1988 ANNUAL REPORT

to the

GOVERNMENTS OF CANADA, UNITED STATES,

SASKATCHEWAN AND MONTANA

by the

POPLAR RIVER BILATERAL MONITORING COMMITTEE

COVERING CALENDAR YEAR 1988

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POPLAR RIVER BILATERAL MONITORING COMMITTEE

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

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

Department of External Affairs
Ottawa, Ontario, Canada

Saskatchewan Environment
Regina, Saskatchewan, Canada

Gentlemen:

During 1988, the Poplar River Bilateral Monitoring Committee continued to fulfill the responsibilities assigned by the governments under the Poplar Cooperative Monitoring Arrangement dated September 23, 1980. Through the exchange of Diplomatic Notes, on March 12, 1987, the Arrangement was extended to March 1991. Water quantity, water quality, and air quality relevant to the International Boundary were monitored in accordance to the 1987 Technical Monitoring Schedule. The monitoring data were exchanged on a quarterly basis. Herein is the report of activities of 1988 and the proposed monitoring schedule for 1989.

The report summarizes current conditions relative to pre-project conditions and compares current conditions to guidelines for specific parameter values that were developed by the International Joint Commission under the 1977 Reference from Canada and the United States. References are made to State, Provincial, or Federal standards or objectives where these are relevant. After examination and evaluation of the monitoring information for 1988, the Committee finds that the measured conditions are within the norms of the accepted objectives.

During 1988, monitoring continued with only minor changes in site locations and schedules from 1987. Coal mining will continue in 1989 west of Girard Creek in a northwesterly direction. Prairie Coal Limited plans to move the drag lines in the latter part of 1989 and begin mining the South Block.

Yours sincerely,

J. R. Knapton
Chairman, United States Section

R. A. Halliday
Chairman, Canadian Section

R. E. Driear
Member, United States Section

D. A. Fast
Member, Canadian Section

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1988 HIGHLIGHTS

The Poplar River Power Station completed its fifth full year of operation in 1988. The two 300 megawatt coal-fired units generated 4,568,800 gross megawatt hours of electricity, up 5 percent from 1987 and 15 percent from 1986. Following the trend of past years, plant startups decreased, resulting in a decreased oil consumption of 200 tonnes compared to 1987.

Monitoring information collected in both Canada and the United States was exchanged on a quarterly basis. In general the sampling locations, frequency of collection, and parameters met the requirements identified in the 1988 Technical Monitoring Schedules set forth in the 1987 annual report.

Regional drought conditions resulted in streamflows being much below normal in 1988. The recorded flow volume of the East Poplar River at the International Boundary for 1988 was only 23 percent of the mean annual flow since completion of the Morrison Dam in 1975. However, the United States received a continuous flow in the East Poplar River throughout the year and all aspects of the International Joint Commission's apportionment recommendations were met.

The concentrations of boron and total dissolved solids on the East Poplar River were below the long-term and short-term objectives recommended to Government by the International Joint Commission. One excursion of a minor nature of other water quality objectives was measured on the East Poplar River at the International Boundary. Quality control sample splits showed improved comparability between Canadian and United States laboratories.

The outer limit of the cone of depression from coal seam dewatering remained about the same distance north of the International Boundary. Pumpage from the mine had a 37 percent decrease compared to pumpage in 1987.

The total estimate of seepage from the ash lagoons and polishing pond was 0.90 litre per second, much less than seepage limits proposed by the International Poplar River Water Quality Board. The leachate front was calculated to have advanced 10.79 metres towards Cookson Reservoir since the ponds were first filled.

Plant stack emissions did not cause or contribute to violation of Montana, United States or Saskatchewan ambient air quality standards.

INTRODUCTION

The Poplar River Bilateral Monitoring Committee was authorized for an initial period of 5 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. On March 12, 1987 the Arrangement was extended by the Governments for 4 years to March 1991.

The Committee is composed of representatives of the Government of the United States of America, State of Montana, and Government of Canada and Province of Saskatchewan. In addition to the representatives of Governments, two ex-officio members who are local representatives of the State of Montana and Province of Saskatchewan participate in the activities of the Committee. During 1988, the members and ex-officio members of the Committee were:

Mr. J.R. Knapton
U.S. Geological Survey
Chairman, United States Section

Mr. R.E. Driear
Governor's Office
Member, United States Section

Mr. C.W. Tande
Daniels County Commissioner
Ex-Officio Member, Montana

Mr. R.A. Halliday
Environment Canada
Chairman, Canadian Section

Mr. D.A. Fast
Environment Canada
Member, Canadian Section

Mr. J.R. Totton
Reeve, R.M. of Hart Butte
Ex-Officio Member, Saskatchewan

The monitoring programs are in response to potential impacts of a transboundary nature resulting from Saskatchewan Power Corporation's 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 both surface water and ground water and for air quality. Participants from both countries, including Federal, Provincial, and State 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, with the report for 1988 being the eighth report in the series. 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 forthcoming year. The Committee will continue to review and propose changes to the Technical Monitoring Schedules as information requirements change.

Another responsibility of the Committee includes an ongoing quarterly exchange of data acquired through the monitoring programs. The exchange of monitoring information was initiated with the first quarter of 1981, and is an expansion of the informal quarterly information exchange program initiated between Canada and the United States in 1976. Special reports dealing with aspects of monitoring and monitoring results requested by the Committee are sometimes published. Any such reports are reviewed annually by the Committee. Reports reviewed by the Committee during 1988 are identified in Annex 3. Exchanged data and reports are available for public viewing at the agencies of the participating governments or from Committee members.

POPLAR RIVER POWER STATION

Operations

The 1988 operating statistics for the two units at Poplar River Power Station are shown in Table 1. The capacity factor of 96.2 percent of Unit No. 2 was the highest since the unit was commissioned. A major repair of the boiler for Unit No. 1 during the fourth quarter accounts for the lower capacity factor of Unit No. 1.

Table 1. 1988 Operating Statistics for Generating Units No. 1 and No. 2

	Unit No. 1	Unit No. 2
Hours of Operation	6,958	8,458
Gross MWH Generated	2,083,500	2,485,300
Availability (hours)(percent)	79.21	96.29
Capacity Factor (percent)	79.6	96.2
Number of Start-ups	10	6
Coal Consumed (tonnes)	1,787,510	2,129,321
Oil Consumed (tonnes)	1,412	747
Hours in Period	8,784	8,784

The average sulphur content of the coal was 0.60 percent. Analyses were conducted by the Poplar River Power Station laboratory. Analyses of a monthly duplicate coal sample by an independent laboratory indicated, on average, a 0.1 percent lower value. Testing was done in accordance with ASTM procedure D3176. The sulphur content of the fuel oil was 0.80 percent.

Two reportable spills occurred during 1988, April 13 and July 27. Both spills involved the discharge of ash/ash water. The April 13, 1988 spill resulted from a failed gasket on ash line "C" by the west side of Ash Lagoon No. 1. Ash/ash water in the amount of 15 cubic meters (m^3) was released and all was contained in a small area.

The 1988 July 27 spill occurred because of an eroded elbow on ash line "C" west of the ash recirculation building. About 250 m^3 of ash/ash water were released. None reached the reservoir. To reduce the occurrence of an ash/ash water spill in the future, two of the three ash lines from the power station and the lagoons were completely changed in the third quarter of 1988. The Poplar River Power Station has also instituted an ash line thickness monitoring program to keep track of the condition of the ash lines.

Operation of the ash lagoons was similar to 1987. Most of the ash was directed to Ash Lagoon No. 1 during 1988. Ash Lagoon No. 3 was used to a greater extent in 1988. Surcharging continued on Ash Lagoon No. 1. Monitoring of the surcharge ash will be started in 1989.

The revegetation project started in 1987 was continued and expanded in 1988. Several species continued to show promise. Testing will continue in 1989.

Construction

There was no construction activity during 1988.

Mining

Coal mining continued to the west of Girard Creek and will continue in a northwesterly direction in 1989. The South Block infrastructure was developed in 1988, including construction of the causeway crossing the East Poplar River. Prairie Coal Limited plans to move the draglines to the South Block by the end of June 1989 to begin mining operations there. Saskatchewan Power Corporation plans to continue dewatering operations at the abandoned mine site to supplement the water supply in Cookson Reservoir.

SURFACE WATER QUANTITY

Streamflow

Streamflow in the Poplar River basin was much below normal during 1988, assuming the recorded flow of the Poplar River at the International Boundary is a good indicator of natural runoff conditions in the basin. The March to October recorded flow volume at the gauge was only 1,180 cubic decametres (dam^3), or 7 percent of the long-term average. The volume is the smallest since records began in 1931 and indicative of general drought conditions in the great plains. A comparison of the flows of 1988 with those of the 1951-80 median flow is shown in Figure 1.

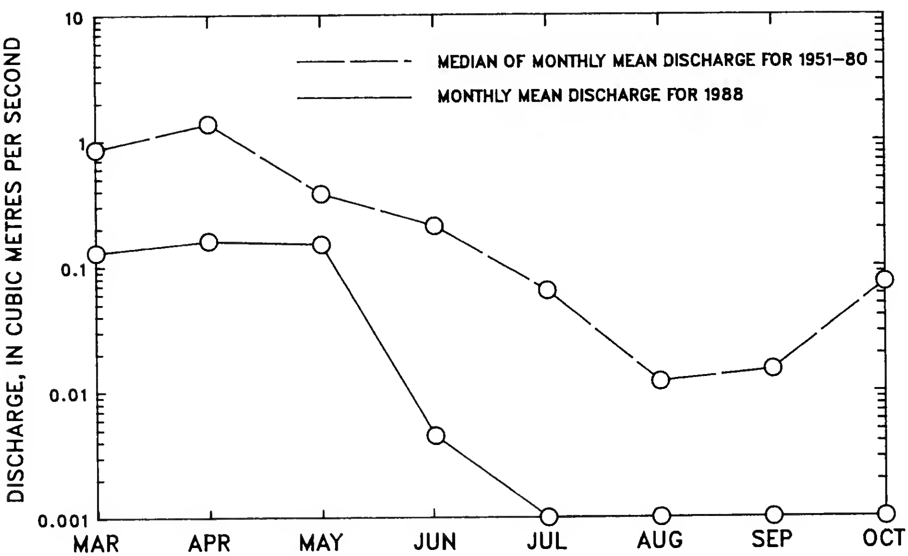


Figure 1. Discharge during 1988 Compared with Median Discharge for 1951-1980 for the Poplar River at International Boundary.

The recorded flow volume of the East Poplar River at the International Boundary for 1988 was 2,560 dam^3, or 23 percent of the mean annual flow since the completion of Morrison Dam in 1975.

Quality Control

A set of simultaneous streamflow measurements was made on the East Poplar River at the International Boundary on May 17, 1988, by personnel of Environment Canada (EC), and the U.S. Geological Survey (USGS). Measurement results were within allowable differences. The results are shown in Table 2.

Table 2. Simultaneous Streamflow Measurement Results

Agency	Cross Section	Width (m)	Mean Area (m^2)	Velocity (m/s)	Gauge Height (m)	Dis- charge (m^3/s)
EC	A	5.60	0.66	0.330	1.698	0.218
USGS	A	5.49	0.64	0.320	1.695	0.206
USGS	B	--	--	--	1.695	0.202

Notes

1. Section A is the GEOWEB measuring section; Section B is a "head" determination at the 90 V-notch control applied to a theoretical equation.

2. Measurements at Section A were made with a Pygmy meter.

3. Original work by USGS was done in English units and converted to metric.

Reservoir Storage

Cookson Reservoir was near 80 percent of the full-supply volume (43,400 dam^3) for the first four months of the year, but contents decreased to 61 percent of capacity by December 31 because of much below normal precipitation. Elevations and contents for selected dates are given in Table 3.

Table 3. Cookson Reservoir Storage Statistics for 1988

Date (1988)	Elevation (m)	Contents (dam^3)
January 1	751.822	34,700
March 23 (maximum)	751.829	34,700
December 31	750.491	26,400
Full-Supply Level	753.000	43,400

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 apportionment of waters of the Poplar River basin. Although not officially adopted by the two countries, the Poplar River Bilateral Monitoring Committee has adhered to the Apportionment Recommendations in each of its annual reports. Annex 4 contains the apportionment recommendation.

Minimum Flows

The recorded runoff volume of the Poplar River at the International Boundary from March 1 to May 31, 1988 was 1,160 dam^3. For the purposes of interpreting the apportionment recommendations of the IJC, the recorded flow is assumed to be the natural flow. Based on these recommendations, this volume entitled the United States to a minimum discharge of 0.028 cubic metre per second (m^3/s) from June 1, 1988 to May 31, 1989, on the East Poplar at the International Boundary. The minimum flow of 0.028 m^3/s for the first 5 months of 1988 had previously been determined on the basis of March 1 to May 31, 1987 Poplar River flow volume.

A hydrograph of flow in the East Poplar River at the International Boundary and the minimum flow as recommended by the IJC are shown in Figure 2.

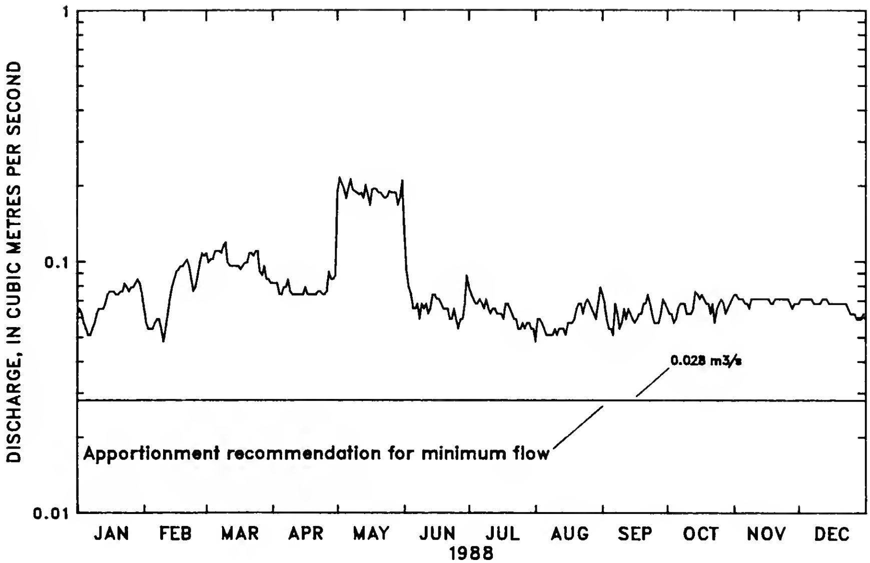


Figure 2. Hydrograph of Water Discharge of the East Poplar River at the International Boundary and Recommended Minimum Flow.

On-Demand Release

Based on the apportionment recommendation of the IJC, the United States is entitled to an on-demand volume of 370 dam^3 at any time from June 1, 1988 to May 31, 1989. As of December 31, 1988 Montana had not requested this release. The on-demand volume entitlement for 1987 of 370 dam^3 was requested on March 21, 1988, to be delivered May 1 to 30. A volume of 488 dam^3 was delivered during this period.

SURFACE WATER QUALITY

East Poplar River

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 mg/L for boron and 1500 mg/L for total dissolved solids 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 1000 mg/L or less for total dissolved solids in the East Poplar River at the International Boundary.*

For the period prior to 1982, three-month moving flow-weighted concentrations (FWC) for boron and total dissolved solids (TDS) have been calculated solely from monthly monitoring results. Since the beginning of 1982, the USGS has monitored specific conductance daily in the East Poplar River at the International Boundary, allowing estimates of daily boron and TDS concentration to be derived from regression relationships with specific conductance. Thus, three-month FWCs for the period 1982 to 1988 have been calculated from both the results of monthly monitoring and the daily concentration estimates.

The Bilateral Monitoring Committee has adopted the approach that for the purposes of comparison with the proposed IJC long-term objectives, the boron and TDS data are best graphically plotted as 5-year moving flow-weighted concentrations which are advanced one month at a time. Prior to this year, long-term averages were calculated from a 5 year period in which 2.5 years preceded and 2.5 years followed each plotted point. The FWCs in this report are calculated from the five year period preceding each plotted point. For example, the FWC for December 1988 refers to the FWC of the period December 1983 to December 1988. It should be emphasized that the calculations have been based on the results of all samples collected, and not restricted to samples collected during March to October.

Total Dissolved Solids

Grab sample TDS concentrations during 1988 ranged from 859 milligrams per liter (mg/L) (September 7) to 1,169 mg/L (January 6). The 1988 TDS results are presented in Figure 3.

