total | AA-Solvent Extraction | SUS |
| 10301 | pH | Electrometric | SUS |
| 92111 | Uranium | Fluometric | SUS |

***** - Computer Storage and Retrieval System -- Environment Canada
**AA** - Atomic Absorption　　**UV** - Ultraviolet
**NFR** - Nonfilterable Residue　　**ICAP** - Inductively Coupled Argon Plasma.　　SUS – Suspended

## PARAMETERS

Responsible Agency: Water Security Agency
Data Collected by: SaskPower

| ESQUADAT* Code | Parameter | Analytical method | Sampling Frequency Station No. | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2 | 3 | 4 | 5 | 6 |
| 10151 | Alkalinity-phenol | Pot-Titration | DIS | Q | DIS | DIS | OF |
| 10101 | Alkalinity-tot | Pot-Titration | DIS | Q | DIS | DIS | OF |
| 13004 | Aluminum-tot | AA-Direct | DIS | A | DIS | DIS | |
| 33004 | Arsenic-tot | Flameless AA | DIS | A | DIS | DIS | |
| 06201 | Bicarbonates | Calculated | DIS | Q | DIS | DIS | OF |
| 05451 | Boron-tot | ICAP | DIS | Q | DIS | DIS | W |
| 48002 | Cadmium-tot | AA-Solvent Extract (MIBK) | DIS | A | DIS | DIS | |
| 20113 | Calcium | AA-Direct | DIS | Q | DIS | DIS | OF |
| 06052 | Carbon-tot Inorganic | Infrared | DIS | Q | DIS | DIS | OF |
| 06005 | Carbon-tot Organic | Infrared | DIS | Q | DIS | DIS | OF |
| 06301 | Carbonates | Calculated | DIS | Q | DIS | DIS | OF |
| 17203 | Chloride | Automated Colourimetric | DIS | Q | DIS | DIS | OF |
| 06711 | Chlorophyll- 'a' | Spectrophotometry | DIS | Q | DIS | DIS | |
| 24004 | Chromium-tot | AA-Direct | DIS | A | DIS | DIS | |
| 36012 | Coliform-fec | Membrane filtration | DIS | Q | DIS | DIS | OF |
| 36002 | Coliform-tot | Membrane filtration | DIS | Q | DIS | DIS | OF |
| 02041 | Conductivity | Conductivity Meter | DIS | Q | DIS | DIS | W |
| 29005 | Copper-tot | AA-Solvent Extract (MIBK) | DIS | A | DIS | DIS | |
| 09105 | Fluoride | Specific Ion Electrode | DIS | A | DIS | DIS | |
| 82002 | Lead-tot | AA-Solvent Extract (MIBK) | DIS | A | DIS | DIS | |
| 12102 | Magnesium | AA-Direct | DIS | Q | DIS | DIS | OF |
| 80011 | Mercury-tot | Flameless-AA | DIS | A | DIS | DIS | |
| 42102 | Molybdenum | AA-Solvent Extract (N-Butyl acetate) | DIS | A | DIS | DIS | |
| 07015 | N-TKN | Automated Colourimetric | DIS | Q | DIS | DIS | OF |
| 10401 | NFR | Gravimetric | DIS | Q | DIS | DIS | OF |
| 10501 | NFR( F) | Gravimetric | DIS | Q | DIS | DIS | OF |
| 28002 | Nickel-tot | AA-Solvent Extract (MIBK) | DIS | Q | DIS | DIS | OF |
| 07110 | Nitrate + $NO_2$ | Automated Colourimetric | DIS | Q | DIS | DIS | OF |
| 06521 | Oil and Grease | Pet. Ether Extraction | DIS | A | DIS | DIS | |
| 08102 | Oxygen-diss | Meter | DIS | Q | DIS | DIS | OF |
| 15406 | Phosphorus-tot | Colourimetry | DIS | Q | DIS | DIS | OF |
| 19103 | Potassium | Flame Photometry | DIS | Q | DIS | DIS | OF |
| 34005 | Selenium-Ext | Hydride generation | DIS | A | DIS | DIS | |
| 11103 | Sodium | Flame Photometry | DIS | Q | DIS | DIS | OF |
| 16306 | Sulphate | Colourimetry | DIS | Q | DIS | DIS | OF |
| 10451 | TDS | Gravimetric | DIS | Q | DIS | DIS | OF |
| 02061 | Temperature | Thermometer | DIS | Q | DIS | DIS | OF |
| 23004 | Vanadium-tot | AA-Direct | DIS | A | DIS | DIS | |
| 30005 | Zinc-tot | AA-Solvent Extract (MIBK) | DIS | A | DIS | DIS | |
| 10301 | pH | Electrometric | DIS | Q | DIS | DIS | W |

* Computer storage and retrieval system - Water Security Agency.

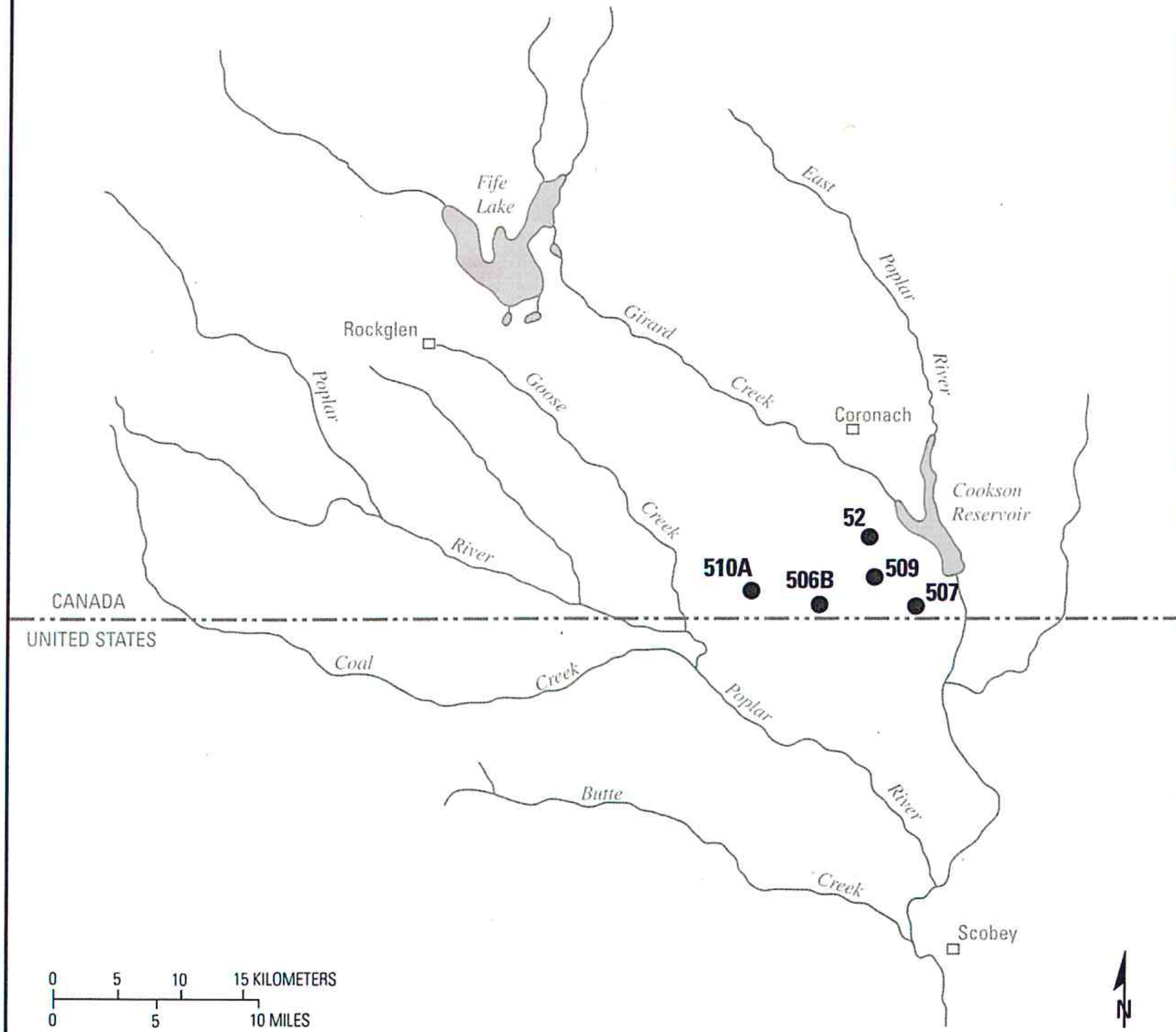
**Symbols**:
W – Weekly during overflow; OF– Once during each period of overflow greater than 2 weeks' duration;
Q – Quarterly; A – Annually; AA – Atomic Absorption; Pot – Potentiometric; tot – total; Pet – Petroleum;
fec – fecal; diss – dissolved; EXT – extract; NFR – Nonfilterable residue; NFR(F) – Nonfilterable residue, fixed;
ICAP – Inductively Coupled Argon Plasma; (MIBK) – sample acidified and extracted with Methyl Isobutyl Ketone;
DIS - Discontinued.

**GROUNDWATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN**

**DUE TO COAL-SEAM DEWATERING NEAR THE INTERNATIONAL BOUNDARY**

| **Responsible Agency: Water Security Agency*** | | | |
|---|---|---|---|
| **Measurement Frequency: Quarterly** | | | |
| **Piezometer Number** | **Location** | **Tip of Screen Elevation (m)** | **Perforation Zone (depth in metres)** |
| 52 | NW 14-1-27 W3 | 738.43 | 43-49 (in coal) |
| 506B | SW 4-1-27 W3 | 48.27 | 81-82 (in coal) |
| 507 | SW 6-1-26 W3 | 725.27 | 34 - 35 (in coal) |
| 509 | NW 11-1-27 W3 | 725.82 | 76-77 (in coal) |
| 510A | NW 1-1-28 W3 | 769.34 | 28-29 (in coal and clay) |

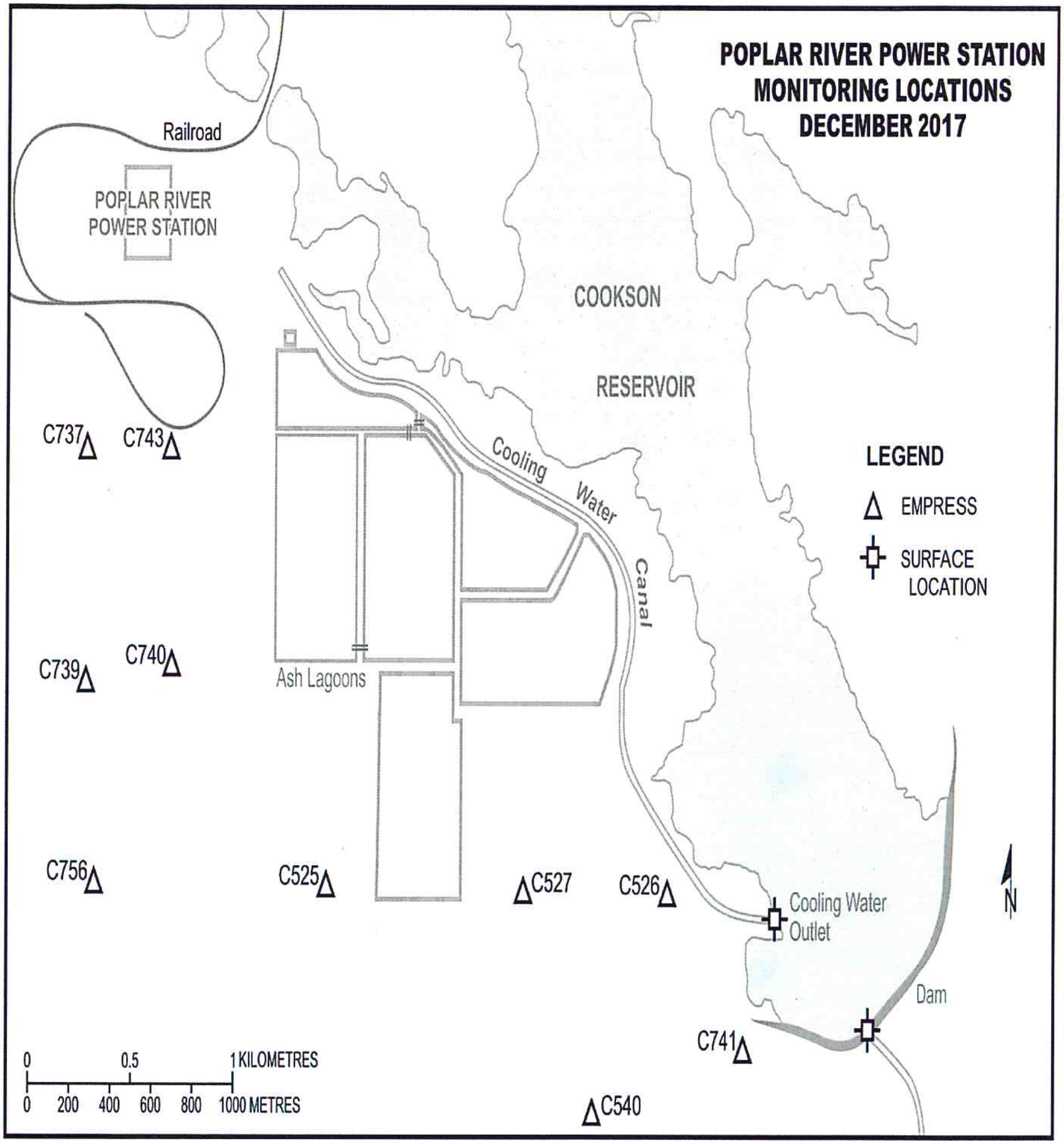
*Data Collected by: SaskPower




**GROUND-WATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL-SEAM DEWATERING**

| GROUNDWATER PIEZOMETER MONITORING<br>POPLAR RIVER<br>POWER STATION AREA--WATER LEVELS | |
|---|---|
| **SPC Piezometer Number** | **Completion Formation** |
| C525 | Empress |
| C526 | Empress |
| C527 | Empress |
| C539 | Empress |
| C540 | Empress |
| C737 | Empress |
| C739 | Empress |
| C740 | Empress |
| C741 | Empress |
| C743 | Empress |
| C756 | Empress |

| GROUNDWATER PIEZOMETER MONITORING<br>POPLAR RIVER<br>POWER STATION AREA--WATER QUALITY | |
|---|---|
| **SPC Piezometer Number** | **Completion Formation** |
| C526 | Empress |
| C540 | Empress |
| C741 | Empress |

