

S Poplar River Bilateral
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by the

POPLAR RIVER BILATERAL MONITORING COMMITTEE

COVERING CALENDER YEAR 1982

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POPLAR RIVER BILATERAL MONITORING COMMITTEE

REPORT TO GOVERNMENTS OF CANADA, UNITED STATES,

SASKATCHEWAN AND MONTANA

FOR

CALENDAR YEAR 1982

MARCH, 1983

POPLAR RIVER BILATERAL MONITORING COMMITTEE

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

Department of External Affairs
Ottawa, Ontario, Canada

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

Saskatchewan Environment
Regina, Saskatchewan, Canada

Gentlemen:

The Poplar River Bilateral Monitoring Committee continues to address those responsibilities assigned to it by Governments under the Poplar River Cooperative Monitoring Arrangement dated September 23, 1980. Water quantity, water quality and air quality data of significance to impacts at the International Boundary were exchanged between countries on a quarterly basis. The monitoring information exchanged were in accordance with the locations, frequency and parameters detailed in the Technical Monitoring Schedule.

The Committee has examined and evaluated the monitoring for 1982 and concludes the measured conditions fall within accepted objectives or norms for the parameters involved. No major trends are yet apparent at the International Boundary.

This second annual report to Governments covers the calendar year 1982, roughly corresponding to the second year of operation of the Saskatchewan Power Corporation 300 MW coal-fired thermal generating stations located on the East Poplar River. The results of the monitoring program are summarized and narrative descriptions relative to pre-project conditions, and guidelines for specific parameters that may have been developed as joint activities under International Joint Commission references are included.

The Committee, in accordance with recommendations of the International Joint Commission has devised a flow-weighting scheme for boron and total dissolved solids. The results are presented in this report.

Yours sincerely,



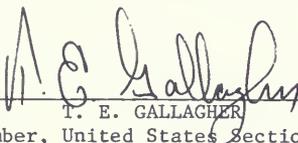
R. C. AVERETT

Chairman, United States Section



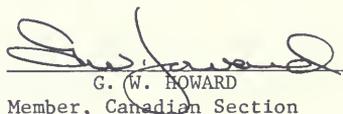
D. A. DAVIS

Chairman, Canadian Section



T. E. GALLAGHER

Member, United States Section



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Member, Canadian Section

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1982 HIGHLIGHTS

The first 300 MW coal-fired electrical generating unit at the Saskatchewan Power Corporation Poplar River Power Station began commercial operation in July 1981.

The quarterly exchange of monitoring information collected by both countries was carried out during 1982. In general, the frequency, location and type of information exchanged met the requirements identified by both countries in the Technical Monitoring Schedule.

The United States received a continuous discharge in the East Poplar River throughout the year and in addition was entitled to an on demand release of up to 1,230 cubic decameters between June 1, 1982 and May 31, 1983. As of December 31, 1982 this release had not been requested. The snowmelt runoff was much above normal in 1982 and resulted in large spill volumes from Cookson Reservoir. Recorded flow below Cookson Reservoir was less than the minimum discharge recommended by the International Joint Commission (IJC) 19 percent of the time.

The ground-water drawdown associated with coal seam dewatering was shown to have no impact closer than one-half mile north of the International Boundary. Boron and total dissolved solids (TDS) vary widely in the ground water with generally poorer quality water in the lower aquifers.

Boron and TDS in the East Poplar River were below the long-term and short-term objectives recommended to Governments by the IJC. There was no discernible trend from pre-project conditions. Water quality met the objectives for other parameters recommended by the International Poplar River Water Quality Board to the IJC with one exceedence being observed for total zinc.

Water quality in piezometers near the Saskatchewan Power Corporation ash lagoons was highly variable, with questionable results reported. Steps are proposed by the Committee to improve results.

Ground-water seepage from the ash lagoon was computed to be less than the construction standards established by Saskatchewan.

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

INTRODUCTION

The Poplar River Bilateral Monitoring Committee was authorized 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.