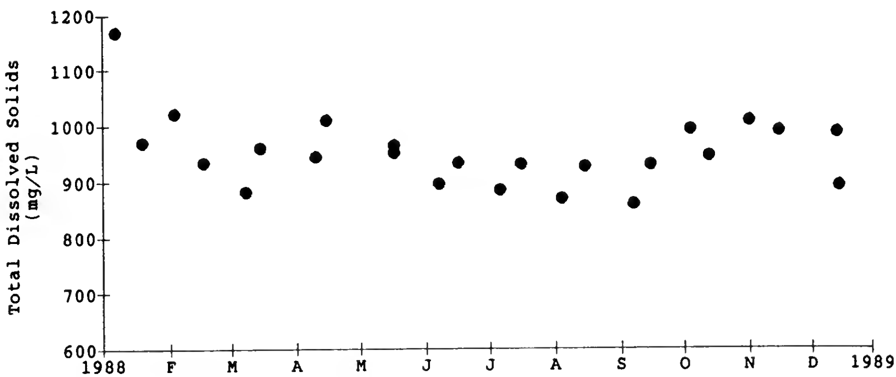


Figure 3. 1988 TDS Grab Sample Data, East Poplar River at International Boundary

The proposed short-term objective for TDS is 1,500 mg/L. A time plot of the three-month moving FWCs for TDS is presented in Figure 4. No exceedences of the objective have been observed during any three month period since 1975. The three-month FWCs moved within a narrow range near 900 mg/L during 1988, reflecting lower than normal discharges during the spring period.

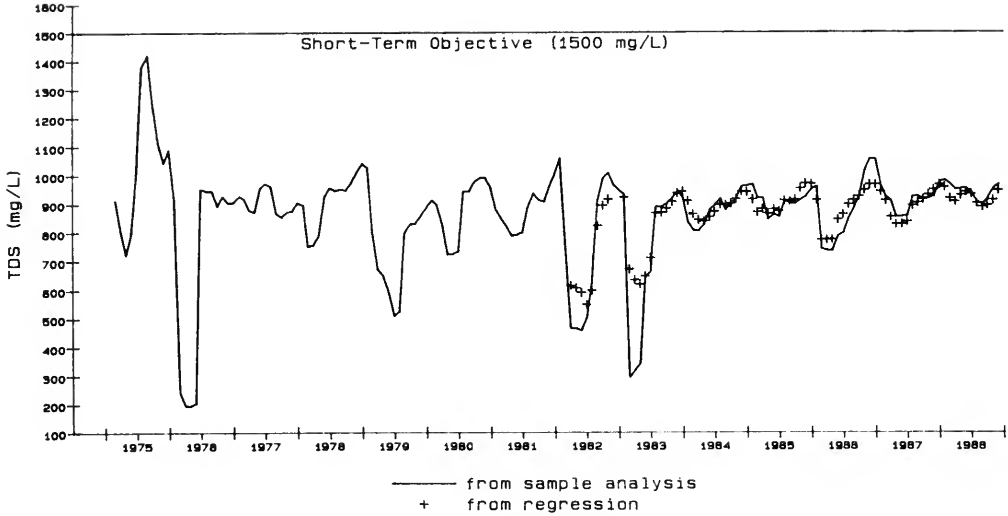


Figure 4. TDS Three-Month Moving Flow-Weighted Concentration, East Poplar River at International Boundary.

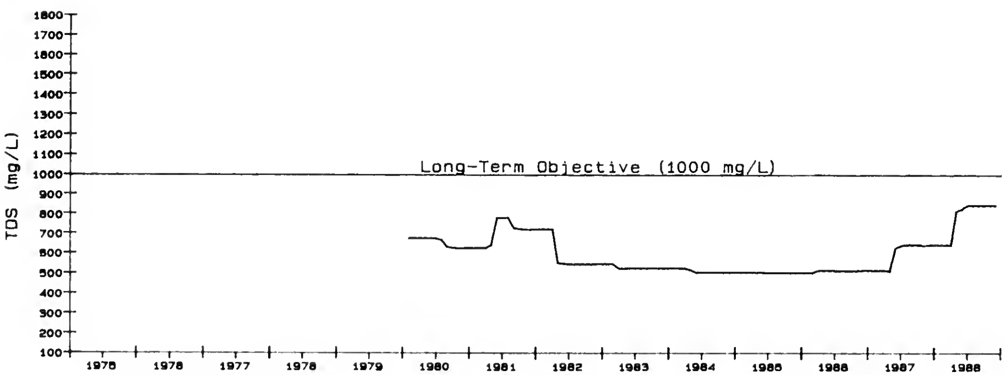


Figure 5. TDS Five-Year Moving Flow-Weighted Concentration, East Poplar River at International Boundary.

Five-year FWCs for TDS (Figure 5) remained below the long-term objective of 1,000 mg/L. A 200 mg/L increase in the five-year FWCs occurred in early 1988. This corresponds to a loss of the influence of high 1983 spring flows. A similar increase was seen during 1987, a remnant of 1982 discharge. Relatively low spring discharges have occurred since 1984; it is expected that the five-year FWCs for the next few years will level off if spring discharges remain low, or decrease if high runoff years occur.

The relationship between TDS and specific conductance generated from data collected to the end of 1988 was as follows:

$$TDS = (0.640 \times \text{specific conductance}) + 10.875$$
$$(R^2 = 0.87,\ n=350)$$

Boron

During 1988, boron concentrations in the East Poplar River at the International Boundary varied from 1.7 mg/L (May 17) to 2.6 mg/L (January 6) (Figure 6).

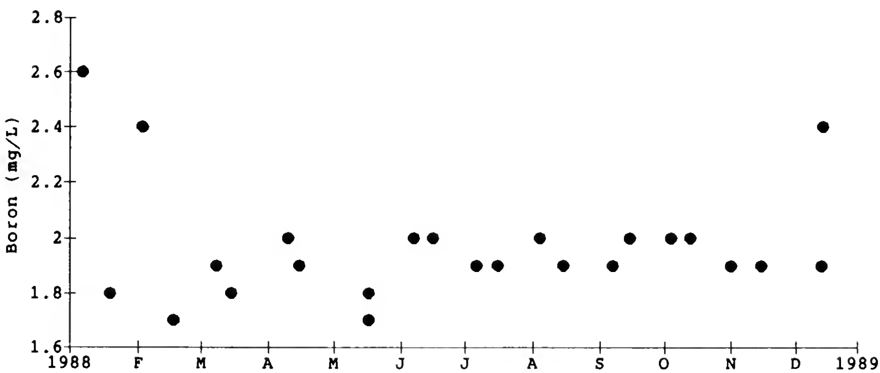


Figure 6. 1988 Boron Grab Sample Data, East Poplar River at International Boundary.

Three-month boron FWCs for the period of record are shown in Figure 7. The short term objective of 3.5 mg/L boron has not been exceeded in the period 1975-1987. (The similarity in shape between the TDS and boron plots is an indication of the major influence of discharge in FWC functions.)

The five-year boron FWCs appearing in Figure 8 remained well below the long term objective of 2.5 mg/L boron. As was the case with TDS, the five-year calculations for boron were significantly influenced by high discharge during the springs of 1982 and 1983.

The relationship between boron and specific conductance at the East Poplar River sampling location during the period 1975-1988 is described by the equation:

$$\text{boron} = (0.00148 \times \text{specific conductance}) - 0.285$$
$$(R^2=0.73,\ n=350)$$

Other Water Quality Variables

Table 4 contains the multi-purpose water quality objectives for the East Poplar River at the International Boundary, recommended by the International Poplar River Water Quality Board to the IJC.

One exceedence of the multi-purpose objectives occurred in 1988. The 4.0 mg/L objective for dissolved oxygen was exceeded on July 15, 1988, when 3.6 mg/L was measured by the USGS. The sample was collected at 8 a.m. in mid summer when oxygen depletion by heavy algae growth would be expected. A reading by Environment Canada 9 days earlier at mid day had indicated 7.5 mg/L dissolved oxygen. A review of Saskatchewan Power Corporation automonitor data has shown that very low dissolved oxygen was present during the first half of July, with concentrations on occasion dropping as low as 1.0 mg/L. A number of winter measurements by both the USGS and Environment Canada were in the 5.0 mg/L range, just above the objective.

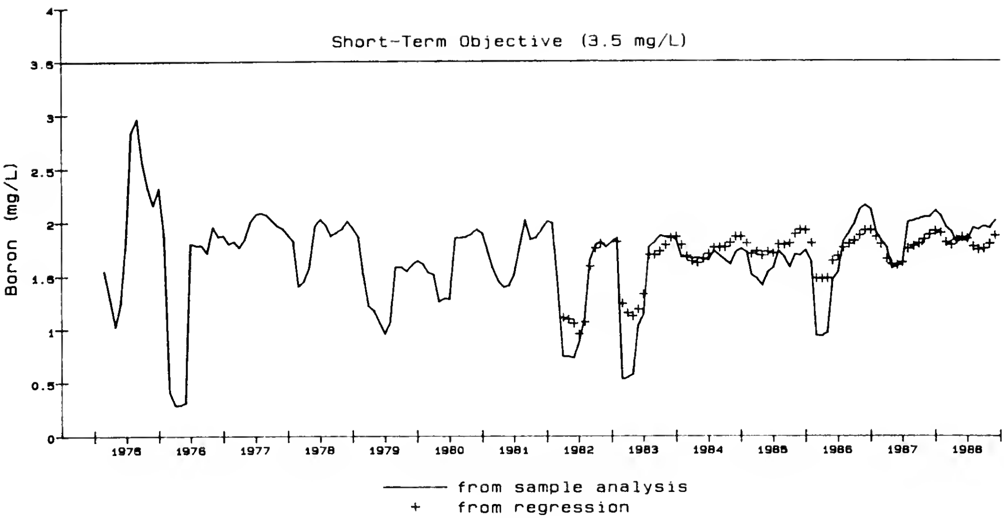


Figure 7. Boron Three-Month Moving Flow-Weighted Concentration, East Poplar River at International Boundary.

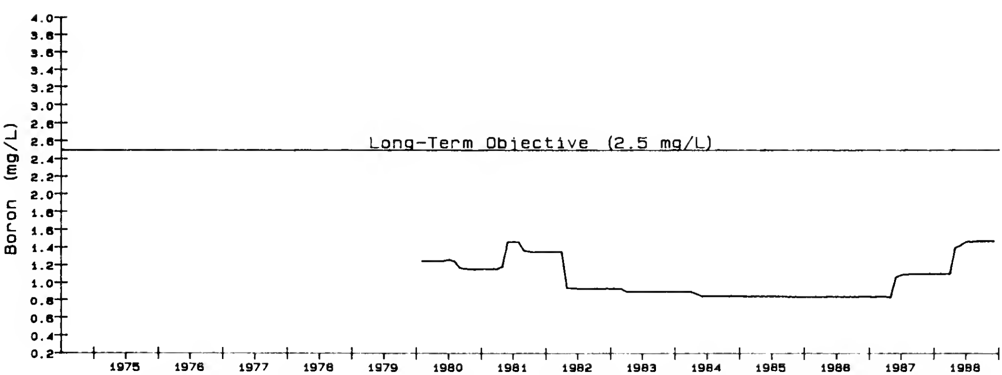


Figure 8. Boron Five-Year Moving Flow-Weighted Concentration, East Poplar River at International Boundary.

Table 4. Recommended Water Quality Objectives and Excursions, 1988 Sampling Program, East Poplar River at the International Boundary (units in mg/L except as otherwise noted)

Parameter	Objective	No. of samples USA	No. of samples Canada	Excursions
Objectives recommended by IJC to Governments				
Boron - total	3.5, 2.5 (1)	14	14	nil
Total dissolved solids	1500, 1000 (1)	14	14	nil
Objectives recommended by Board to IJC				
Aluminum-dissolved	0.1	3	13	nil
Ammonia un-ionized (as N)	0.2	14	14	nil
Cadmium-total	0.0012	--	14	nil
Chromium-total	0.05	3	11	nil
Copper-dissolved	0.005	--	--	nil
Copper-total	1.0	3	14	nil
Fluoride-dissolved	1.5	14	14	nil
Lead-total	0.03	3	14	nil
Mercury-dissolved	0.0002	--	14	nil
Mercury-whole fish (mg/kg)	0.5	--	--	--
Nitrate (as N)	10.0	14	14	nil
Oxygen-dissolved	4.0, 5.0 (2)	12	13	1 (5)
Sodium adsorption ratio	10.	14	--	nil
Sulphate-dissolved	800.	14	14	nil
Zinc-total	0.03	3	14	nil
Water temperature (°C)	30. (3)	12	12	nil
pH (pH units)	6.5 (4)	12	14	nil
Coliform				
fecal (no./100 mL)	2,000.	--	13	nil
total (no./100 mL)	20,000.	--	9	nil

1. Five-year average of flow-weighted concentrations (March to October) should be <2.5 mg/L boron and <1,000 mg/L TDS. Three-month average of flow-weighted concentrations should be <3.5 mg/L boron and <1,500 mg/L TDS.

2. 5.0 mg/L (minimum April 10 to May 15), 4.0 mg/L (minimum remainder of year).

3. Natural temperature (April 10 to May 15), <30 degrees Celsius (remainder of year).

4. Less than 0.5 pH units above natural, minimum pH = 6.5.

5. USGS result July 15, 1988 (3.6 mg/L). Environment Canada result July 6, 1988 (7.5 mg/L).

Environment Canada monitored the East Poplar River for phenoxy-acid herbicides and organochlorine compounds during 1987. Trace concentrations of MCPA (in one of twelve samples), 2,4-DP (in one of twelve samples), and alpha-BHC (in three of twelve samples) were recorded. Traces of these compounds are not uncommon in prairie waters, and the concentrations measured are not considered a hazard. All other organic compounds monitored were reported as being below analytical detection limits.

Girard Creek and Cookson Reservoir

Saskatchewan Environment and Public Safety reported quarterly on the water quality at four locations in the Poplar River Basin during 1987. Sites included Girard Creek south of Coronach, Cookson Reservoir at Highway 36, Cookson Reservoir near Morrison Dam, and East Poplar River immediately below Morrison Dam. Sampling at these sites was carried out in February, May, August, and November.

A review of the data from these locations showed concentrations of all water quality variables to be within the recommended water quality objectives for the East Poplar River (listed in Table 4).

Quality Control

Quality control sampling was carried out at the East Poplar River at the International Boundary on May 17, 1988. Participating agencies included the United States Geological Survey, Environment Canada, Saskatchewan Environment and Public Safety, and Saskatchewan Power. Sets of triplicate samples were split from USGS sampling churns and submitted to the respective agency laboratories for analyses. Procedures were identical to those used during 1986 and 1987.

The results were subsequently distributed to all participants for review by both field and analytical personnel. The majority of parameters showed good reproducibility. The results for a number of trace metals and some nutrients were more variable, with order of magnitude differences existing between agencies in some cases. It is thought that much of this variability relates to differences in analytical technique (for example, atomic absorption versus inductively-coupled argon plasma). These annual quality control exchanges will prove very valuable to any future interpretive undertakings.

Review of Flow-Weighted Objectives

During 1988, Environment Canada funded a study to assess the appropriateness of using flow-weighted objectives for the East Poplar River. The study also included the documentation of the current flow-weighted algorithm, and an assessment of the suitability, significance, and representivity of the method.

The report titled, "Evaluation of the Transboundary TDS and Boron Water Quality Objectives for the Poplar River" prepared by Hydro-Qual Consultants, Inc. (October 1988) contained the following recommendations:

1. Flow-weighting should be discontinued, as the relationship between flow-weighted concentration and the toxic effects associated with irrigation is weak.

2. Since the likelihood of exceedance of the boron and TDS and boron objectives now appears to be small, it was recommended that the monitoring effort on the East Poplar River be reduced.

3. If flow-weighting is to be maintained, it was recommended that flow-weighted moving averages be calculated using geometric mean flows, and that the regression relationship between parameters of interest and conductance be derived from the daily conductance readings, rather than from the monthly grab sample results.

The report and recommendations are being studied by the Bilateral Monitoring Committee and will be on the agenda at a future meeting. However, the Committee determined that sampling at East Poplar River at International Boundary would be decreased by 50 percent (bimonthly sampling from both the USGS and EC would yield 12 samples annually rather than the previously collected 24).

Copies of the report are available on request from Environment Canada, Water Quality Branch, Regina, Saskatchewan.