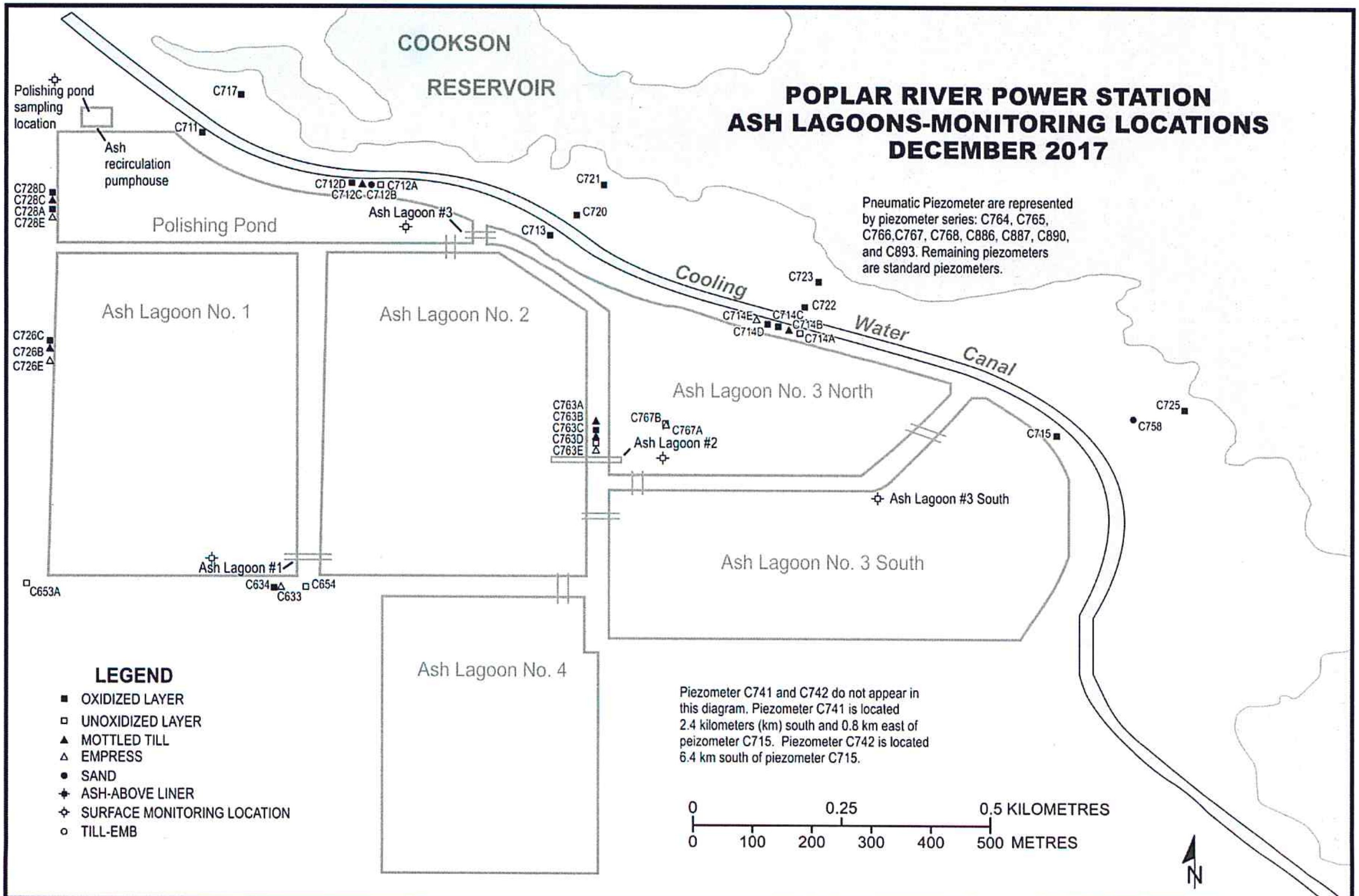

POPLAR RIVER POWER STATION
MONITORING LOCATIONS
DECEMBER 2017
Railroad
POPLAR RIVER
POWER STATION
COOKSON
RESERVOIR
Cooling Water Canal
Ash Lagoons
LEGEND
EMPRESS
SURFACE LOCATION
C737
C743
C739
C740
C756
C525
C527
C526
Cooling Water Outlet
Dam
C741
C540
N
0
0.5
1 KILOMETRES
0 200 400 600 800 1000 METRES

| GROUNDWATER PIEZOMETER MONITORING<br>ASH LAGOON AREA--WATER LEVEL | |
|---|---|
| **SPC Piezometer Number** | **Completion Formation** |
| C533 | Empress |
| C534 | Oxidized Till |
| C654 | Unoxidized Till |
| C711 | Oxidized Till |
| C712A | Unoxidized Till |
| C712B | Intra Till Sand |
| C712C | Mottled Till |
| C712D | Oxidized Till |
| C713 | Oxidized Till |
| C714A | Unoxidized Till |
| C714B | Unoxidized Till |
| C714C | Oxidized Till |
| C714D | Oxidized Till |
| C714E | Empress |
| C715 | Oxidized Till |
| C717 | Oxidized Till |
| C720 | Oxidized Till |
| C721 | Oxidized Till |
| C722 | Oxidized Till |
| C723 | Oxidized Till |
| C725 | Oxidized Till |
| C726B | Unoxidized Till |
| C726C | Oxidized Till |
| C726E | Empress |
| C728A | Oxidized Till |
| C728C | Mottled Till |
| C728D | Oxidized Till |
| C728E | Empress |
| C741 | Empress |
| C742 | Empress |

| GROUNDWATER PIEZOMETER MONITORING<br>ASH LAGOON AREA--WATER LEVEL | |
|---|---|
| **SPC Piezometer Number** | **Completion Formation** |
| C758 | Intra Till Sand |
| C763A | Mottled Till |
| C763B | Oxidized Till |
| C763D | Unoxidized Till |
| C763E | Empress |

| GROUNDWATER PIEZOMETER MONITORING<br>ASH LAGOON AREA -- WATER QUALITY | |
|---|---|
| **SPC Piezometer Number** | **Completion Formation** |
| C533 | Empress |
| C534 | Oxidized Till |
| C654 | Unoxidized Till |
| C711 | Oxidized Till |
| C712A | Unoxidized Till |
| C712B | Intra Till Sand |
| C712C | Mottled Till |
| C712D | Oxidized Till |
| C713 | Oxidized Till |
| C714A | Unoxidized Till |
| C714B | Unoxidized Till |
| C714C | Oxidized Till |
| C714D | Oxidized Till |
| C714E | Empress |
| C715 | Oxidized Till |
| C717 | Oxidized Till |
| C720 | Oxidized Till |
| C721 | Oxidized Till |
| C722 | Oxidized Till |
| C723 | Oxidized Till |
| C725 | Oxidized Till |
| C726B | Unoxidized Till |