The Committee is composed of representatives of the Government of Canada, Province of Saskatchewan, Government of the United States of America, and State of Montana. 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 1982 the members and ex-officio members of the Committee were:

Mr. R. C. Averett
U.S. Geological Survey
Co-Chairman, U.S. Section

Mr. D. A. Davis
Environment Canada
Co-Chairman, Canadian Section

Mr. T. E. Gallagher
Governor's Office
Montana Member, U.S. Section

Mr. G. W. Howard
Saskatchewan Environment
Member, Canadian Section

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

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

The Committee met in Regina, Saskatchewan in March 1982 to prepare the 1981 Annual Reports to Governments. An ad hoc technical group met in Denver, Colorado in December 1982 for the purpose of reviewing monitoring information, quality assurance programs, and the progress to date on development of flow-weighting procedures. The contents of the 1982 report to Governments was also discussed.

The responsibilities of the Committee include an ongoing quarterly exchange of the results of water quantity, water quality and air-quality monitoring programs being conducted in Canada and the United States at or near the International Boundary. The monitoring program is in response to the construction of Saskatchewan Power Corporation's coal-fired thermal generating

station near Coronach, Saskatchewan and to the concerns of transboundary impacts. The exchange of monitoring information was initiated with the first quarter of 1981, and is an expansion of the informal quarterly information program instituted between Canada and the United States in 1976. The data exchanged are documented in a Technical Monitoring Schedule attached as Annex 2. The data are available for public review at agencies of the participating governments or from Committee members.

The Committee is also required to prepare an annual report to Governments which draws to the attention of Governments any definitive changes in the monitored parameters based on evaluation of the data made available by both countries. The Committee has decided to report to Governments on a calendar year basis. The first report covered 1981 and was issued in March 1982. Issuance of this 1982 report roughly corresponds to the second year of operation of the first 300 MW Unit of the coal-fired thermal electric generating station operated by Saskatchewan Power Corporation on the East Poplar River near Coronach, Saskatchewan. Subsequent sections of this report summarize the findings and comment on the results in relation to pre-project conditions, and to objectives or standards recommended by the International Joint Commission.

Another 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 Schedule. The Technical Monitoring Schedule proposed for 1983 is attached as Annex 2, and the concurrence of Governments with the proposed Schedule is requested. It can be expected that the Committee will continue to review and propose changes to the Technical Monitoring Schedule in future years as information requirements change.

POPLAR RIVER POWER STATION

Operation

The first 300 MW unit was commissioned in June 1981 and commenced commercial operation July 1, 1981. The unit operated for the full twelve months of 1982. The station's electrical production statistics for the period were:

Hours of operation	7310
Gross MWh generated	1,974,500
Availability (hours)	83.45%
Capacity Factor	76.67%
Number of startups	35
Coal consumed	1,689,624 tonnes
Oil consumed	5,854,483 litres

Failures in the ash-collection system resulted in eight spills; the last of which occurred on August 6, 1982. With the exception of one case when an estimated two cubic meters entered the reservoir, all ash spills were contained on site.

Spill containment structures were completed in the fall and are now operational.

Construction

Construction of the second 300 MW unit at the Poplar River Power Station was at a virtual standstill from May to December 1982 due to a construction trades strike. Boil out and acid clean for the second unit was scheduled for February 1983; first fire on coal May 1983; and commercial operation is scheduled for July 1983.

SURFACE WATER QUANTITY

Natural Flow

The natural flow in the Poplar River basin was well above normal in 1982, assuming the recorded flow of the Poplar River at International Boundary is a good indicator of basin runoff conditions. Snow accumulation prior to runoff was above normal, and combined with a late melt and rapid warming, resulted in a maximum instantaneous discharge of the Poplar River that was the 5th highest on record; 113 cubic meters per second (m^3/s) on April 13, 1982.

The volume of runoff in the Poplar River between March 1 and October 31, 1982 was 29,500 cubic decametres (dam^3) compared to a long term mean volume of 17,200 dam^3 . The recorded runoff volume of the Poplar River during the March 1 to May 31 period, used as an indicator in setting the minimum and on demand releases in the East Poplar River under the International Joint Commission apportionment recommendations, was 27,400 dam^3 .