GROUND WATER QUANTITY

Saskatchewan

Coal Mine Dewatering

Due to coal mine dewatering activities, a total of 3,492 dam^3 (2,381 acre-feet) of ground water was discharged during 1988. This is down by 2,040 dam^3 (1,650 acre-feet) from 1987 (37 percent). A summary of the monthly pumpages from all the coal dewatering wells is shown in Table 5.

Table 5. 1986 Monthly Pumpages from Mine Dewatering Activities

Month		Pumpages	
		Total (dam^3)	Rate (L/s)
January		293	109
February		302	120
March		402	150
April		344	133
May		323	121
June		160	61
July		405	151
August		213	80
September		228	88
October		251	94
November		282	109
December		289	108
	TOTAL	3,492 dam^3 (2,831 acre-feet)	

Water Levels

Two piezometric pressure maps, dated June and December 1988, were prepared by Prairie Coal Ltd. Figure 9 was compiled from the December map and shows the cone of depression formed by the pressure contours in the Hart coal seam. The southern extent of the cone of depression at the end of 1988 is unchanged from its position in the previous year. The position of the 1 metre contour therefore remains at 1.8 kilometres north of the International Boundary.

Ground water was discharged at 16 locations during 1988. Fourteen discharges were to Girard Creek, one was directly into Cookson Reservoir, and one was into a tributary of Goose Creek. No water from this last discharge reached the main stem of Goose Creek.

There are indications that ground water levels have risen and are causing salinity problems to agricultural lands to the south and west of Morrison Dam. Saskatchewan Power Corporation is considering a plan to dewater the area with a network of pumping wells. Pumpage would be into Cookson Reservoir.

Montana

Location of the Montana monitoring wells is shown in the technical monitoring schedule. During 1988, quarterly water levels were obtained from 21 wells located in Montana. To illustrate past trends, hydrographs for wells 5 and 10, which are completed in alluvium, are presented in Figure 10. The water levels for all wells for the period of record fluctuated within one foot of their average during 1988. These variations are mainly due to regional climatic conditions and not dewatering. Over the period of record, no observable trend in water levels is apparent.

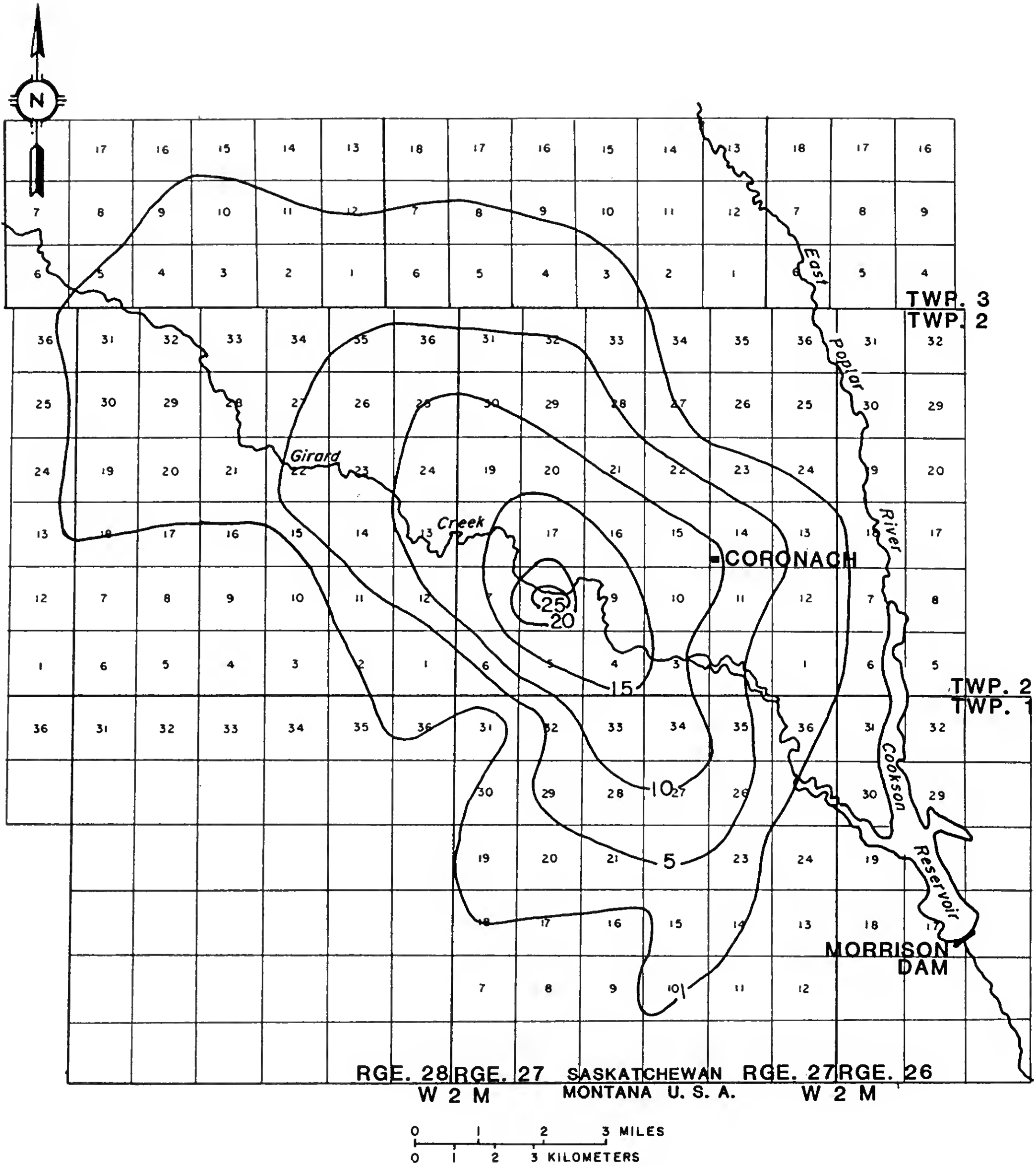


Figure 9. Cone of Depression in the Hart Coal Seam from Dewatering Activities as of December 1988. Contour intervals in meters.

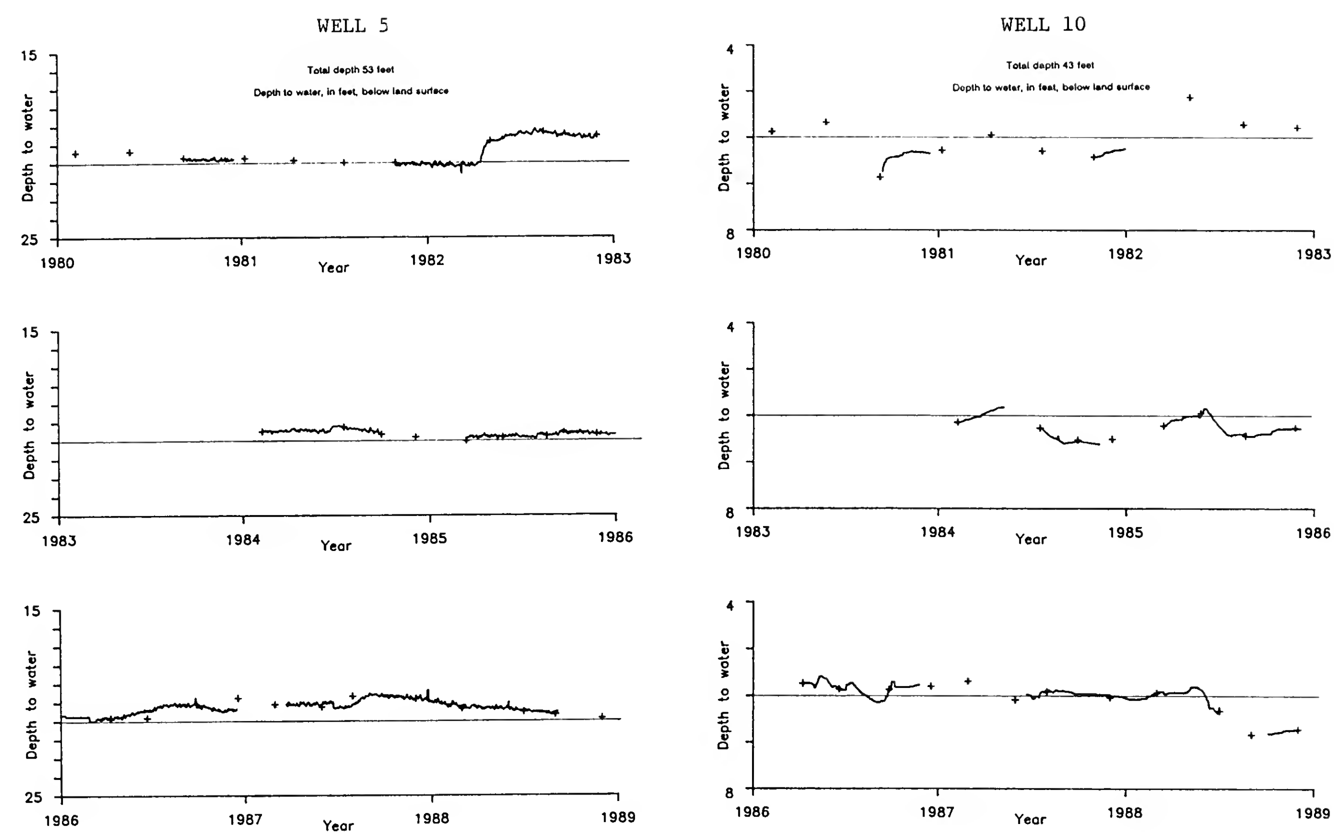


Figure 10. Water Levels of Two Selected Wells in the United States.

GROUND WATER QUALITY

Saskatchewan

Ground water sampling continued in 1988 at the locations specified in the Technical Monitoring Schedule.

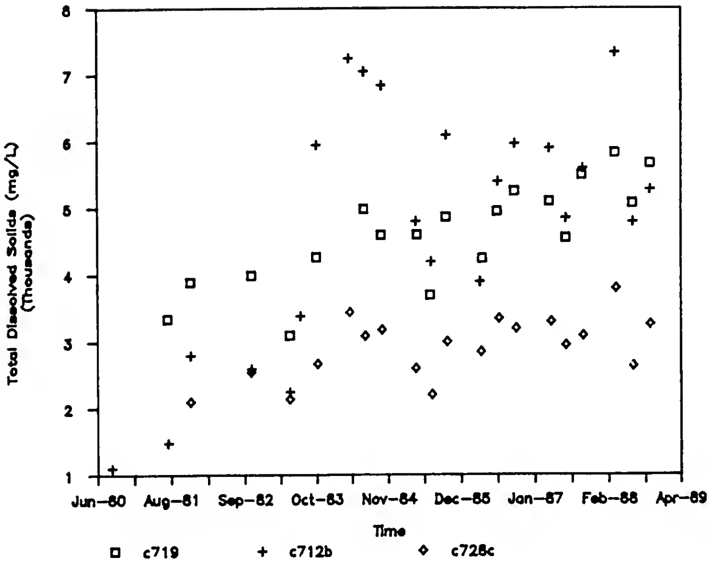
Water Quality in the Tills

The overall quality of ground water from the tills is expressed in Figure 11 and as plots of TDS -vs- time for each piezometer for the period of record. Higher and more variable TDS concentrations are associated with the tills, compared to the Empress Gravels.

At location 2a just north of the polishing pond, piezometer C712B shows an increase in boron concentration from less than 1 mg/L in July, 1987 to 6.93 in November, 1988. TDS in piezometer C712B has shown considerable variation since monitoring began in 1980.

At locations 2b (piezometer C718) and 2c (piezometer C719) near the north end of the polishing pond, there have been no consistent water-quality trends over the period of record. Although these two sites are close together, there are large differences in the quality of water from C718 and C719. The much higher sulphate concentrations in C719 compared to C718 may be due to the presence of gypsum, distributed unevenly throughout the till.

At location 8a, west of cell No. 1 of the ash lagoon, piezometers C726A, C726B, C726C, and C726D display no consistent changes in water quality since 1987.



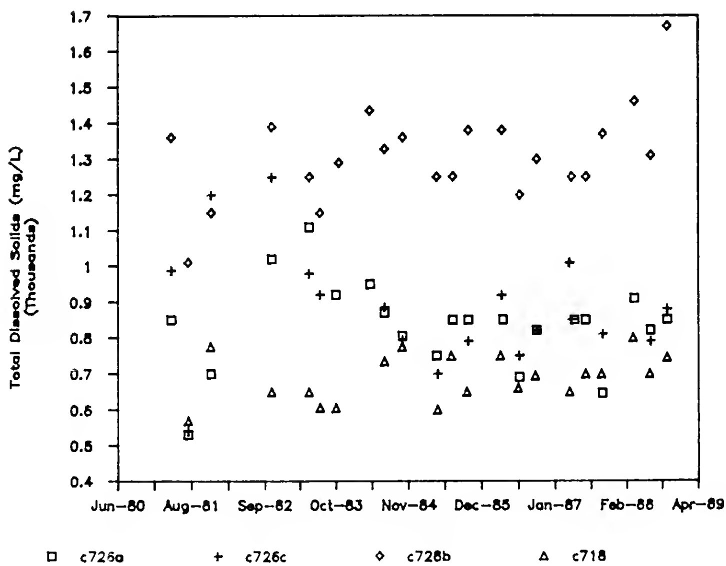


Figure 11. Total Dissolved Solids in Selected Piezometers in the Tills (piezometer number and symbols indicated below each graph).

At location 9a, at the west end of the polishing lagoon data are reported for piezometer C728A, which was dry from 1980 to 1987. Uranium values in the piezometers at location 8a are quite high, relative to other locations. Piezometer C728B shows no consistent water-quality trends over the period of record. Piezometer C728C may show a vaguely-defined long-term trend to lower boron and aluminum, and higher sulphate concentrations over the entire period 1981-1985, but these species have been relatively constant since 1985. Monitoring data obtained over 1986-1988 show that the uranium concentration in C728C has remained fairly constant, and that the long-term trend to higher concentration postulated in the 1988 report did not occur.

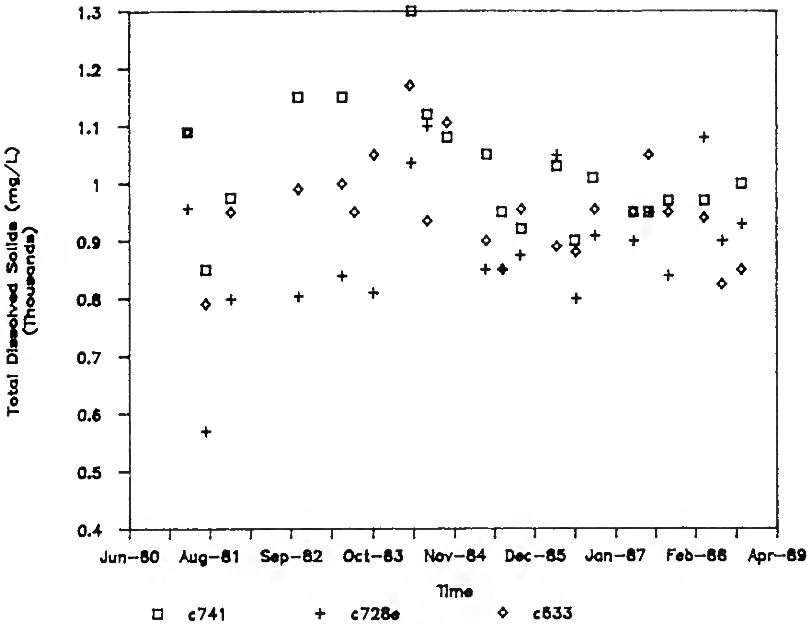
Piezometer C534 is located to the south of the ash lagoon. The TDS concentration has remained fairly constant at around 4,500 mg/L. The aluminum concentration data for 1988 from C534 remained below the 0.01 mg/L detection limit. No trends are seen in the other species monitored.

Water Quality in the Empress Gravels

Figure 12 shows that there are no significant trends in TDS in the Empress Gravels. Piezometer C726E at location 8a, west of ash lagoon cell No. 1, displays a greater variability in TDS concentration than the other piezometers, possibly due to variable recharge from the overlying tills under certain conditions.

Ground water-quality characteristics at locations 2a and 9a (piezometers C726E and C728E, respectively) are generally similar. Boron remains consistently higher in C728E (near 1.2 mg/L) than in C726E (near 0.7 mg/L).