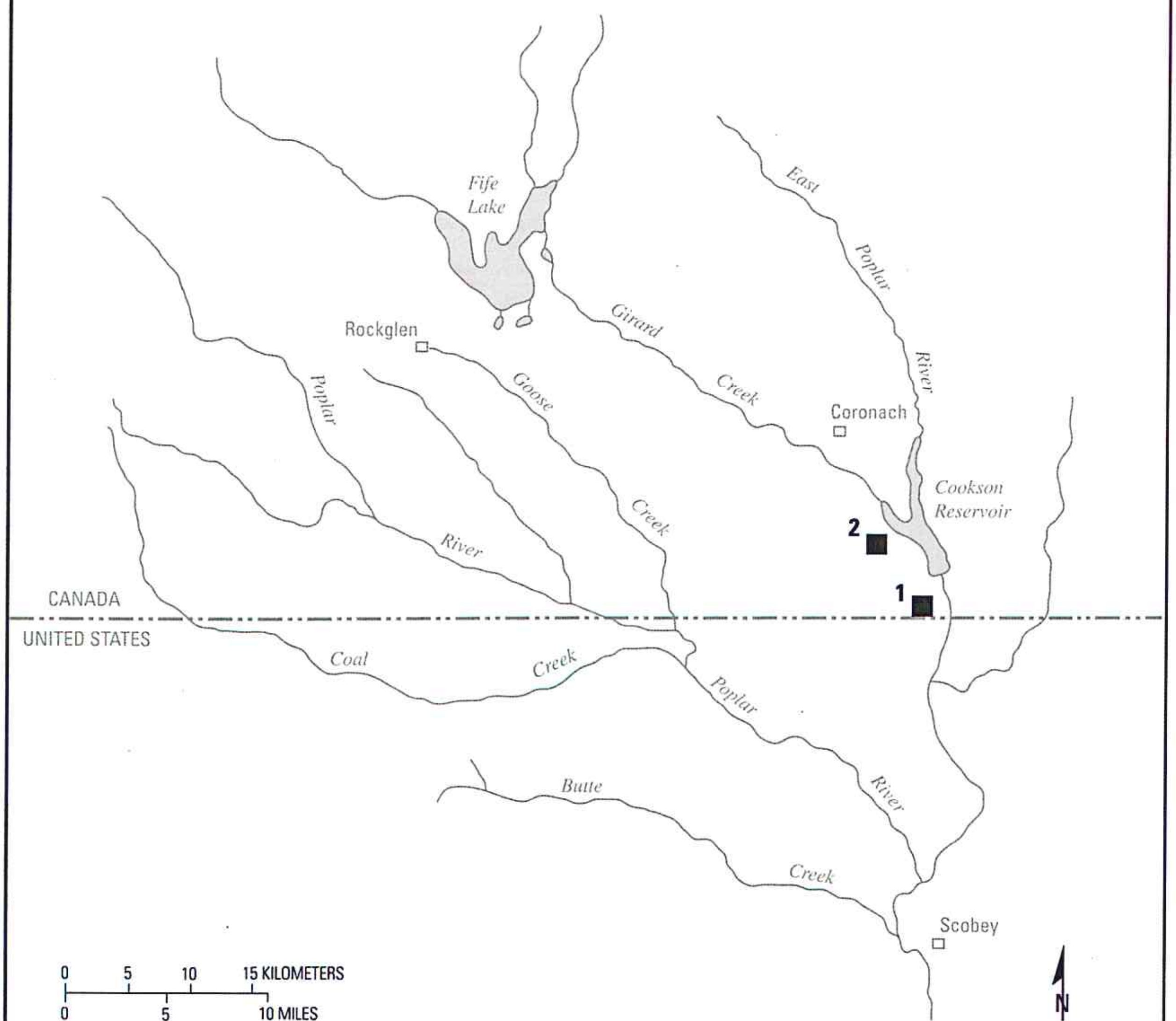
| GROUNDWATER PIEZOMETER MONITORING<br>ASH LAGOON AREA -- WATER QUALITY | |
|---|---|
| **SPC Piezometer Number** | **Completion Formation** |
| C726C | Oxidized Till |
| C726E | Empress |
| C728A | Oxidized Till |
| C728C | Mottled Till |
| C728D | Oxidized Till |
| C728E | Empress |
| C741 | Empress |
| C742 | Empress |
| C758 | Intra Till Sand |
| C763A | Mottled Till |
| C763B | Oxidized Till |
| C763D | Unoxidized Till |
| C763E | Empress |


POPLAR RIVER POWER STATION
ASH LAGOONS-MONITORING LOCATIONS
DECEMBER 2017
COOKSON
RESERVOIR
Pneumatic Piezometer are represented by piezometer series: C764, C765, C766,C767, C768, C886, C887, C890, and C893. Remaining piezometers are standard piezometers.
Polishing pond sampling location
Ash recirculation pumphouse
Polishing Pond
Ash Lagoon No. 1
Ash Lagoon No. 2
Ash Lagoon No. 3 North
Ash Lagoon No. 3 South
Ash Lagoon No. 4
Cooling Water Canal
Ash Lagoon #1
Ash Lagoon #2
Ash Lagoon #3
Ash Lagoon #3 South
C711
C712A
C712B
C712C
C712D
C713
C714A
C714B
C714C
C714D
C714E
C715
C717
C720
C721
C722
C723
C725
C726B
C726C
C726E
C728A
C728C
C728D
C728E
C758
C763A
C763B
C763C
C763D
C763E
C767A
C767B
C633
C634
C653A
C654
LEGEND
OXIDIZED LAYER
UNOXIDIZED LAYER
MOTTLED TILL
EMPRESS
SAND
ASH-ABOVE LINER
SURFACE MONITORING LOCATION
TILL-EMB
Piezometer C741 and C742 do not appear in this diagram. Piezometer C741 is located 2.4 kilometers (km) south and 0.8 km east of peizometer C715. Piezometer C742 is located 6.4 km south of piezometer C715.
0
0.25
0.5 KILOMETRES
0
100
200
300
400
500 METRES
N

## Ambient Air-Quality Monitoring

| **Responsible Agency: Saskatchewan Environment**<br>**Data Collected by: SaskPower** | | | |
|---|---|---|---|
| **No. On Map** | **Location** | **Parameters** | **Reporting Frequency** |
| 1 | International Boundary | Sulphur Dioxide<br><br>Total Suspended Particulate | Continuous monitoring with hourly averages as summary statistics.<br>24-hour samples on 6-day cycle, corresponding to the national air pollution surveillance sampling schedule. |
| 2 | Poplar River Power Station | Wind Speed and Direction | Continuous monitoring with hourly averages as summary statistics |

| **METHODS** | |
|---|---|
| Sulphur Dioxide | Saskatchewan Environment<br><br>Pulsed fluorescence |
| Total Suspended Particulate | Saskatchewan Environment<br><br>High Volume Method |