Minimum Flows

Based on the apportionment recommendations of the International Joint Commission, the United States would be entitled to a minimum discharge of $0.028m^3/s$ from January until May 31; $0.085 m^3/s$ from June 1 until August 31; and $0.057 m^3/s$ from September 1 to December 31, 1982 on the East Poplar River at the International Boundary. This stream regime is designed to enhance instream environmental values during the summer period in years when spring runoff is high.

The minimum discharge in the East Poplar River during the period January 1 to May 31 was $0.023 m^3/s$, with this flow occurring from January 16 to January 25. During the January to May period the recorded flow was marginally below the recommended minimum flow for 46 days, all under ice conditions. Cold temperatures during this period caused large accumulations of ice in the channel between Cookson Reservoir and the International Boundary which reduced flows to less than what had previously been measured. The flow was below the recommended minimum for 24 days in August when a discharge of $0.076 m^3/s$ was recorded on August 6 and August 9 to 31. The minimum flow during the period September 1

to December 31, 1982 was $0.076 \text{ m}^3/\text{s}$, well above the recommended flow of $0.057 \text{ m}^3/\text{s}$ for that time period. During the year the recorded flow was below the recommended minimum flow approximately 19 percent of the time. However, the average flow for each of the three periods exceeded the recommended minimums.

The hydrograph of the East Poplar River at the International Boundary is depicted in Figure 1, along with the International Joint Commission recommended minimum flows. As can be noted from the hydrograph, there was a large and sustained snowmelt runoff during 1982. Of the total volume of $29,000 \text{ dam}^3$ recorded for the year, $22,500 \text{ dam}^3$ occurred in April.

Reservoir Storage

Cookson Reservoir was at elevation 751.867 m on January 1, rising to 753.026 m during the peak of the snowmelt runoff on April 15. The reservoir level was held steady, near full supply levels for several months with the highest level for the year recorded on June 2 at elevation 753.160 m. The reservoir declined slightly over the summer months and the reservoir level at year end was 752.681 m. The corresponding volumes of stored water were:

Full Supply Level	$43,400 \text{ dam}^3$	(elevation 753.000 m)
January 1	$35,000 \text{ dam}^3$	
April 15	$43,600 \text{ dam}^3$	
June 2	$44,700 \text{ dam}^3$	
December 31	$41,000 \text{ dam}^3$	

The increase in storage over the year was $6,000 \text{ dam}^3$, with only small reservoir drawdown in the summer and fall, primarily because coal-seam dewatering discharge entering Cookson Reservoir through Girard Creek was of sufficient volume to help offset evaporative losses and releases from the reservoir. Because of the near full supply level conditions at the end of the year, the reservoir will not have a major modifying influence on the 1983 spring runoff in the East Poplar River.