At location C533, south of the ash lagoon, there are no trends evident in any of the water-quality parameters monitored.



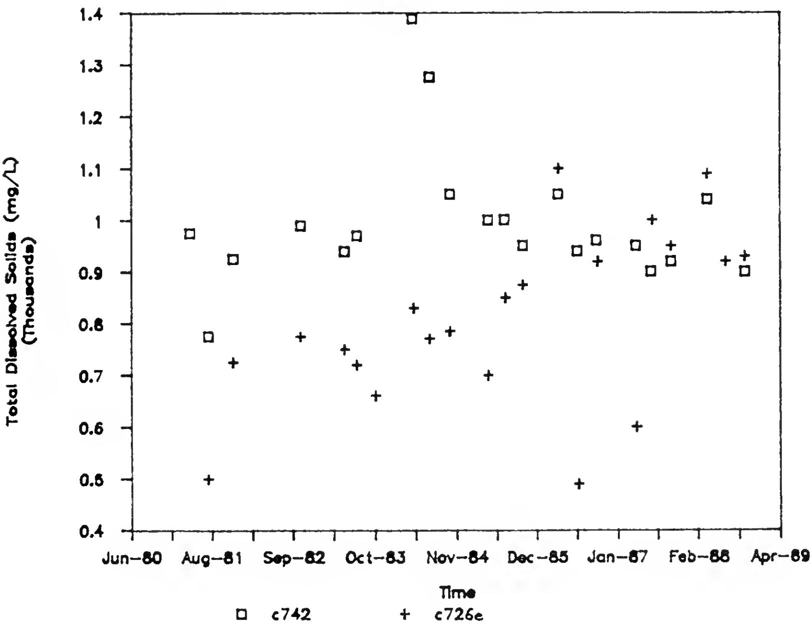


Figure 12. Total Dissolved Solids in Selected Piezometers in the Empress Gravels (piezometer numbers and symbols indicated below each graph)

At location 18 (piezometer C741), situated near the southwest end of Morrison Dam, there are no trends discernible over the past three years. At location 21 (piezometer C742) there are likewise no noteworthy trends in water quality.

Montana

Samples collected and analyzed in 1988 show that previous trends are being maintained and no outstanding anomalies have been noted. Data from the initial group of wells that have been sampled since 1980 are internally consistent. The second group of wells, first sampled as a group in 1985, have data which show minor changes. Annual sampling does not constitute substantial development and these minor shifts may simply represent the diminishing construction effects of "delayed equilibration."

Well 16, reported to be completed in a gravel, has a total depth of 85 feet. Analyses of the water from this well have a trend of decreasing hardness, sulfate, and TDS, coupled with a stable sodium concentration and increasing sodium adsorption ratios (SARs) and alkalinity. The low alkaline earth concentration (Ca=13.4 mg/L, Mg=6.5 mg/L) and elevated sodium concentration (220 mg/L) are not typical of the Empress Gravels. The low chloride concentration eliminates upward leakage from the Fox Hills/Hell Creek aquifer as a possible explanation. Thus, the water chemistry is a bit of an enigma.

The relatively low SAR values and sodium concentrations of less than 100 mg/L associated with the first group of coal wells is in distinct contrast with coal well data from other eastern coal fields in Montana and the second group of wells at this site. These samples may represent waters in the recharge portion of the flow system, alluvial recharge, or a separate flow system. Because the coals are thin, and the monitoring wells south of the border are deep, sealing materials possibly did not isolate permeable units adjacent to the coal bed that was the monitoring target during drilling and well installation. Alternatively, the chemical differences in the analytical results may be the result of ground water interaction with the overburden materials (Fort Union or Ravenscrag Formations). The value of the monitoring wells is not decreased so long as consideration is given to the above conditions. Using the first group of wells completed in the coal as a control group, the September 1988 samples show the following results:

Well No.	Depth (feet)	Sodium (mg/L)	SAR	Hardness (mg/L)
10	43	107.0	2.79	278
6	83	59.4	1.39	343
3	117	86.0	1.67	501
7	147	55.5	1.32	333
2	258	24.5	0.56	362

The hardness represents substantial calcium and magnesium concentrations in the water. These indicate that the water chemistry data reflect shallow overburden effects or even alluvial recharge. This hypothesis is supported by the one Fort Union or Ravenscrag completion (well 9) in the older group. The well is 208 feet deep and its water analyses have a model SAR value of 9.5; even if an arithmetic average were used which would include two (spurious) low values, the SAR from these samples is 8.0, a value distinctly greater than that associated with the coal bed completions.

The second group of monitoring wells, completed in coal and located essentially to the west of the first group, has distinctly higher sodium levels in four of the five wells as evidenced by the September 1988 sample results:

Well No.	Depth (feet)	Sodium (mg/L)	SAR	Hardness (mg/L)
19	195	49.8	1.1	379
13	205	252	8.3	174
14	271	293	18.7	46
15	293	140	5.1	145
21	350	231	16.6	36

The results provide an interesting contrast to the results of the first group. The sodium content does not seem to decrease with depth in a pattern similar to that of the first group. This could be the result of inadequate equilibration time to remove the effects of sealing the zone above the sand-packed screens with a sodium-bentonite sealant; however, the effect is essentially restricted to completion in coal beds.

An alternative interpretation, which has fewer inconsistencies, is that the coal horizons are separated by sands of tributary channels and by crevasse-splay sands. The wells completed in coal beds, which are characterized by higher sodium concentrations and SAR values, are in the western half of the study area. They probably are not hydrologically continuous with the coal-completion wells in the eastern half of the area. The stratigraphic relationships are changing rapidly in this area, with less than eight feet (net) of Hart Coal present at the International Boundary (Irvine and others, 1978, Part 1, p. 71; Part II, pl. 30, 31). Plate 33 of that report also shows that the Cornach Coal thins (net coal of four feet or less) at the International Boundary, and the southern lobe of this deposit has been separated from the more extensive northern lobe by erosion.

In summary, the differences in chemistry seen from samples of wells completed within the coal zone(s) are not unreasonable, as the coals pinch out against the Roncott platform. Water from well 16 is developing a chemistry indicative of the coal zone in the western half of the study area. This type of chemistry is most likely the result of completing this shallow (85 feet) well in a thin stringer of the Coronach Coal, rather than in the clastic portion of the Ravenscrag Formation.

ASH LAGOON QUANTITY AND QUALITY

The ash lagoon system at the Poplar River Power Station continues to be operated on a closed system basis with no discharges to surface waters. During 1988, the sluiced ash was generally directed to either the north end of Lagoon No. 1 or the southeast corner of Lagoon No. 3. For the former, the operating series sequence is Ash Lagoon No. 1, Ash Lagoon No. 2 and the polishing pond. When ash is directed to Ash Lagoon No. 3, the normal series operation is Ash Lagoon No. 3, Ash Lagoon No. 2 and the polishing pond. Water from the polishing pond is returned to the plant for sluicing.

During 1988, maximum and minimum water depths were 5.3 and 4.6 m in Ash Lagoon No. 1, 4.6 and 3.2 m in Ash Lagoon No. 2, 1.6 and 1.2 m in Ash Lagoon No. 3, and 4.6 and 2.3 m in the Polishing Lagoon.

Seepage calculations were made in 1988 using the methods developed by T.A. Prickett, P.E., of Urbana, Illinois. Results of the calculations for Ash Lagoons No. 1, 2, and 3 and the Polishing Lagoon are shown in Table 6.

Table 6. Poplar River Power Station Ash System, 1988 Calculated Seepage Rates

Source	Rate (L/s)
Polishing Lagoon	0.313
Ash Lagoon No. 1	0.246
Ash Lagoon No. 2	0.317
Ash Lagoon No. 3	0.022
Total Seepage	0.898

The 1988 calculated seepage has increased from that calculated for 1987. The calculated total seepage, however, remains well below the seepage limits (5.0 L/s to Cookson Reservoir and 2.0 L/s to the East Poplar River) proposed in 1979 by the International Poplar River Water Quality Board of the IJC. The calculated permeability liners for Ash Lagoons No. 1 and 2 and the Polishing Lagoon was of the same order of magnitude (4 to 28.7 x 10^9 cm/s) as originally calculated by T.A. Prickett. The calculated liner permeability for Ash Lagoon No. 3 North was 10.6 x 10^9 cm/s. The consulting geotechnical engineer for the Poplar River Power Station has recommended that the method of seepage calculation be replaced with a more technologically advanced method of seepage analysis using computer technology. This recommendation is being considered and may be implemented in 1989.

The advancement of the ground water front toward the reservoir in the oxidized till was calculated to be 10.79 m since the lagoons were initially filled, which is an increase of 2.48 m since 1987. The front in the Empress Gravel formation was calculated to have advanced 1032 m southeast of the lagoons, an increase of 120 m since 1987. Examination of the chemistry of water from the Empress Gravel formation and till generally shows no significant changes attributable to lagoon seepage except for increasing boron levels at one location. Monitoring will be continued and remedial action will be undertaken if required. Leachate flow into Cookson Reservoir and into the East Poplar River, however, has not been measurable.

The Saskatchewan Department of Environment and Public Safety requires that the Saskatchewan Power Corporation maintain the stability of the ash lagoon system dykes. In addition to the regular visual inspections, an annual investigation by a geotechnical engineer was conducted in October 1988. The geotechnical consultant indicated that the ash lagoon dykes and liners have good integrity and the ash is contained effectively. The consultant noted that the lagoon system is performing as designed. Some recommendations were made regarding remedial measures for erosion protection and continued monitoring.

The Saskatchewan Power Corporation intends to review and implement the recommendations during 1989. The freeboard requirements were not exceeced during 1988. The Saskatchewan Power Corporation continues to experiment with the surcharging of dry ash into the lagoons. The experimental program began in 1987 to determine suitable types of vegetation for the exposed ash continued in 1988. Three species of grass have shown good results and will be further tested in 1989.

The Saskatchewan Power Corporation has, since May 1983, analyzed filtered ash lagoon water samples to obtain appropriate information on potential leachate quality. Generally, the water quality data continue to show increases in the ash and polishing lagoons for sodium, potassium, sulphate, fluoride, boron, and molybdenum; and continued variability in the levels of uranium. The changes are to be expected in a closed system of this type.

AIR QUALITY

Saskatchewan

Saskatchewan Environment

Ambient sulphur dioxide (SO_2) monitoring began in Coronach in 1979. To date few high concentrations have been recorded. The monitoring site (Coronach Water Treatment Plant) is located 5.0 kilometres north of the power plant, on the southern outskirts of the town of Coronach. There were no recorded violations of Saskatchewan Environment and Public Safety's hourly or 24 hour standards of 0.17 parts per million (ppm) and 0.06 ppm, respectively, in 1988. The highest recorded hourly value of 0.082 ppm was recorded on August 15 at 1200 hours, as compared to 0.071 ppm recorded in September of 1987. Weather information gained from the site indicated that winds at the time were blowing from the northeast. As the power plant is located south of the monitoring location, it can be discounted as the source. The largest 24-hour average readings of 0.009 ppm occurred on April 15, May 13 and August 15 and were identical to the highest 24-hour average reading recorded in 1987. Downtime for the monitor during the 12 month period was 4.0 percent, mainly due to an episode of windblown damage and a short datalogger malfunction. Figures 13 and 14 show, in graphical form, maximum hourly and daily (24 hour) readings obtained at the monitoring station during the last five years.

Suspended particulate concentrations obtained from a high volume monitor at the same site for the 12 month period did not exceed Saskatchewan Environment and Public Safety's 24 hour average standard of 120 micrograms per cubic metre ($\mu g/m^3/24$ hrs.). The highest reading of 98.5 $\mu g/m^3/24$ hrs occurred on June 26. Wind data for that date points to field blown dusts as the most probable source, as there were no accountable particulate stack emissions during the testing period.

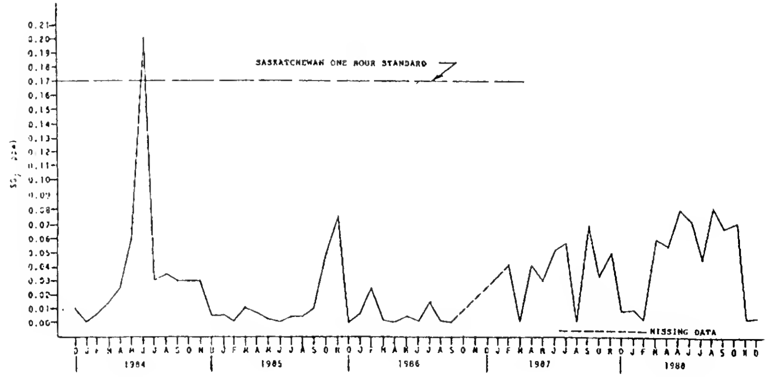


Figure 13. Saskatchewan Maximum Hourly SO_2 Air Quality Data, Coronach Water Treatment Plant, 1983-1988.

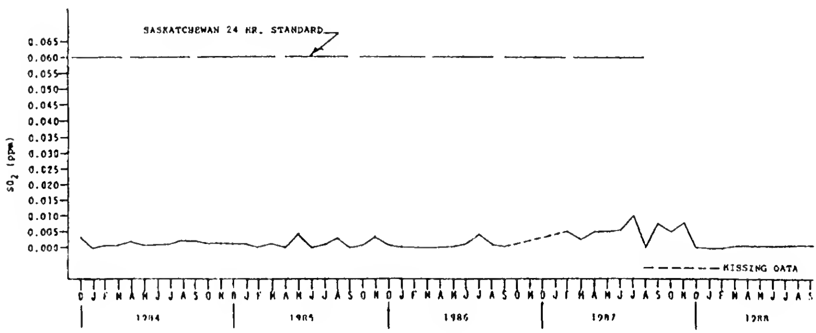


Figure 14. Saskatchewan Maximum Daily SO_2 Air Quality Data, Coronach Water Treatment Plant, 1983-1988.

Saskatchewan Power Corporation

Ambient SO_2 monitoring conducted 8.0 kilometres southeast of the plant, near the 49th parallel, showed no violations for 1988, the same as 1987. The highest hourly reading of 0.056 ppm occurred on February 19, at 0200 and 0300 hours. Weather data recorded by Environment Canada's weather station located at Rockglen (37 kilometres northwest of the plant) indicated winds blowing from the plant towards the monitor at the time. This reading compares to the highest hourly reading recorded in 1987 of 0.053 ppm. Downtime for the monitor was 3.0 percent as compared to 0.7 percent in 1987.

Suspended particulate concentrations at the monitoring station exceeded Saskatchewan Environment and Public Safety's 24 hour standard on seven occasions in 1988, the same as in 1987. The largest recorded value of 672.3 $\mu g/m^3/24$ hrs. occurred on June 8. That violation, as well as the other six violations, was probably caused by field blown dusts, as no specific episodes of heavy particulate release from the plant stack on violation days could be determined. The annual geometric mean of 38.7 ug/m^3 is well below the provincial standard of 70.0 and compares with the 1987 mean of 34.6. Downtime for the sampler was 1.6 percent, virtually the same as the 1.7 percent in 1987.

Sulphur dioxide averages from in-stack monitoring were slightly greater in 1988 than 1987, with daily concentrations ranging from 1,749 to 3,421 milligrams per cubic meter (mg/m^3) (corrected to 3 percent O_2). The average yearly concentration was 2,698 as compared to 2,556 in 1987. Downtime for the SO_2 in-stack monitor was the same as during 1987--15 percent. Nitrogen oxide averages were lower in 1988, with daily concentrations ranging from 603 to 1,089 mg/m^3 (corrected to 3 percent O_2). The average yearly concentration was 776 in 1988 and 806 in 1987. Downtime for the nitrogen oxide in-stack monitor was 16 percent compared to 18 percent in 1987. Daily opacity readings ranged from 0 to 90 percent, with a yearly average of 18 percent. Saskatchewan's opacity standard of 40 percent was exceeded 193 times in 1988, significantly less than the 330 times in 1987.

Downtime for the opacity monitor was 2.2 percent in 1988 and 0.3 percent in 1987. Stack gas flow rates ranged from 378 to 658 m^3/s, with an average flow of 590 in 1988, which is close to the 580 m^3/s in 1987. Downtime for the 12 month period in 1988 was 5.2 percent, up from 1.9 percent in 1987.