**AMBIENT AIR-QUALITY MONITORING (CANADA)**

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

2018

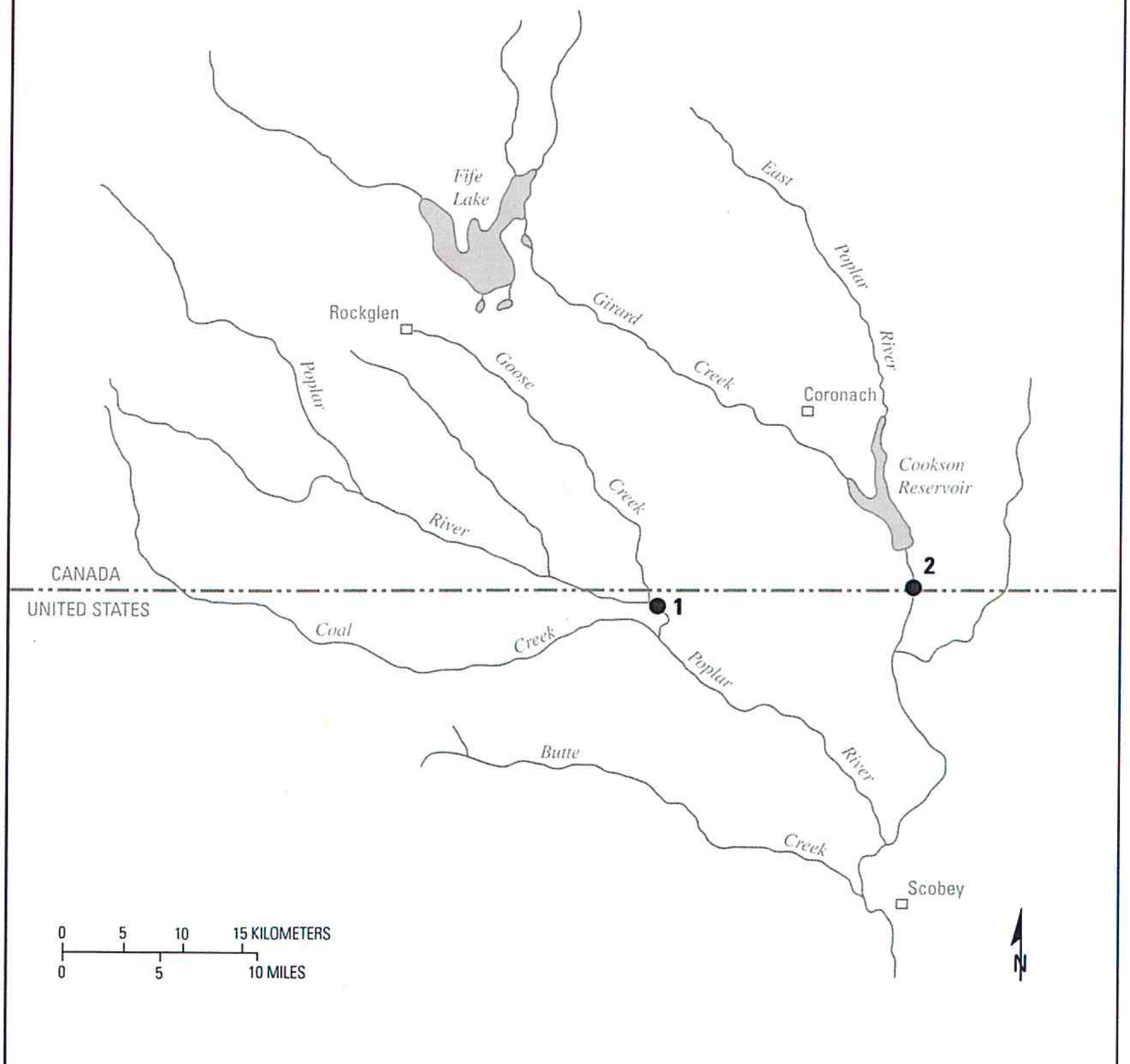
UNITED STATES

## STREAMFLOW MONITORING

Daily mean discharge and monthly statistics as normally published in surface-water-data publications.

| Responsible Agency: U.S. Geological Survey | | |
|---|---|---|
| **No. on Map** | **Station Number** | **Station Name** |
| 1* | 06178000 (11AE008) | Poplar River at International Boundary |
| 2* | 06178500 (11AE003) | East Poplar River at International Boundary |

* International gauging station.




**HYDROMETRIC GAUGING STATIONS (UNITED STATES)**

## SURFACE-WATER-QUALITY MONITORING -- Station Locations

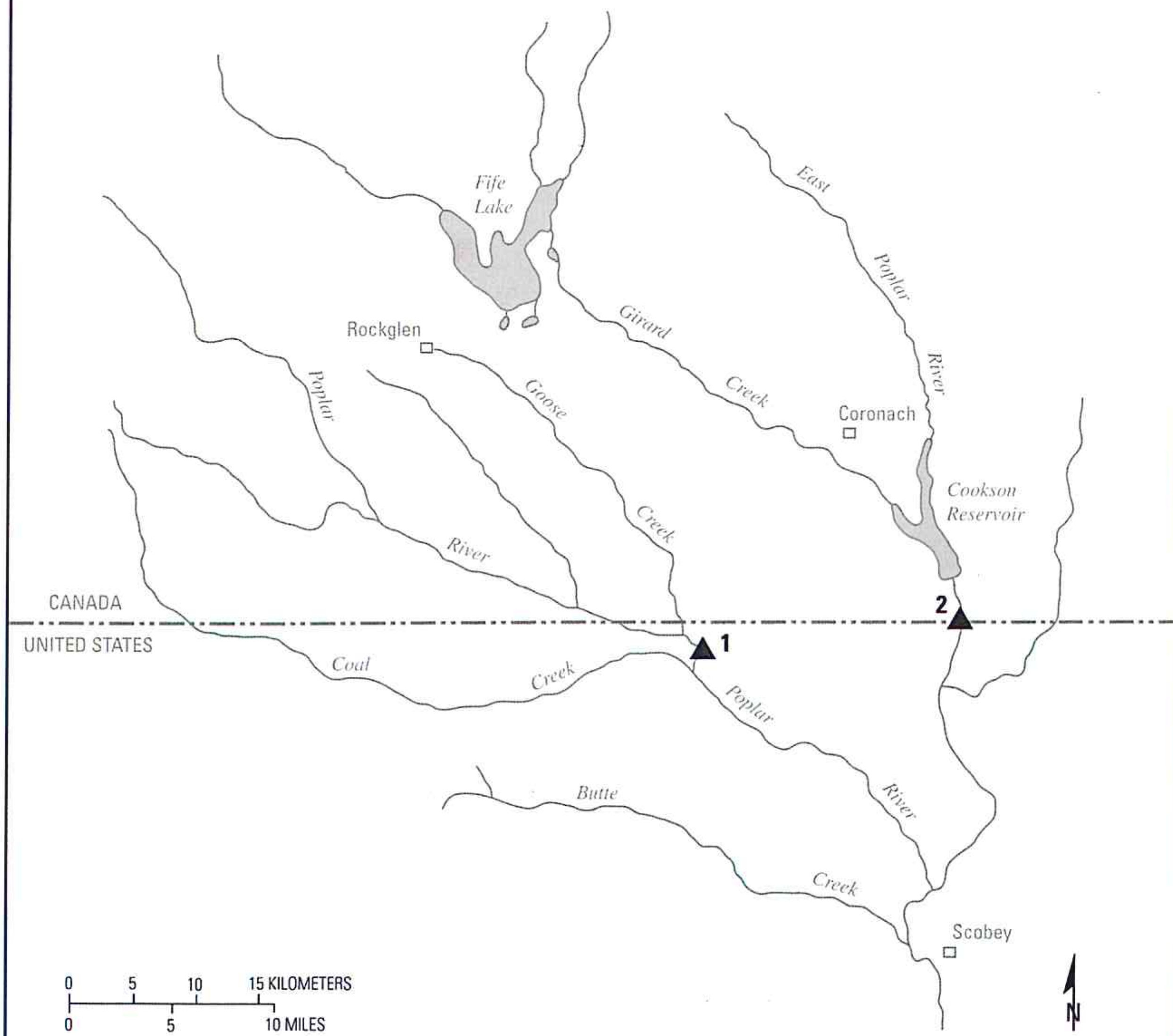
| Responsible Agency: U.S. Geological Survey | | |
|---|---|---|
| **No. On Map** | **USGS Station No.** | **STATION NAME** |
| 1 | 06178000 | Poplar River at International Boundary |
| 2 | 06178500 | East Poplar River at International Boundary |

### PARAMETERS

| | | | Annual Sampling Frequency | |
|---|---|---|---|---|
| **Analytical Code** | **Parameter** | **Analytical Method** | **Site 1*** | **Site 2**** |
| 29801 | Alkalinity - lab | Fixed endpoint Titration | SUS | SUS |
| 00608 | Ammonia - diss | Colorimetric | SUS | SUS |
| 01002 | Arsenic - tot | ICP, MS | SUS | SUS |
| 00025 | Barometric pressure | Barometer, field | SUS | SUS |
| 01020 | Boron – diss | ICP | SUS | SUS |
| 01027 | Cadmium - tot/rec | ICP, MS | SUS | SUS |
| 00915 | Calcium - diss | ICP, AES | SUS | SUS |
| 00940 | Chloride - diss | IC | SUS | SUS |
| 00095 | Conductivity | Electrometric, field | SUS | SUS |
| 00061 | Discharge - inst | Direct measurement | SUS | SUS |
| 00900 | Hardness | Calculated | SUS | SUS |
| 00950 | Fluoride - diss | ISE | SUS | SUS |
| 01051 | Lead - tot/rec | ICP, MS | SUS | SUS |
| 00925 | Magnesium - diss | ICP | SUS | SUS |
| 00613 | Nitrate - diss | Colorimetric | SUS | SUS |
| 00631 | Nitrate + Nitrite - diss | Colorimetric | SUS | SUS |
| 62855 | Nitrogen, total | Colorimetric | SUS | SUS |
| 00300 | Oxygen-diss | Oxygen membrane, field | SUS | SUS |
| 00400 | pH | Electrometric, field | SUS | SUS |
| 00671 | Phos, Ortho-diss | Colorimetric | SUS | SUS |
| 00665 | Phosphorous - tot | Colorimetric | SUS | SUS |
| 00935 | Potassium - diss | ICP, AES | SUS | SUS |
| 00931 | SAR | Calculated | SUS | SUS |
| 80154 | Sediment - conc. | Filtration-Gravimetric | SUS | SUS |
| 70331 | Sediment - %<.063mm | Sieve | SUS | SUS |
| 80155 | Sediment - load | Calculated | SUS | SUS |
| 00955 | Silica - diss | ICP, AES | SUS | SUS |
| 00930 | Sodium - diss | ICP, AES | SUS | SUS |
| 00945 | Sulphate - diss | IC | SUS | SUS |
| 70301 | Total Dissolved Solids | Calculated | SUS | SUS |
| 00010 | Temp Water | Stem Thermometer | SUS | SUS |
| 00020 | Temp Air | Stem Thermometer | SUS | SUS |
| 01092 | Zinc - tot/rec | ICP, MS | SUS | SUS |

**Samples collected obtained during the monthly periods:**
* -- March - April; May; June; July - September
** -- May; June; July; August - September

**Abbreviations:** **AES** - atomic emission spectroscopy; **conc.** – concentration; **diss** – dissolved; **IC** - ion exchange chromatography; **ICP** - inductively coupled plasma; **ISE** – ion-selective electrode; **MS** – mass spectroscopy ; **Org** – organic; **phos.** – phosphate; SAR – sodium adsorption ratio; **SUS** – sampling suspended; **tot** – total; **tot/rec** - total recoverable




**SURFACE-WATER-QUALITY MONITORING STATIONS (UNITED STATES)**

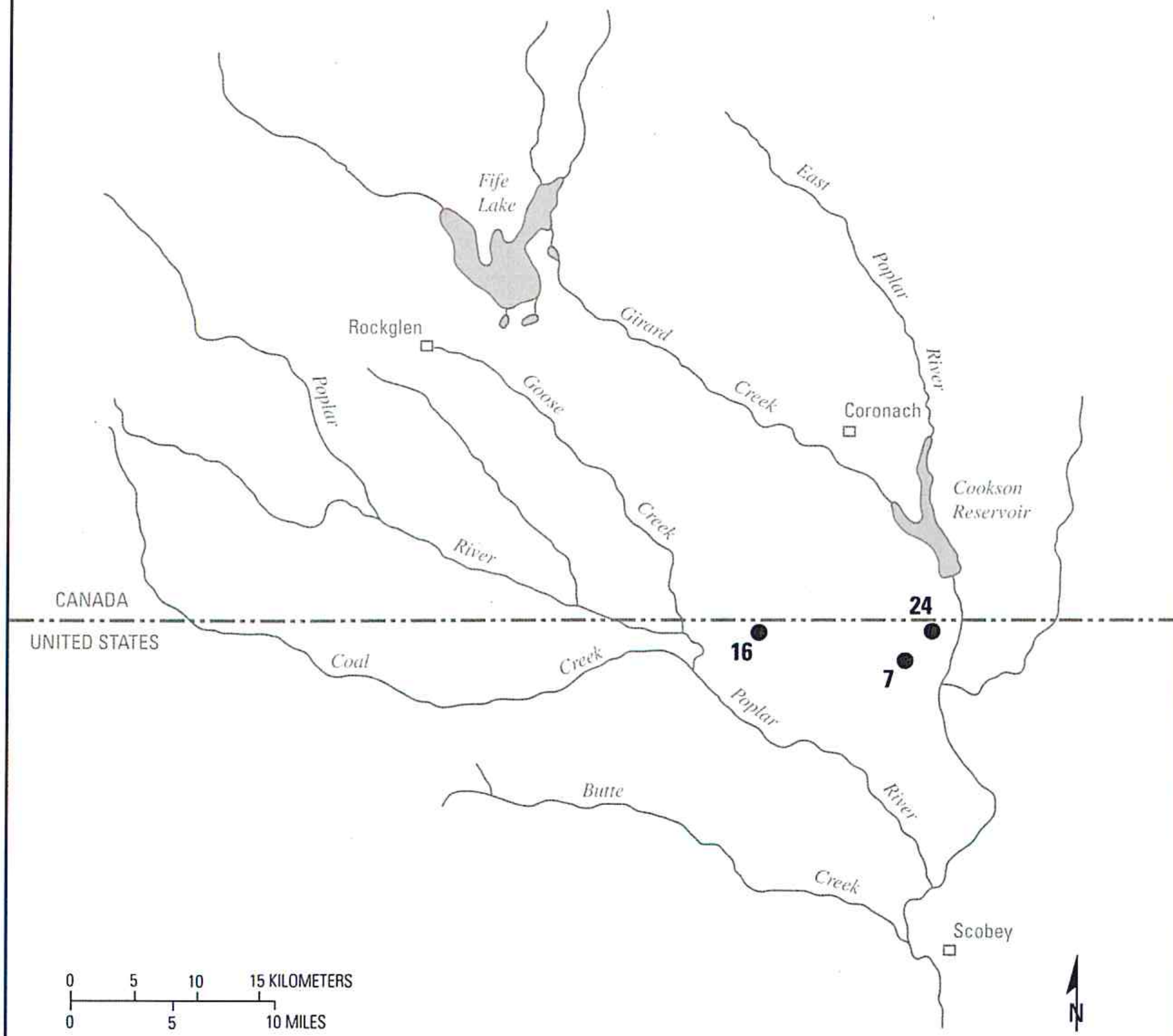
## GROUND-WATER-QUALITY MONITORING -- Station Locations

| Map Number | Well Location | Total Depth (m) | Casing Diameter (cm) | Aquifer | Perforation Zone (m) |
|---|---|---|---|---|---|
| 7 | 37N47E12BBBB | 44.1 | 10.2 | Hart Coal | 39-44 |
| 16 | 37N46E3ABAB | 25.5 | 10.2 | Fort Union | 23-25 |
| 24 | 37N48E5AB | 9.6 | 10.2 | Alluvium | 9.2-9.6 |