Montana

The Montana Department of Health and Environmental Sciences, Air Quality Bureau, operates five sulfation plate sampling sites in the Scobey area--Richardson Residence (Scobey), Flaxville, TV Tower Hill, Scobey Downtown, and Four Buttes. Samples from these sites are indicators of sulfation levels in the area, and a high concentration would give warning of a potential problem. There is no standard for sulfation rate; readings greater than 0.5 mg/100 centimeters squared per day (cm^2/d) indicate possible trouble spots. The highest reading for 1988 was 0.07 mg/100 cm^2/d at the Flaxville site in February. Table 7 gives the sampling results for 1988.

Table 7. Sulfation Rate of Sulfur Trioxide in Milligrams per 100 Square Centimeters per day at Five Locations During 1988.

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Richardson (Scobey)	.03	.04	.01	.01	.04	.00	--	.00	.00	.00	.06	.00
Flaxville	.05	.07	.04	--	.04	.00	.00	--	.00	.01	.00	.00
TV Tower Hill	.03	.04	.03	.03	.05	--	.03	.00	.02	.00	.00	.00
Scobey Downtown	.03	.04	.04	.03	.04	--	.00	.00	--	--	.00	.00
Four Buttes	.00	.00	.02	.02	.05	.00	.00	.00	.00	.00	.00	.00

REFERENCES CITED

Irvine, J.A., Whitaker, S.H., and Broughton, P.L., 1978, Coal resources of southern Saskatchewan -- A model for evaluation methodology: (Note: this report is listed three ways) Geological Survey of Canada Economic Geology Report 30 or Department of Mineral Resources Report 209, or Saskatchewan Research Council Report 20; Part I, 151 p., Part II, 56 oversize plates.

Linton, L.R., McDonald, R.A., and Hamilton, H.R., 1988, Evaluation of transboundary TDS and Boron water quality objectives for the Poplar River: HydroQual Consultants Inc., Calgary, Alberta (prepared for Environment Canada, Inland Waters Directorate, Western and Northern Region), 78 p.

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 the Saskatchewan Power Corporation 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 Public Safety
Government of the United States of America: U.S. 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. Cochairmen 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 fulfill 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 Cochairman will be responsible for transmitting to his counterpart Cochairman on a regular, and not less than quarterly 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 Cochairmen 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

1989

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.

Significant additional information 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, groundwater 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 is also being collected on either a routine or specific studies basis by various agencies.

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

1989

CANADA

STREAMFLOW MONITORING

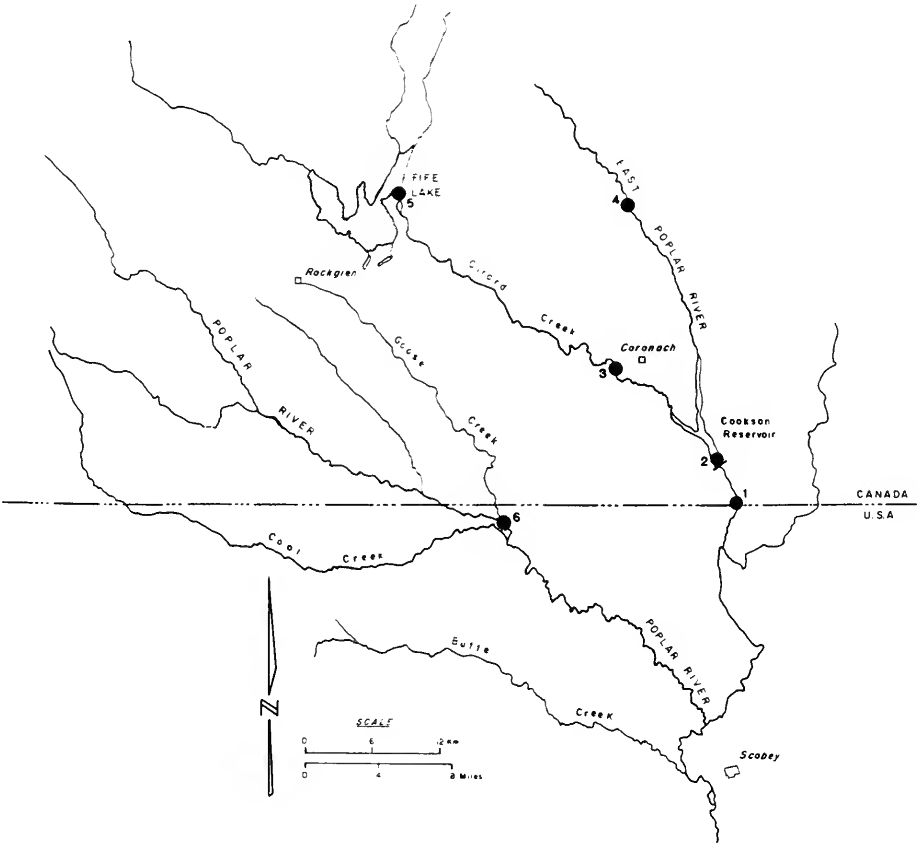
Responsible Agency: Environment Canada

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

No. on Map	Station No.	Station Name
1.	11AE003 (06178500)	East Poplar River at International Boundary
2.	11AE013	Cookson Reservoir near Coronach
3.	11AE015	Girard Creek near Coronach Cookson Reservoir
*4.	11AE014	East Poplar River above Cookson Reservoir
5.	**Fife Lake Overflow	
*6.	11AE008 (06178000)	Poplar River at International Boundary

* - International gauging station

** - Miscellaneous measurements of outflow to be made by Sask Water during periods of outflow only.



HYDROMETRIC GAUGING STATIONS (CANADA)

SURFACE WATER QUALITY MONITORING

Sampling Locations

Responsible Agency: Saskatchewan Environment and Public Safety

No. on Map	Station No.	Station Name
1	01SK02000002	Fife Lake Overflow
2	05SK02000007	Girard Creek at Coronach Reservoir Outflow
3	05SK02000008	Upper End of Cookson Reservoir at Highway 36
4	05SK02000004	Cookson Reservoir near Dam
5	05SK02000003	East Poplar River at culvert immediately below Cookson Reservoir

Responsible Agency: Environment Canada

6	00SA11AE0008	East Poplar River at International Boundary

Parameters

Responsible Agency: Saskatchewan Environment and Public Safety

ESQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station No: 1	2	3	4	5
10151	Alkalinity-pheno	Pot. Titration	OF	Q	Q	Q	Q
10101	Alkalinity-tot	Pot. Titration	OF	Q	Q	Q	Q
13004	Aluminum tot	AA-direct		A	A	A	A
33004	Arsenic-tot	Flameless-A.A.		A	A	A	A
06201	Bicarbonates	Calculated	OF	Q	Q	Q	Q
05451	Boron-tot	ICPA	W	Q	Q	Q	Q
48002	Cadmium-tot	AA-Solvent extract (MIBK)		A	A	A	A
20103	Calcium	AA-Direct	OF	Q	Q	Q	Q
06052	Carbon-tot Inorg	IR	OF		Q	Q	Q
06005	Carbon-tot Org	IR	OF		Q	Q	Q
06301	Carbonates	Calculated	OF	Q	Q	Q	Q
17203	Chloride	Colourimetery	OF	Q	Q	Q	Q
06711	Chlorophyll 'a'	Colourimetery		Q	Q	Q	Q
24004	Chromium-tot	AA-direct		A	A	A	A
36012	Coliform-fec	MF	OF	Q	Q	Q	Q
36002	Coliform-tot	MF	OF	Q	Q	Q	Q
02041	Conductivity	Conductivity meter	W	Q	Q	Q	Q
29005	Copper-tot	AA-Solvent extract (MIBK)		A	A	A	A
09105	Flouride	Specific ion electrode		A	A	A	A
82002	Lead-tot	AA-Solvent extract (MIBK)		A	A	A	A
12102	Magnesium	AA-direct	OF	Q	Q	Q	Q
80011	Mercury-tot	Flameless AA		A	A	A	A
42005	Molybdenum	AA-Solvent Extract (MIBK)		A	A	A	A
07015	N-TKN	Colourimetry	OF	Q	Q	Q	Q
10401	NFR	Gravimetric	OF	Q	Q	Q	Q
10501	NFR (F)	Gravimetric	OF	Q	Q	Q	Q
28002	Nickel-tot	AA-Solvent extract (MIBK)	OF	Q	Q	Q	Q
07110	Nitrate + NO_2	Colourimetry	OF	Q	Q	Q	Q
06521	Oil and Grease	Pet. Ether Extraction		A	A	A	A
08102	Oxygen-diss	Meter	OF	Q	Q	Q	Q
15406	Phosphorus-tot	Colourimetry	OF	Q	Q	Q	Q
19103	Potassium	Flame Photometery	OF	Q	Q	Q	Q
34005	Selenium-Ext	Hydride Generation		A	A	A	A
11002	Sodium	Flame Photometry	OF	Q	Q	Q	Q
16306	Sulphate	Colourimetry	OF	Q	Q	Q	Q
10451	TDS	Gravimetric	OF	Q	Q	Q	Q
0206YZ	Temperature	Thermometer	OF	Q	Q	Q	Q
23004	Vanadium-tot	AA-Direct		A	A	A	A
30005	Zinc-tot	AA-Solvent extract (MIBK)		A	A	A	A
10301	pH	Electrometric	W	Q	Q	Q	Q

*Computer storage and retrieval system - Saskatchewan Environment and Public Safety.

Symbols: W - Weekly during overflow; OF - once during each period of overflow greater than 2 weeks' duration; Q - quarterly; A - annually in the fall; AA - atomic absorption; IR - infrared; Pot - potentiometric; NFR - nonfilterable residue NFRF - nonfilterable residue, fixed.

AA - Solvent Extract (MIBK): Sample digested with HNO_3 and extracted with methyl isobutyl ketone.

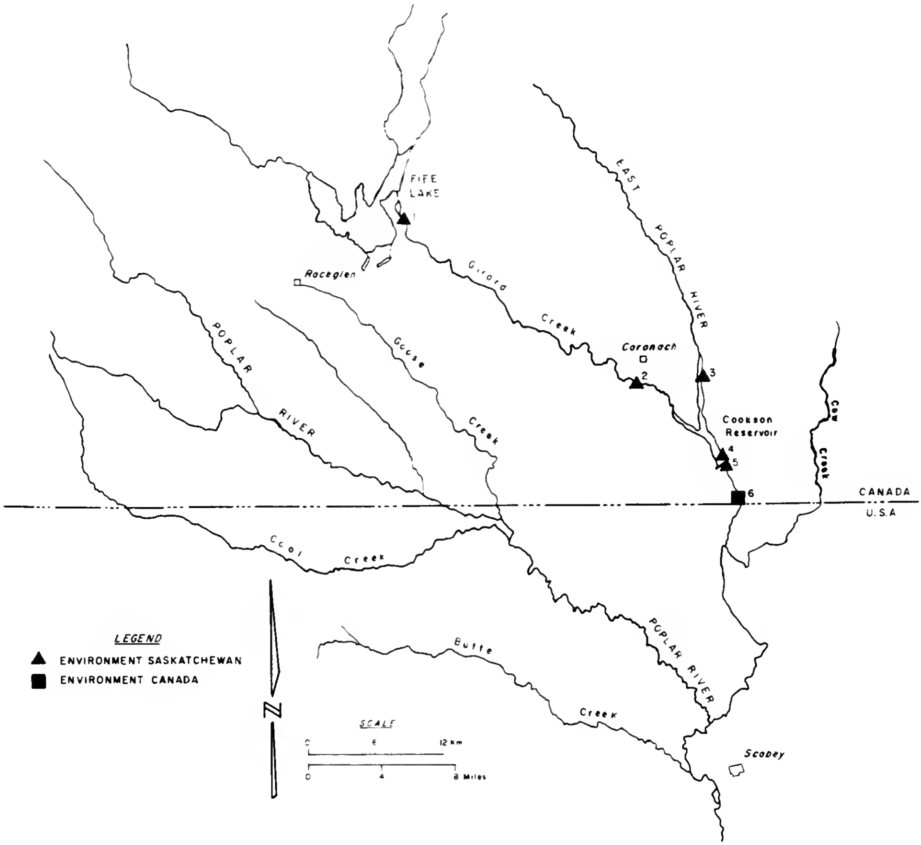
ICPA - Plasma emission.

MF - membrane filtration.

Responsible Agency: Environment Canada

NAQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station No: 6
10151	Alkalinity-pheno	Potentiometric	M
10111	Alkalinity-tot	Potentiometric	M
13102	Aluminum-Diss.	AA-Direct	M
13302	Aluminum-ext	AA-Direct	M
07570	Ammonia-Free	Calculated	M
07540	Ammonia-tot	Colourimetric	M
33108	Arsenic-diss	Plasma	M
56001	Barium-tot	AA Direct	M
06201	Bicarbonatea	Calculated	M
05105	Boron-diss	Carminic Acid	M
48002	Cadmium-tot	AA Solv. Ext.	M
20103	Calcium	AA-Direct	M
06104	Carbon-diss org	IR Detector	M
06901	Carbon-partic	Elemental Analyzer	M
06002	Carbon-tot Org	Calculated	M
06301	Carbonates	Calculated	M
17206	Chloride	Colourimetric	M
06717	Chlorophyll a	Spectrophotometric	M
24003	Chromium-tot	AA-Solv. Ext.	M
27002	Cobalt-tot	AA Solv. Ext.	M
36012	Coliform-fec	MF	M
36002	Coliform-tot	MF	M
02021	Colour	Comparator	M
02041	Conductivity	Wheatstone Bridge	M
29005	Copper-tot	AA-Solv. Ext.	M
06604	Cyanide	UV-Colourimetric	M
09106	Fluoride	Electrometric	M
10602	Hardness	Calculated	M
08501	Hydroxide	Calculated	M
26104	Iron-diss	AA-direct	M
82002	Lead-tot	AA-Solv. Ext.	M
12102	Magnesium	AA-direct	M
25104	Manganese-diss	AA-direct	M
80011	Mercury-tot	Flameless AA	M
07901	N-particulate	Elemental Analyzer	M
07651	N-tot diss	UV Colourimetric	M
10401	NFR	Gravimetric	M
28002	Nickel-tot	AA-Solv. Ext.	M
07110	Nitrate/Nitrite	Colourimetric	M
07603	Nitrogen-tot	Calculated	M
180XX	Organo Chlorines	GC	M
08101	Oxygen-diss	Winkler	M
15901	P-particulate	Calculated	M
15103	P-tot diss	Colourimetric	M
06535	Phenolics	Colourimetric	M
185XX	Phenoxy Herbicides	GC	M
15406	Phosphorus-tot	Colourimetric	M
19103	Potassium	Flame Emission	M
11250	Percent Sodium	Calculated	M
00210	Sat Index	Calculated	M
34108	Selenium-diss	Plasma	M
14102	Silica	Colourimetric	M
11103	Sodium	Flame Emission	M
00211	Stab Index	Calculated	M
16306	Sulphate	Colourimetric	M
00201	TDS	Calculated	M
02061	Temperature	Alcohol Thermometer	M
02081	Turbidity	Nephelometric	M
23002	Vanadium-tot	AA-Solv. Ext.	M
30005	Zinc-tot	AA-Solv. Ext.	M
10301	pH	Electrometric	M
92111	Uranium	Flurometric	MC

*Computer storage and retrieval system - Environment Canada
Symbols: M-Monthly; AA-atomic absorption; MF-membrane filtration; UV-ultraviolet; NFR-nonfilterable residue; GC-gas chromatography; MC-Monthly Composite; IR-infrared



SURFACE WATER QUALITY MONITORING STATIONS (CANADA)

GROUND WATER QUALITY MONITORING

Sampling Locations

Responsible Agency: Saskatchewan Environment and Public Safety

Map Location No.	SPC Piezometer No.	Station Description: Tip of Screen Elevation (m)	Station Description: Material
8a	C726A	746.338	unoxidized till
	C726C	752.739	oxidized till
8a	C726E	738.725	Empress gravel
9a	C728A	753.405	oxidized till
	C728B	743.265	unoxidized till
	C728C	747.645	mottled till
	C728D	752.305	oxidized till
9a	C728E	739.912	Empress gravel
2a	C712B	746.112	oxidized till
2b	C718	748.385	mottled till
2c	C719	747.715	oxidized till
22	C533	740.441	Empress gravel
23	C534	753.499	till
18	C741**	735.153	Empress gravel
21	C742**	741.800	Empress gravel
24	C714A	745.333	unoxidized till
25	C714D	750.459	oxidized till
26	C714E	738.230	Empress gravel
27	C774B	749.370	oxidized till
28	C775A	753.320	oxidized till
29	C775D	740.190	Empress gravel