**Parameters**

| Storet ** Code | Parameter | Analytical Method | Sampling Frequency Station No. |
|---|---|---|---|
| 00410 | Alkalinity | Calculated | Sample collection is annually for all locations identified above. The analytical method descriptions are those of the Montana Bureau of Mines and Geology Laboratory where the samples are analyzed. |
| 01106 | Aluminum dissolved | ICP or ICP-MS | |
| 01095 | Antimony dissolved | ICP or ICP-MS | |
| 50250 | Arsenic dissolved | ICP or ICP-MS | |
| 01005 | Barium dissolved | ICP or ICP-MS | |
| 01010 | Beryllium dissolved | ICP or ICP-MS | |
| 00440 | Bicarbonates | Electrometric Titration | |
| 01020 | Boron-diss | Emission Plasma, ICP | |
| 82298 | Bromide | Ion Chromatography | |
| 01025 | Cadmium,dissolved | ICP or ICP-MS | |
| 00915 | Calcium | Emission Plasma | |
| 00445 | Carbonates | Electrometric Titration | |
| 00940 | Chloride | Ion Chromatography | |
| 01030 | Chromium, dissolved | ICP or ICP-MS | |
| 01035 | Cobalt, dissolved | ICP or ICP-MS | |
| 00095 | Conductivity | Wheatstone Bridge | |
| 01040 | Copper, dissolved | ICP or ICP-MS | |
| 00950 | Fluoride | Ion Chromatography | |
| 09000 | Hardness | Calculated | |
| 01046 | Iron-diss | Emission Plasma, ICP | |
| 01049 | Lead-diss | Emission Plasma, ICP | |
| 01130 | Lithium-diss | Emission Plasma, ICP | |
| 00925 | Magnesium | Emission Plasma, ICP | |
| 01056 | Manganese-diss | Emission Plasma, ICP | |
| 01060 | Molybdenum | Emission Plasma, ICP-MS | |
| 01065 | Nickel, dissolved | ICP or ICP-MS | |
| 00630 | Nitrate | Ion Chromatography | |
| 00671 | Orthophosphate | Ion Chromatography | |
| 00400 | pH | Electrometric | |
| 00935 | Potassium | Emission Plasma, ICP | |
| 00931 | SAR | Calculated | |
| 01145 | Selenium-diss | ICP-MS | |
| 00955 | Silica | Emission Plasma, ICP-MS | |
| 01075 | Silver, dissolved | ICP-MS | |
| 00930 | Sodium | Emission Plasma, ICP | |
| 01080 | Strontium-diss | Emission Plasma, ICP | |
| 00445 | Sulphate | Ion Chromatography | |
| 01057 | Thallium, dissolved | ICP or ICP-MS | |
| 01150 | Titanium, dissolved | ICP or ICP-MS | |
| 28011 | Uranium, dissolved | ICP-MS | |
| 01085 | Vanadium, dissoved | ICP or ICP-MS | |
| 00190 | Zinc-diss | Emission Plasma, ICP | |
| 01160 | Zirconium, dissolved | ICP or ICP-MS | |
| * | Sum of diss. Constituents | Calculated | |
| 70301 | TDS | Calculated | |

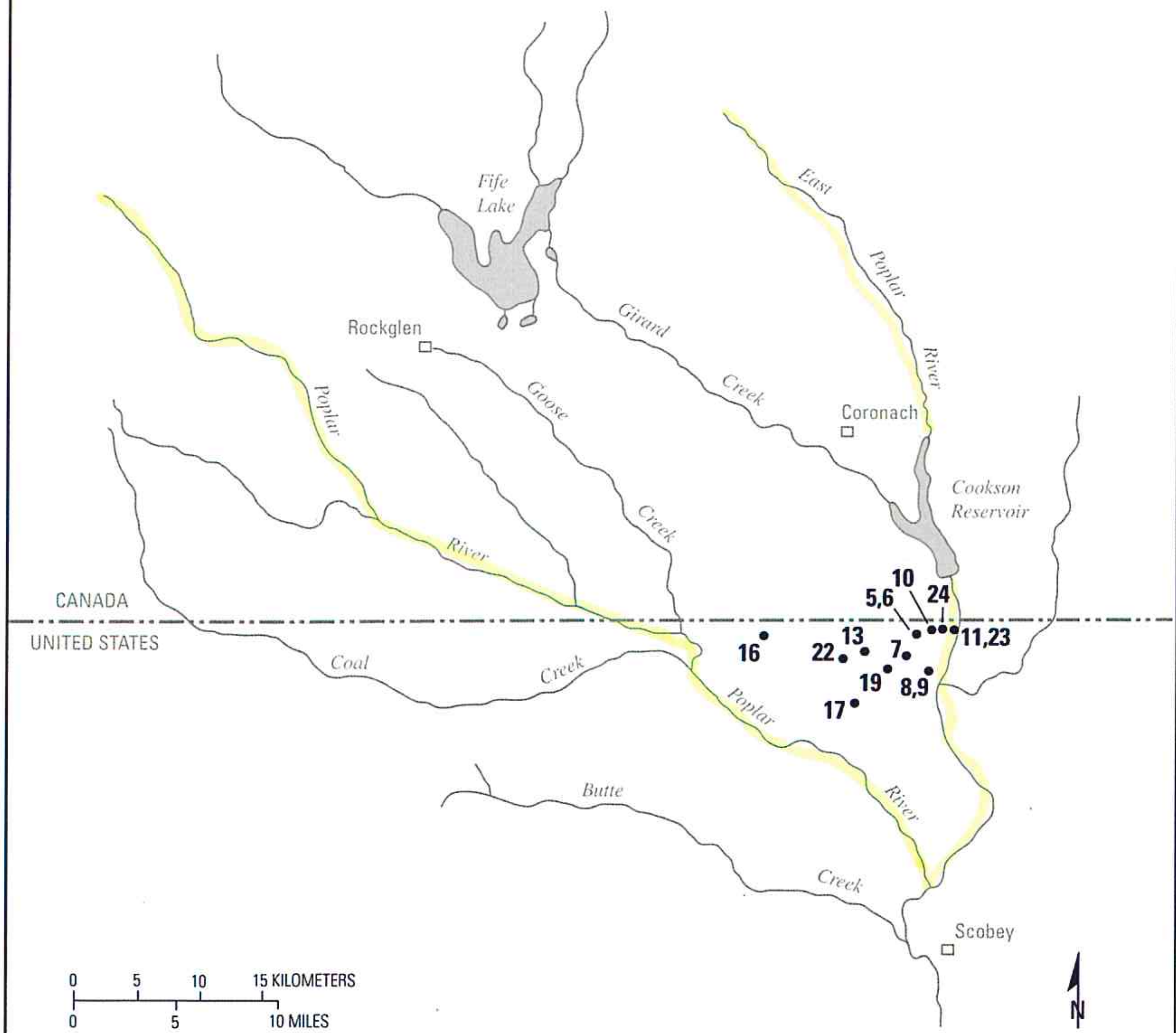
**SYMBOLS:**
* - Sum of Dissolved Constituents; calculated the same as TDS but includes all reported bicarbonate
** - Computer storage and retrieval system -- EPA **ICP** – Inductively Coupled Plasma Unit
**cm** – centimetre **ICP – MS** – Inductively Coupled Plasma – Mass Spectrometry **diss** – dissolved **m** – metre