Parameters

Responsible Agency: Saskatchewan Environment and Public Safety

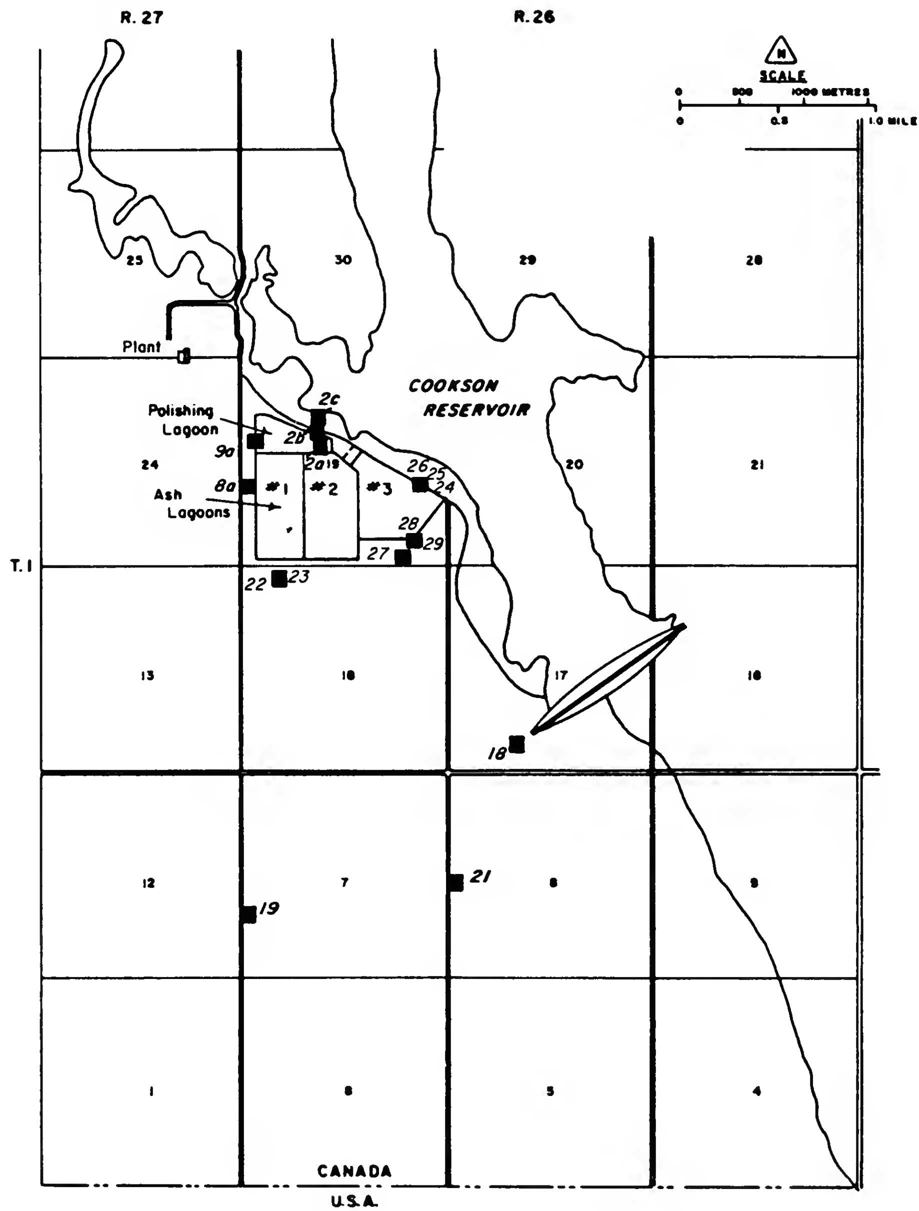
ESQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station No: Piezometers
10101	Alkalinity-tot	Pot-Titration	A
13105	Aluminum-Diss	AA-Direct	3**
33104	Arsenic-Diss	Flameless AA	A
56104	Barium-Diss	AA-Direct	A
06201	Bicarbonates	Calculated	A
05106	Boron-diss	Colourimetry	3**
48102	Cadmium-Diss	AA-Solvent Extract (MIBK)	A
20103	Calcium-Diss	AA-direct	A
06301	Carbonates	Calculated	A
17203	Chloride-Diss	Colourimetry	A
24104	Chromium-Diss	AA-Direct	A
27102	Co balt-Diss	AA-Solvent Extract (MIBK)	A
02011	Colour	Comparator	A
02041	Conductivity	Conductivity meter	3**
29105	Copper-Diss	AA-Solvent Extract (MIBK)	A
09105	Fluoride-Diss	Specific Ion Electrode	A
26014	Iron-Diss	AA-Direct	A
82103	Lead-Diss	AA-Solvent Extract (MIBK)	A
12102	Magnesium-Diss	AA-Direct	A
25104	Manganese-Diss	AA-Direct	A
80111	Mercury-Diss	Flameless AA	A
42102	Molybdenum-Diss	AA-Solvent extract (N-Butyl acetate)	A
10301	pH	Electrometric	3**
19103	Potassium-Diss	Flame Photometry	A
34105	Selenium-Diss	Hydride generation	A
14102	Silica-Diss	Colourimetry	A
11103	Sodium-Diss	Flame Photometry	A
38101	Strontium-Diss	AA-Direct	3**
16306	Sulphate-Diss	Colourimetry	3**
10451	TDS	Gravimetric	3**
92111	Uranium-Diss	Fluorometry	3**
23104	Vanadium-Diss	AA-Direct	A
97025	Water Level		A
30105	Zinc-Diss	AA-Solvent Extract (MIBK)	A

No zinc or iron for piezometers C533 or C534.

*Computer Storage and Retrieval System - Saskatchewan Environment and Public Safety.

Symbols: AA - atomic absorption. A - Annually. 3 - Three times per year
AA-Solvent Extract (MIBK): sample acidified and extracted with Methyl Isobutyl Ketone.

**Analyze annually only for piezometer Nos. C741 and C742.



GROUND WATER QUALITY MONITORING (CANADA)

GROUND WATER PIEZOMETERS TO MONITOR

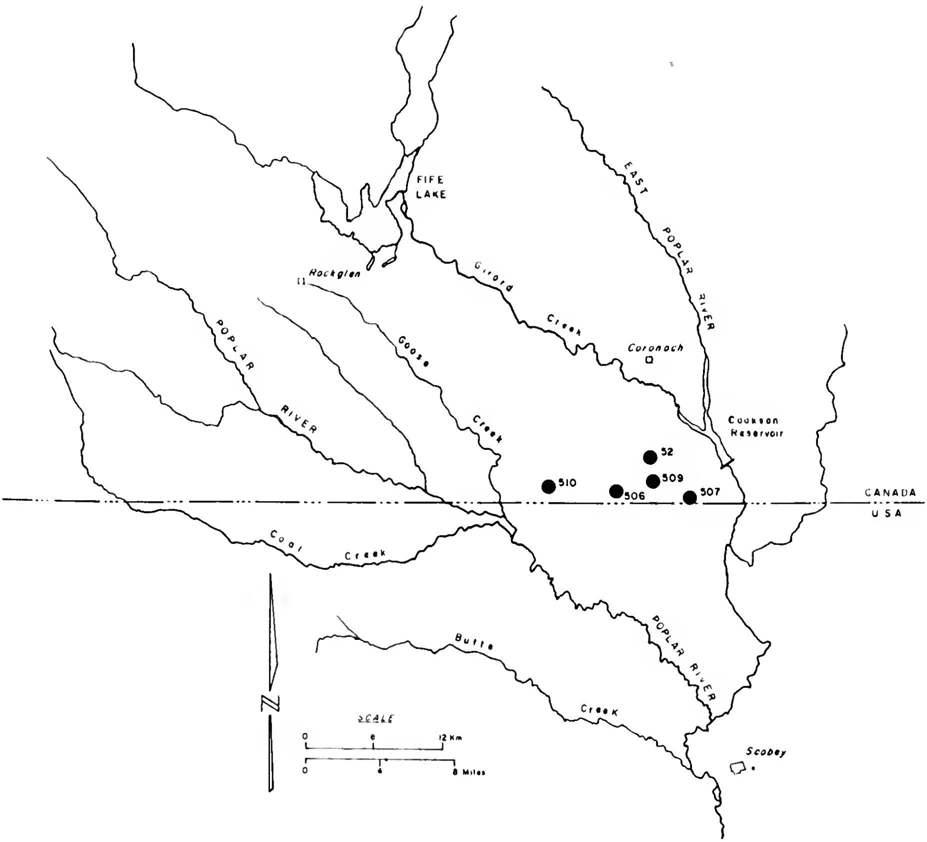
POTENTIAL DRAWDOWN DUE TO COAL

SEAM DEWATERING

Responsible Agency: Saskatchewan Environment and Public Safety

Measurement Frequency: Quarterly

Piezometer Number	Location	Tip of Screen Elevation (m)	Perforation Zone (depth in metres)
52	NW14-1-27W3	738.43	43 - 49 (in coal)
506A	SW4-1-27W3	748.27	81 - 82 (in coal)
507	SW6-1-26W3	725.27	34 - 35 (in coal)
509	NW11-1-27W3	725.82	76 - 77 (in coal)
510	NW1-1-28W3	769.34	28 - 29 (in layered coal and clay)



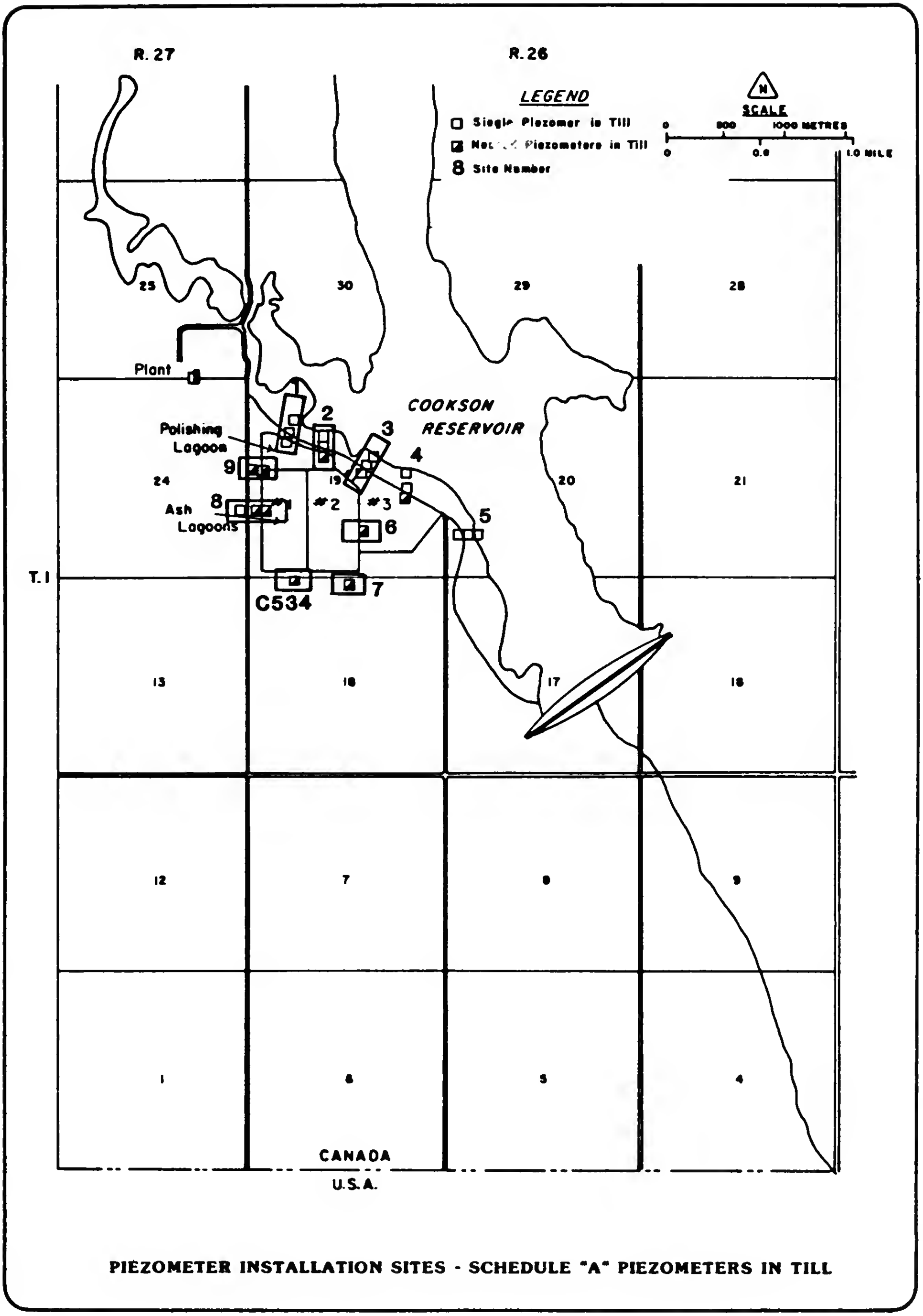
GROUNDWATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL SEAM DEWATERING

GROUND WATER PIEZOMETER LEVEL MONITORING - ASH LAGOON AREA

SCHEDULE A - PIEZOMETERS IN TILL

Responsible Agency: Saskatchewan Environment and Public Safety

Station	Piezometer No.	Frequency of Measurement
1a	C716	All piezometer levels are measured quarterly
1b	C717	
1c	C711	
$2a_1$	C712A	
$2a_2$	C712B	
$2a_3$	C712C	
$2a_4$	C712D	
2b	C718	
2c	C719	
3a	C713	
3b	C720	
3c	C721	
$6a_1$	C763A	
$6a_2$	C763B	
$6a_3$	C763C	
$6a_4$	C763D	
$7a_1$	C729A	
$7a_2$	C729B	
$7a_3$	C729C	
$7a_4$	C729D	
C534	C534	
$8a_1$	C730A	
$8a_2$	C730B	
$8a_3$	C730C	
$8a_4$	C730D	
$8b_1$	C727A	
$8b_2$	C727B	
$8b_3$	C727C	
$8c_1$	C726A	
$8c_2$	C726B	
$8c_3$	C726C	
8d	C748	
$9a_1$	C764A	
$9a_2$	C764B	
$9a_3$	C764C	
$9a_4$	C764D	
$9b_1$	C728A	
$9b_2$	C728B	
$9b_3$	C728C	
$9b_4$	C728D	



PIEZOMETER INSTALLATION SITES - SCHEDULE "A" PIEZOMETERS IN TILL

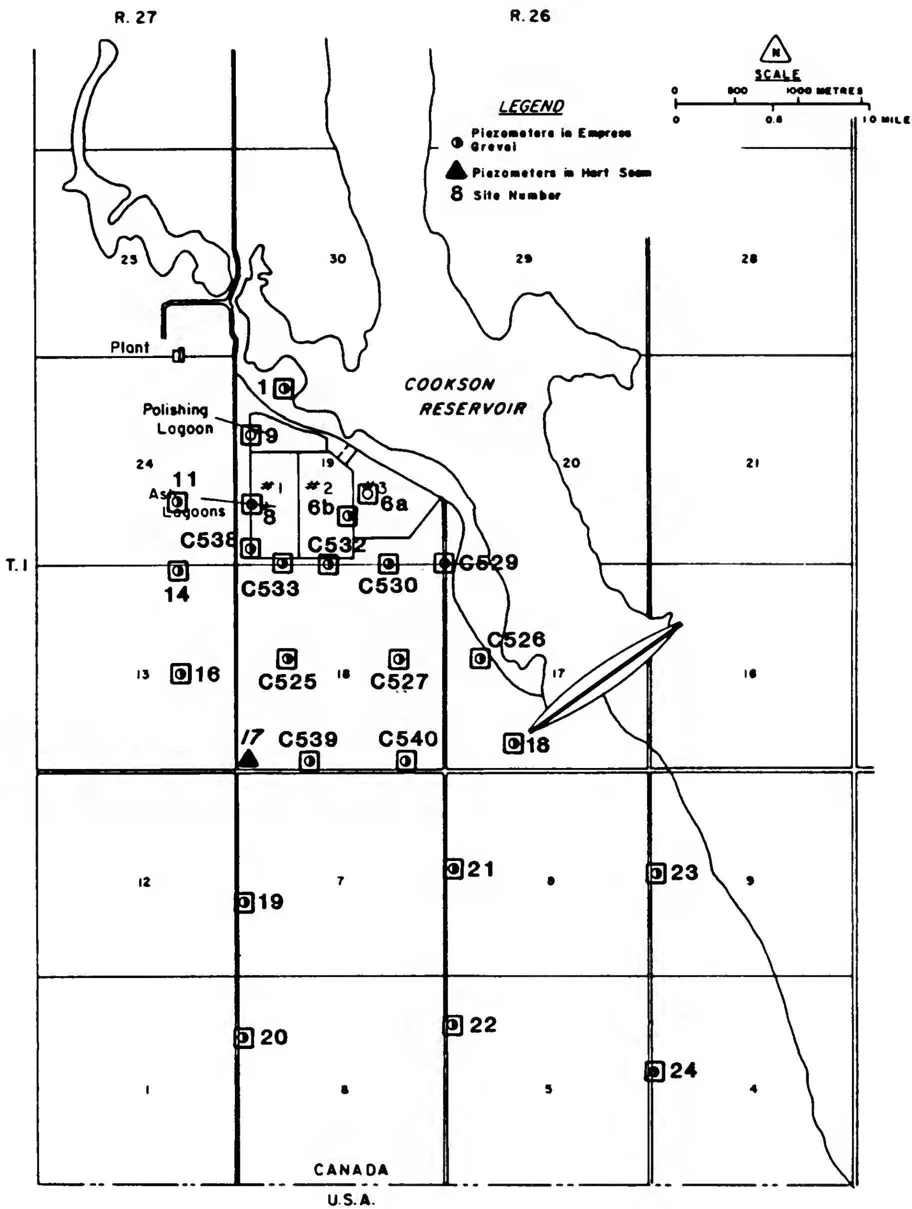
GROUND WATER PIEZOMETER LEVEL MONITORING - ASH LAGOON AREA AND

INTERNATIONAL BOUNDARY AREA

SCHEDULE B - PIEZOMETERS IN EMPRESS GRAVEL

Responsible Agency: Saskatchewan Environment and Public Safety

Station Immediate Ash Lagoon Area	Piezometer No.	Frequency of Measurement
1	C731	All piezometers are monitored quarterly
6a	C763E	
6b	C765A	
C529	C529	
C530	C530	
C532	C532	
C533	C533	
C538	C538	
8	C730E	
9	C728E	
West of Ash Lagoon Area		
11	C743	
14	C740	
16	C756	
South of Ash Lagoon Area		
C525	C525	
C526	C526	
C527	C527	
C539	C539	
C540	C540	
18	C741	
20	C736	
21	C742	
22	C733	
23	C732	
24	C734	



PIEZOMETER INSTALLATION SITES - SCHEDULE "B" PIEZOMETERS IN EMPRESS GRAVEL

AMBIENT AIR QUALITY MONITORING

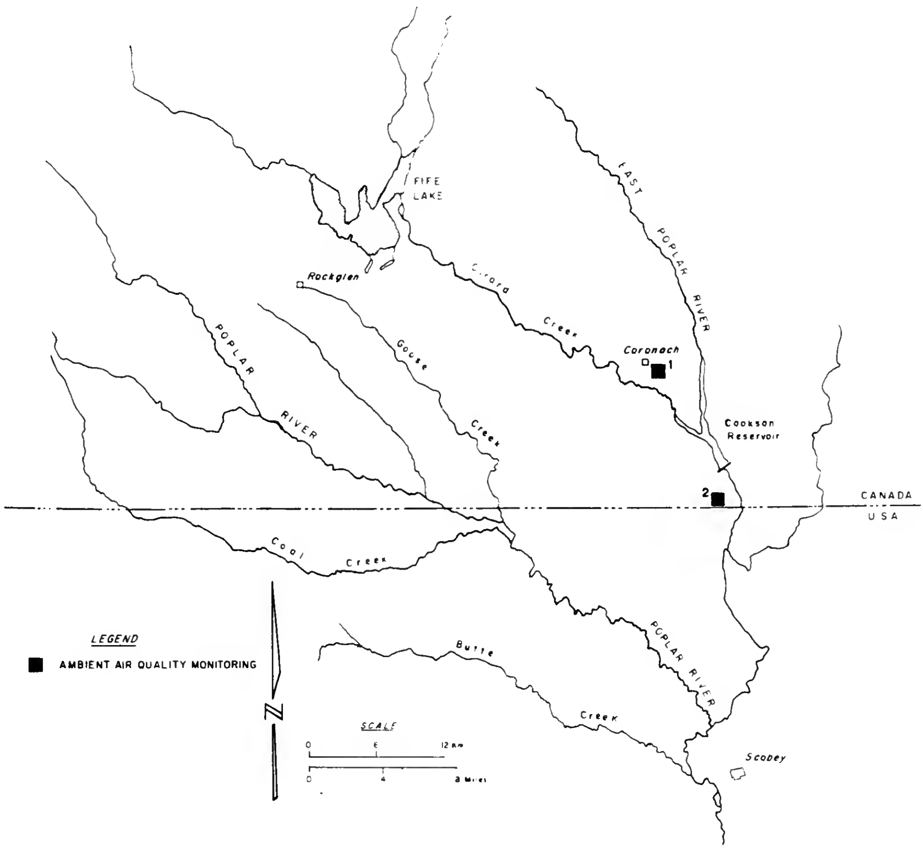
Responsible Agency: Saskatchewan Environment and Public Safety

No. on Map	Location	Parameters	Reporting Frequency
1	Coronach	Sulphur Dioxide	Continuous monitoring with hourly averages as summary statistics.
		Wind speed and direction	Continuous monitoring with hourly averages as summary statistics.
		Total Suspended Particulates	24-hour samples on a 6-day cycle, corresponding to the National Air Pollution Surveillance Sampling Schedule.
2	International Boundary*	Sulphur Dioxide	Continuous monitoring with hourly averages as summary statistics.
		Total Suspended Particulates	24-hour samples on 6-day cycle, corresponding to the National Air Pollution Surveillance Sampling Schedule.

METHODS

Sulphur Dioxide	Saskatchewan Environment and Public Safety Colourimetric Titration, Pulsed Fluorescence
Total Suspended Particulates	Saskatchewan Environment and Public Safety High Volume Method

* This station is operated by Saskatchewan Power.



AMBIENT AIR QUALITY MONITORING (CANADA)

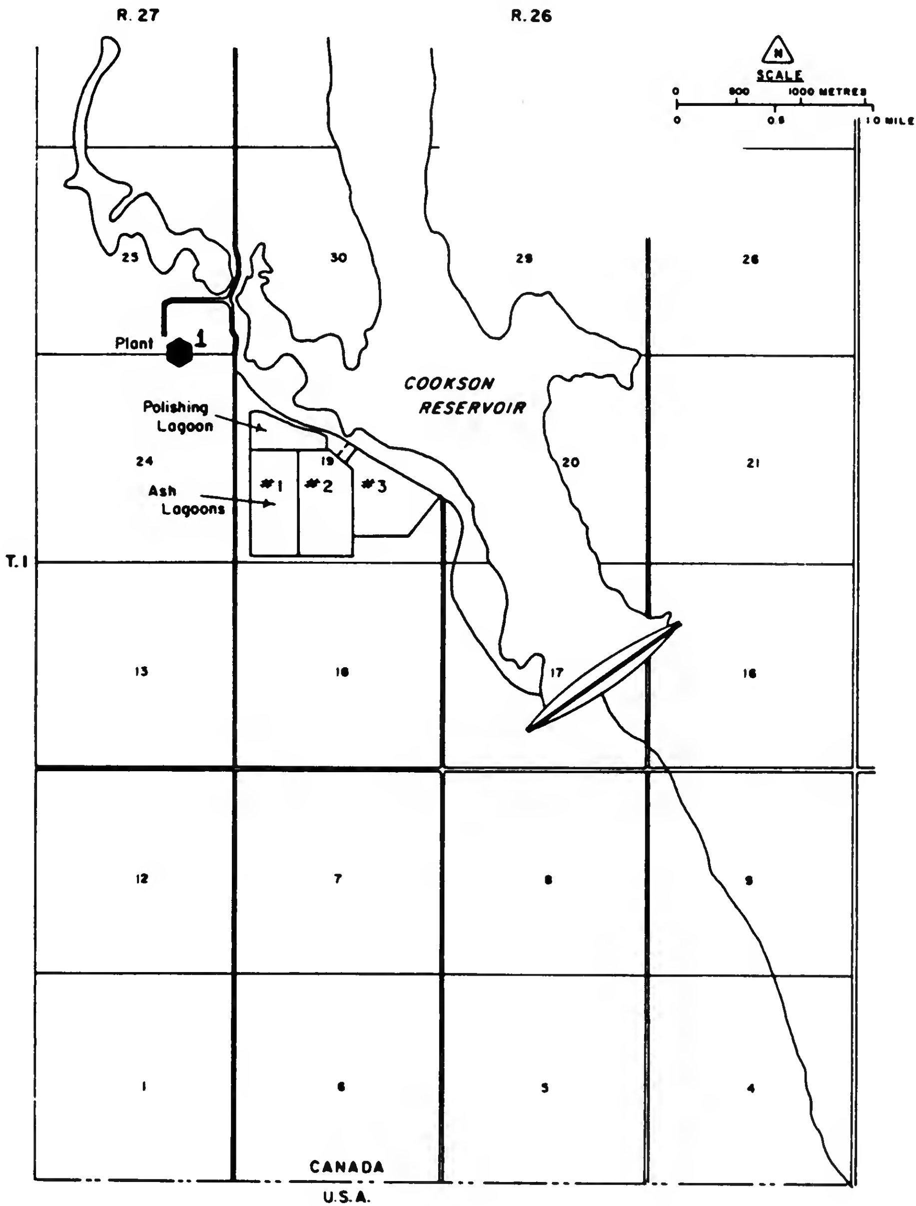
SOURCE EMISSION MONITORING

Responsible Agency: Saskatchewan Environment and Public Safety

No. on Map	Station Location	Parameters	Sampling Frequency
1	At Poplar River Power Plant	Sulphur Dioxide, Nitrogen Dioxide, Opacity.	Continuously reported as Hourly Averages

METHODS

Sulphur Dioxide	Saskatchewan Environment and Public Safety - Ultraviolet Absorption
Nitrogen Dioxide	Saskatchewan Environment and Public Safety - Chemiluminescence
Opacity	Saskatchewan Environment and Public Safety - Optical



SOURCE EMISSION MONITORING

POPLAR RIVER

COOPERATIVE MONITORING ARRANGEMENT

TECHNICAL MONITORING SCHEDULES

1989

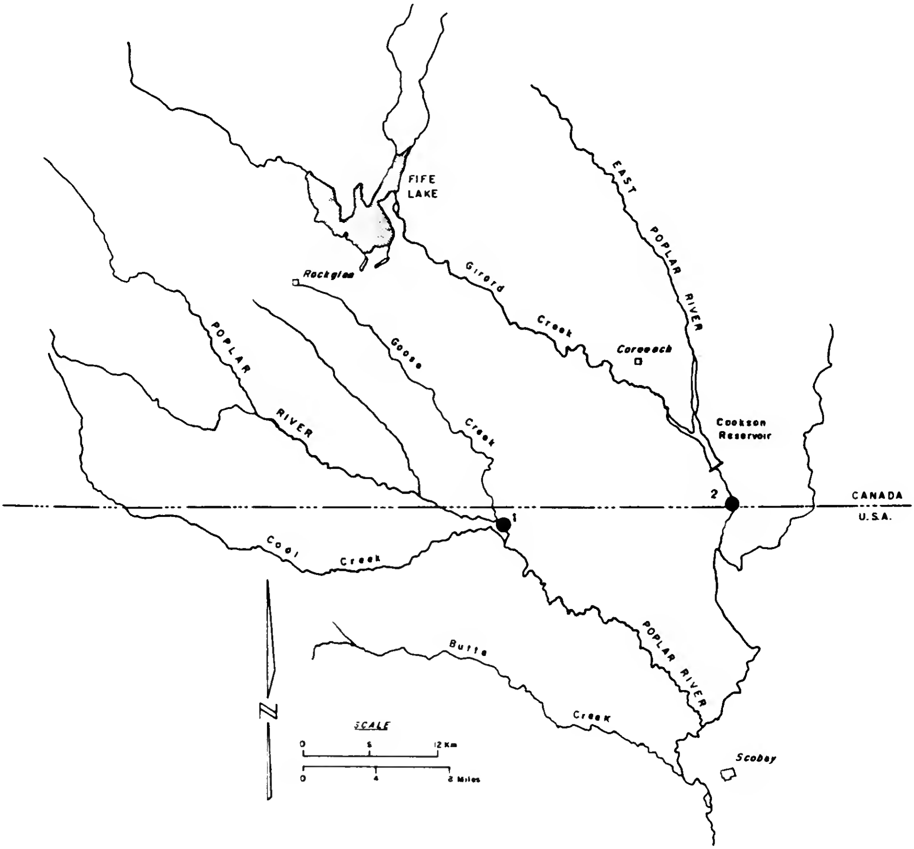
UNITED STATES

STREAMFLOW MONITORING

Responsible Agency: United States 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 Location

Responsible Agency: U.S. Geological Survey

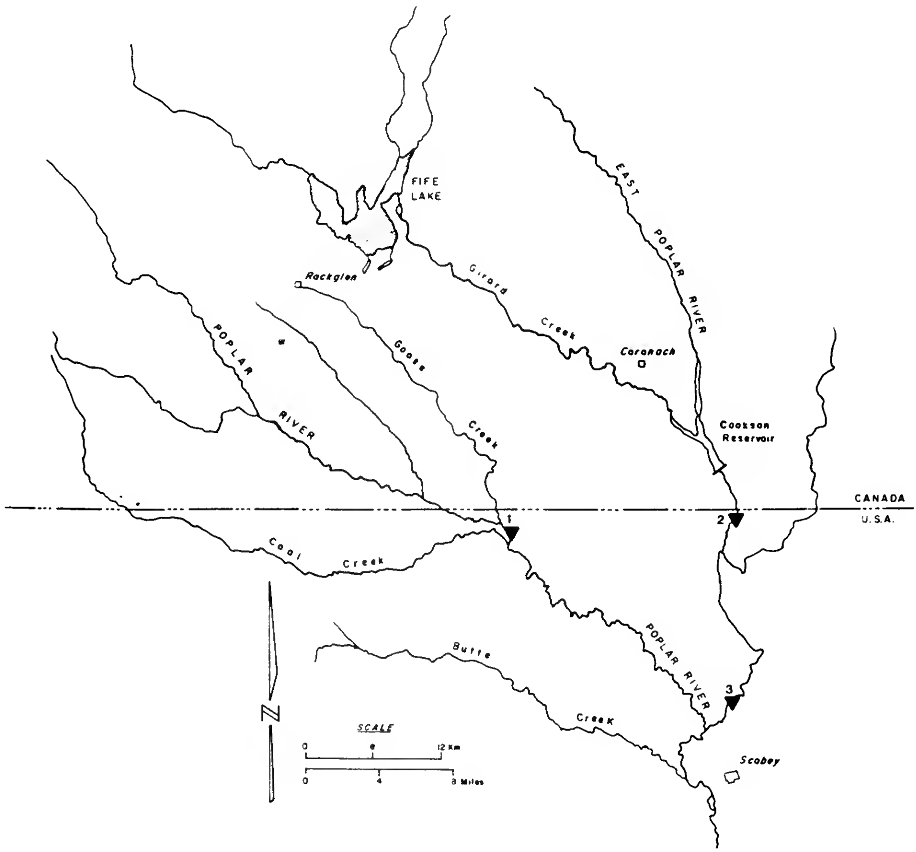
No. on Map	USGS Station No.	Station Name
1	06178000	Poplar River at International Boundary
2	06178500	East Poplar River at International Boundary
3	06179000	East Poplar River near Scobey