**GROUND-WATER-QUALITY MONITORING (UNITED STATES)**

## GROUNDWATER LEVELS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL-SEAM DEWATERING

| **Responsible Agency: Montana Bureau of Mines and Geology** | | |
|---|---|---|
| **No. on Map** | **Montana Ground Water Information Center ID No.** | **Sampling** |
| 5 | GWIC ID 4231 | Determine water levels quarterly |
| 6 | GWIC ID 4227 | Determine water levels quarterly |
| 7 | GWIC ID 4267 | Determine water levels quarterly |
| 8 | GWIC ID 4287 | Determine water levels quarterly |
| 9 | GWIC ID 4274 | Determine water levels quarterly |
| 10 | GWIC ID 4340 | Determine water levels quarterly |
| 11 | GWIC ID 4329 | Determine water levels quarterly |
| 13 | GWIC ID 4248 | Determine water levels quarterly |
| 16 | GWIC ID 4211 | Determine water levels quarterly |
| 17 | GWIC ID 4297 | Determine water levels quarterly |
| 19 | GWIC ID 4290 | Determine water levels quarterly |
| 22 | GWIC ID 4261 | Determine water levels quarterly |
| 23 | GWIC ID 124105 | Determine water levels quarterly |
| 24 | GWIC ID 144835 | Determine water levels quarterly |




**GROUND-WATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL-SEAM DEWATERING**

**ANNEX 3**

# RECOMMENDED FLOW APPORTIONMENT

# IN THE POPLAR RIVER BASIN

# BY THE INTERNATIONAL SOURIS-RED RIVERS ENGINEERING BOARD,

# POPLAR RIVER TASK FORCE (1976)

## *RECOMMENDED FLOW APPORTIONMENT IN THE POPLAR RIVER BASIN

The aggregate natural flow of all streams and tributaries in the Poplar River Basin crossing the International Boundary shall be divided equally between Canada and the United States subject to the following conditions:

1. The total natural flow of the West Fork Poplar River and all its tributaries crossing the International Boundary shall be divided equally between Canada and the United States but the flow at the International Boundary in each tributary shall not be depleted by more than 60 percent of its natural flow.

2. The total natural flow of all remaining streams and tributaries in the Poplar River Basin crossing the International Boundary shall be divided equally between Canada and the United States. Specific conditions of this division are as follows:

    (a) Canada shall deliver to the United States a minimum of 60 percent of the natural flow of the Middle Fork Poplar River at the International Boundary, as determined below the confluence of Goose Creek and Middle Fork.

    (b) The delivery of water from Canada to the United States on the East Poplar River shall be determined on or about the first day of June of each year as follows:

        (i) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period does not exceed 4,690 cubic decameters (3,800 acre-feet), then a continuous minimum flow of 0.028 cubic metres per second (1.0 cubic foot per second) shall be delivered to the United States on the East Poplar River at the International Boundary throughout the succeeding 12 month period commencing June 1st. In addition, a volume of 370 cubic decameters (300 acre-feet) shall be delivered to the United States upon demand at any time during the 12 month period commencing June 1st.

* Canada-United States, 1976, Joint studies for flow apportionment, Poplar River Basin, Montana-Saskatchewan: Main Report, International Souris-Red Rivers Board, Poplar River Task Force, 43 pp.

(ii) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period is greater than 4,690 cubic decameters (3,800 acre-feet), but does not exceed 9,250 cubic decameters (7,500 acre-feet), then a continuous minimum flow of 0.057 cubic metres per second (2.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.028 cubic metres per second (1.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 617 cubic decameters (500 acre-feet) shall be delivered to the United States upon demand at any time during the 12-month period commencing June 1st.

(iii) When the total natural flow of the Middle Fork Poplar River, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period is greater than 9,250 cubic decameters (7,500 acre-feet), but does not exceed 14,800 cubic decameters (12,000 acre-feet), then a continuous minimum flow of 0.085 cubic metres per second (3.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.057 cubic metres per second (2.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 617 cubic decameters (500 acre-feet) shall be delivered to the United States upon demand at any time during the 12 month period commencing June 1st.

(iv) When the total natural flow of the Middle Fork Poplar, as determined below the confluence of Goose Creek, during the immediately preceding March 1st to May 31st period exceeds 14,800 cubic decameters (12,000 acre-feet) then a continuous minimum flow of 0.085 cubic metres per second (3.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary during the succeeding period June 1st through August 31st. A minimum delivery of 0.057 cubic metres per second (2.0 cubic feet per second) shall then be maintained from September 1st through to May 31st of the following year. In addition, a volume of 1,230 cubic decameters (1,000 acre-feet) shall be delivered to the United States upon demand at any time during the 12-month period commencing June 1st.

(c) The natural flow at the International Boundary in each of the remaining individual tributaries shall not be depleted by more than 60 percent of its natural flow.

3. The natural flow and division periods for apportionment purposes shall be determined, unless otherwise specified, for periods of time commensurate with the uses and requirements of both countries.

# ANNEX 4

CONVERSION FACTORS

CONVERSION FACTORS

| | | |
|---|---|---|
| ac | = | 4,047 $m^3$ = 0.04047 ha |
| ac-ft | = | 1,233.5 $m^3$ = 1.2335 $dam^3$ |
| °C | = | 5/9(°F-32) |
| cm | = | 0.3937 in. |
| $cm^2$ | = | 0.155 $in^2$ |
| $dam^3$ | = | 1,000 $m^3$ = 0.8107 ac-ft |
| $ft^3$ | = | 28.3171 x $10^{-3} m^3$ |
| ha | = | 10,000 $m^2$ = 2.471 ac |
| hm | = | 100 m = 328.08 ft |
| $hm^3$ | = | 1 x $10^6$ $m^3$ |
| I. gpm | = | 0.0758 L/s |
| in | = | 2.54 cm |
| kg | = | 2.20462 lb = 1.1 x $10^{-3}$ tons |
| km | = | 0.62137 miles |
| $km^2$ | = | 0.3861 $mi^2$ |
| L | = | 0.3532 $ft^3$ = 0.21997 I. gal = 0.26420 U.S. gal |
| L/s | = | 0.035 cfs = 13.193 I. gpm = 15.848 U.S. gpm |
| m | = | 3.2808 ft |
| $m^2$ | = | 10.765 $ft^2$ |
| $m^3$ | = | 1,000 L = 35.3144 $ft^3$ = 219.97 I. gal= 264.2 U.S. gal |
| $m^3$/s | = | 35.314 cfs |
| mm | = | 0.00328 ft |
| tonne | = | 1,000 kg = 1.1023 ton (short) |
| U.S. gpm | = | 0.0631 L/s |

<u>For Air Samples</u>

ppm = 100 pphm = 1000 x (Molecular Weight of substance/24.45) mg/$m^3$