PARAMETERS

WATSTORE* Code	Parameter	Analytical method	Sampling Frequency No. 1	2	3
90410	Alkalinity-lab	Elect. Titration	M	M	M
01106	Aluminum-diss	AA	SA	SA	SA
00610	Ammonia-tot	Colorimetric	M	M	M
00625	Ammonia+Org N-tot	Colorimetric	M	M	M
01000	Arsenic-diss	AA, hydride	SA	SA	SA
01002	Arsenic-tot	AA, hydride	A	A	A
01010	Beryllium-diss	AA	SA	SA	SA
01012	Beryllium-tot/rec	AA-Persulfate	A	A	A
01020	Boron-diss	ICP	M	M	M
01025	Cadmium-diss	AA	SA	SA	SA
01027	Cadmium-tot/rec	AA-persulfate	A	A	A
00915	Calcium	AA	M	M	M
00680	Carbon-tot Org	Wet Oxidation	SA	SA	SA
00940	Chloride-diss	Ion chromatography	M	M	M
01030	Chromium-diss	AA	SA	SA	SA
01034	Chromium-tot/rec	AA-persulfate	A	A	A
00080	Color	Electrometric, visual	M	M	M
00095	Conductivity	Wheatstone Bridge	M	D	M
01040	Copper-diss	AA	SA	SA	SA
01042	Copper-tot/rec	AA-persulfate	A	A	A
00061	Discharge-inst	Direct measur.	M	M	M
00950	Fluoride	Electrometric	M	M	M
01046	Iron-diss	AA	M	M	M
01045	Iron-tot/rec	AA-persulfate	A	A	A
01049	Lead-diss	AA	SA	SA	SA
01051	Lead-tot/rec	AA-persulfate	A	A	A
00925	Magnesium-diss	AA	M	M	M
01056	Manganese-diss	AA	SA	SA	SA
01055	Manganese-tot/rec	AA-persulfate	A	A	A
01065	Nickel-diss	AA	SA	SA	SA
01067	Nickel tot/rec	AA-persulfate	A	A	A
00615	Nitrite-tot	Colorimetric	M	M	M
00630	Nitrate+Nitrite-tot	Colorimetric	M	M	M
00300	Oxygen-diss	Winkler/meter	M	M	M
70507	Phos, Ortho-tot	Colorimetric	M	M	M
00400	pH	Electrometric	M	M	M
00665	Phophorous-tot	Colorimetric	M	M	M
00935	Potassium-diss	AA	M	M	M
00931	SAR	Calculated	M	M	M
80154	Sediment-conc.	Filtration-gravimetric	M	M	M
80155	Sediment-load	Calculated	M	M	M
01145	Selenium-diss	AA, hydride	SA	SA	SA
01147	Selenium tot	AA, hydride	A	A	A
00955	Silica	Colorimetric	M	M	M
00930	Sodium	AA	M	M	M
00945	Sulfate-diss	Colorimetric	M	M	M
70301	Total Dissolved Solids	Calculated	M	M	M
00010	Temp Water	Toluene	M	M	M
00020	Temp Air	Toluene	M	M	M
00076	Turbidity	Nephelometric	M	M	M
80020	Uranium-diss	Fluorimetric	-	MC	-
01090	Zinc-diss	AA	SA	SA	SA
01092	Zinc-tot/rec	AA-persulfate	A	A	A

*Computer storage and retrieval system - USGS

Symbols: C-continuous; D-daily; M-monthly; MC-monthly composite; A-annually at high flow; SA-semi-annually at low and high flow; AA-atomic absorption; tot-total; rec-recoverable; diss-dissolved



SURFACE WATER QUALITY MONITORING STATIONS (UNITED STATES)

GROUND WATER QUALITY MONITORING

Station Locations

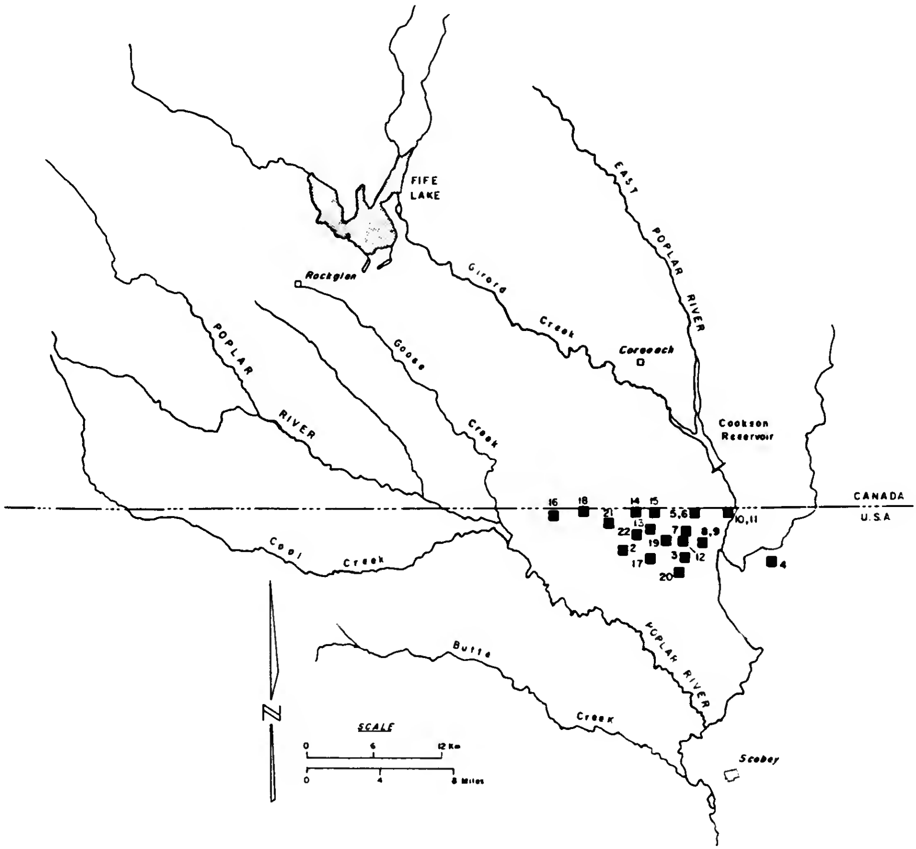
Responsible Agency: Montana Bureau of Mines and Geology

Map Number	Well Location	Total Depth (m)	Casing Diameter (cm)	Aquifer	Perforation Zone (m)
2	37N47E17DABB	79	3.8 PVC	Hart Coal	76-79
3	37N47E23AADD	36	3.8 PVC	Hart Coal	33-36
4	37N48E23BBCC	104	3.8 PVC	Fox Hills-Hell Creek	102-104
5	37N47E1ABBB1	16	10.2 PVC	Alluvium	10-15
6	37N47E1ABBB2	25	10.2 PVC	Hart Coal	19-25
7	37N47E12BBBB	45	10.2 PVC	Hart Coal	39-45
8	37N47E13AADD	14	10.2 PVC	Alluvium	10-13
9	37N47E13ADAA01	43			
		63	10.2 PVC	Fort Union	16-62
10	37N48E5BABB	13	10.2 PVC	Alluvium-Coal	7-13
11	37N48E5AAAA	67	15.2 STEEL	Fox Hills-Hell Creek	65-67
12	37N47E Sec 11 DDDD	26	5.08	Hart Coal	15-18
13	37N47E Sec 3 CCCC	62.5	10.2	Hart Coal	56-59
14	37N47E Sec 4 BBAB	82.6	10.2	Hart Coal	75-78
15	37N47E Sec 3 BBAA	89	10.2	Hart Coal	83-86
16	37N46E Sec 3 ABAB	26	10.2		24-25
17	37N47E Sec 16 DDDD	88	10.6	Hart Coal	80-83
18	37N46E Sec 1 BBBA	90	10.2	Hart Coal	80-82
19	37N47E Sec 15 AAAB	59	10.2	Hart Coal	54-56
20	37N47E Sec 24 CCCC	22	5.08		19-22
21	37N47E Sec 6 DBAA	106	10.2	Hart Coal	100-103
22	37N47E Sec 9 CBCC	21	10.2		18-21

Parameters

Storet* Code	Parameter	Analytical Method	Sampling Frequency Station No.
00440	Bicarbonates	Electrometric Titration	Sample collection is annually for all locations identified above.
01020	Boron-diss	Emission Plasma ICP	
00915	Calcium	Emission Plasma	
00445	Carbonates	Electrometric Titration	The analytical method descriptions are those of the Montana Bureau of Mines and Geology Laboratory where the samples are analyzed.
00940	Chloride	Ion Chromatography	
00095	Conductivity	Wheatstone Brdg	
01040	Copper-diss	Emission Plasma, ICP	
00950	Fluoride	Ion Chromatography	
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	
00630	Nitrate	Ion Chromatography	
00400	pH	Electrometric	
00935	Potassium	Emission Plasma, ICP	
01145	Selenium-diss	AA	
00955	Silica	Emission Plasma, ICP	
00930	Sodium	Emission Plasma, ICP	
01080	Strontium-diss	Emission Plasma, ICP	
00445	Sulphate	Ion Chromatography	
22703	Uranium	Fusion Flurometric	
00190	Zinc-diss	Emission Plasma, ICP	
70301	TDS	Calculated	

*Computer storage and retrieval system - United States Geological Survey
Symbols: AA-Atomic Absorption; ICP-Inductively Coupled Plasma Unit



GROUND WATER QUALITY MONITORING (UNITED STATES)

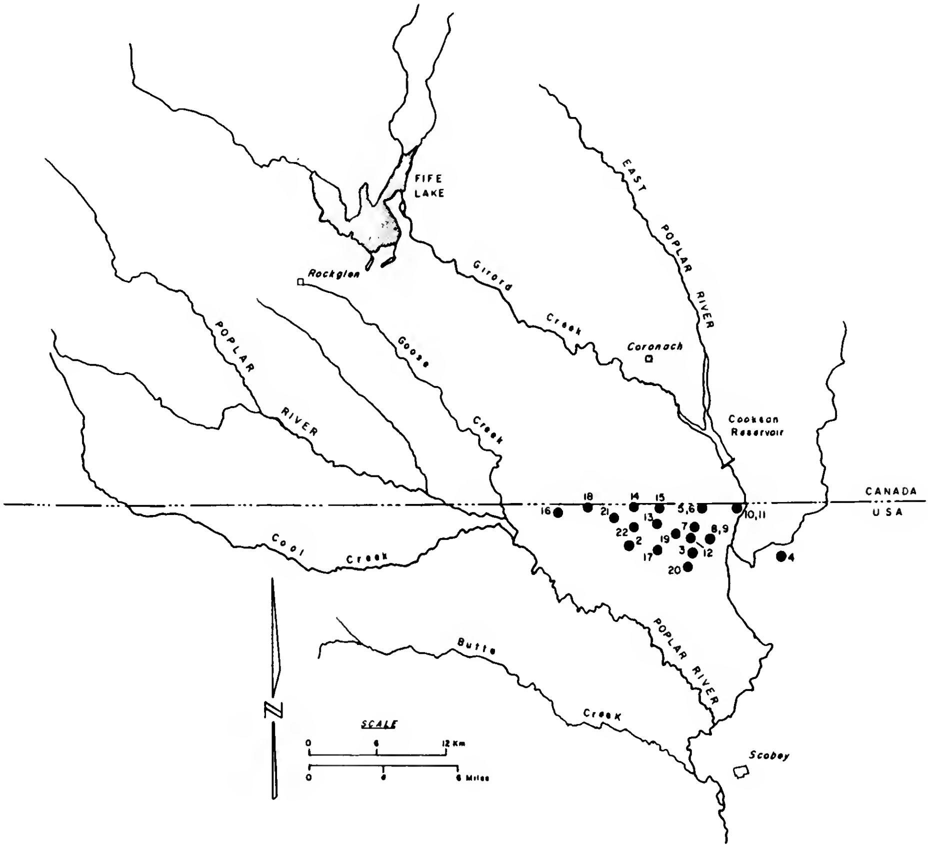
GROUND WATER LEVELS TO MONITOR

POTENTIAL DRAWDOWN DUE TO

COAL SEAM DEWATERING

Responsible Agency: Montana Bureau of Mines and Geology

No. on Map	Sampling
2 to 22	Determine water levels quarterly



GROUNDWATER PIEZOMETERS TO MONITOR POTENTIAL DRAWDOWN DUE TO COAL SEAM DEWATERING

AMBIENT AIR QUALITY MONITORING

Responsible Agency: State of Montana
Air Quality Bureau

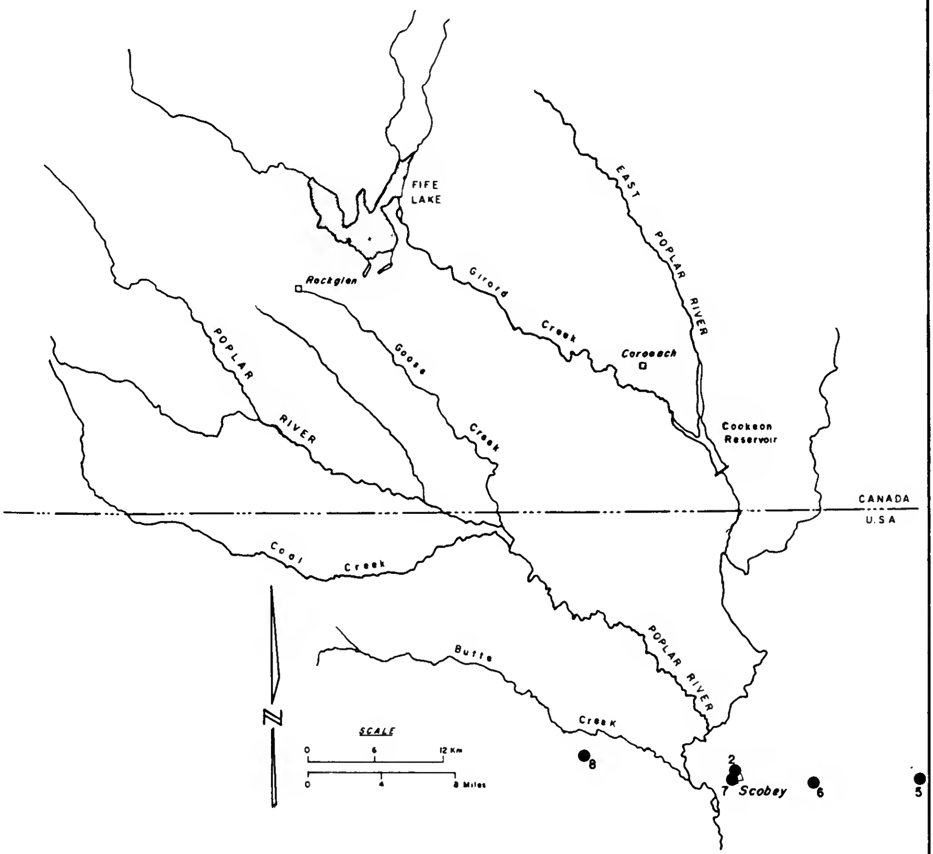
No. on Map	Location
2	Richardson
5	Flaxville
6	TV Tower Hill
7	Scobey Downtown
8	Four Buttes

TYPES OF SAMPLING

Sulfation Rate - Monthly Averages

METHODS

Methods of Air Sampling and Analysis, 2nd Edition, "Tentative Method of Analysis of the Sulfation Rate of the Atmosphere (Lead Dioxide Plate Method - Turbidimetric Analysis," p. 691.



AMBIENT AIR QUALITY MONITORING (UNITED STATES)

ANNEX 3

REPORTS REVIEWED DURING 1988

BY THE POPLAR RIVER BILATERAL MONITORING COMMITTEE

REPORTS REVIEWED DURING 1988

BY THE POPLAR RIVER BILATERAL MONITORING COMMITTEE

1. Saskatchewan Power Corporation, 1987, Poplar River Power Station, Uranium in Groundwaters, Environmental Programs, 12 p.

2. Linton, L. R., McDonald, R.A. and Hamilton, H.R., 1988, Evaluation of the Transboundary TDS and Boron Water Quality Objectivies for the Poplar River, Environment Canada, Water-Quality Branch, Regina, Saskatchewan, 78 p.

ANNEX 4

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 decametres (3,800 acre-feet), then a continuous minimum flow of 0.028 cubic metres per second (1.0 cubic feet per second) shall be delivered to the United States on the East Poplar River at the International Boundary throughout the suceeding 12 month period commencing June 1st. In addition, a volume of 370 cubic decametres (300 acre-feet) shall be delivered to the United States upon demand at any time during the 12 month period commencing June 1st.

      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 decametres (3,800 acre-feet), but does not exceed 9,250 cubic decametres 7,500 acre-feet), then a continuous minimum flow of 0.057

*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.

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 decametres (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 decametres (7,500 acre-feet), but does not exceed 14,800 cubic decametres (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 decametres (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 decametres (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 suceeding 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 decametres (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 5

METRIC CONVERSIONS

METRIC CONVERSION FACTORS

ac	=	4,047 m^2 = 0.4047 ha
ac-ft	=	1,233.5 m^3 = 1.2335 dam^3
C°	=	1.8 F°
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	=	10.7636 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