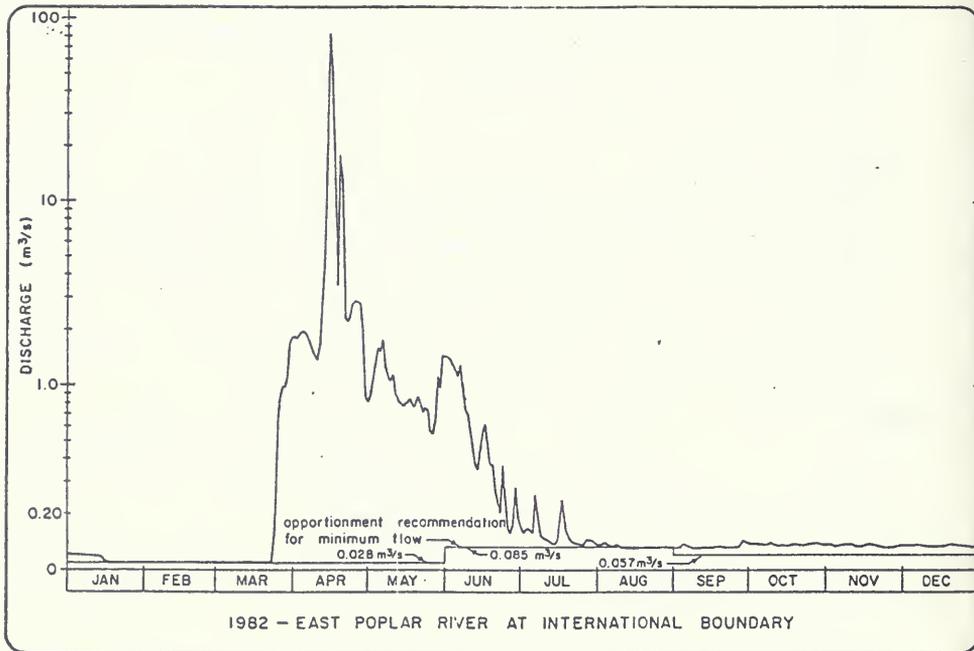


Figure 1 : Mean daily discharge of the East Poplar River at International Boundary.

On Demand Release

The 1982 runoff volume on the Middle Fork of the Poplar River at the International Boundary from March 1 to May 31 was 27,440 dam³. Based on the apportionment recommendations of the International Joint Commission, the United States would be entitled to an on-demand release of up to a maximum of 1,230 dam³ during the period from June 1, 1982 to May 31, 1983. As of December 31, 1982 no request had been received for this on-demand release. All past commitments for on-demand releases have been met.

SURFACE WATER QUALITY

Surface water quality has been assessed using the data exchanged under the terms of the Technical Monitoring Schedule. Additional data on conductivity, collected by the United States Geological Survey from March to October, was used in regression equations for determining flow-weighted concentrations.

Flow-Weighted Concentrations

In order to assess compliance of the East Poplar River quality with the recommended IJC objectives for boron and TDS, flow-weighted concentrations must be computed. The IJC report recommends: (1) a long-term objective computed as a five-year moving flow-weighted concentration, and (2) a short-term objective for any given year computed as a three-month moving flow-weighted concentration. The objectives apply to the March to October period which the IJC determined to be the maximum time interval over the annual cycle in which water may be used for irrigation purposes. Flow-weighted concentrations have been computed using the following concept:

$$C_Q = \frac{C_1 Q_1 + C_2 Q_2 + C_3 Q_3 + \dots + C_n Q_n}{Q_1 + Q_2 + Q_3 + \dots + Q_n}$$

where C_Q = Flow-weighted concentration

C_1 = Instantaneous concentration at mean daily flow Q_1

Q_1 = Mean daily flow for C_1

n = Last observation for the period of record

Consideration was given to using different combinations of daily and monthly flows, instantaneous and mean concentrations, and advancing the time period for computing the moving averages either by one day, month or year. The techniques used and the results can be obtained by writing the Canadian Chairman of the Poplar River Bilateral Monitoring Committee.

Flow-Weighted Concentrations for Comparison to the Long-Term Objective

The Committee has adopted the approach that for the purpose of determining compliance of the East Poplar River Water Quality with the recommended IJC long-term objective, the data are best presented as a five-year moving average, advancing one month at a time.

It should be noted that in addition to the instantaneous sample data, daily boron and TDS concentrations have been calculated using a regression with daily electrical conductivity values. Eventually, the long-term average will be computed using the approximately 240 data points from each annual eight-month irrigation period rather than from the present sixteen (two samples per month).

Flow-Weighted Concentrations for Comparison to the Short-Term Objective

To determine compliance of the East Poplar River boron and TDS quality with the recommended short-term IJC objective, the Committee adopted the approach of computing three-month (90 day) moving flow-weighted concentrations advancing one month at a time while dropping the first month in the time period. This method has been applied to the entire period of data record and was based on data from instantaneous samples. The only exception to this was during 1982, when calculated daily boron and TDS were obtained using a regression with electrical conductivity. These 1982 calculated concentrations were then used to compute the short-term (90 day) moving flow-weighted concentrations while advancing one day at a time throughout the period March to October.

Data Compatibility

Environment Canada and the United States Geological Survey improved their knowledge on data compatibility by exchanging and splitting water samples

during June 1982. For most relevant parameters reported there was agreement between agencies. The TDS and boron data compared extremely well, but some discrepancies in pH and electrical conductivity results remained; the reason for these discrepancies are being investigated. The agencies will be repeating the entire intensive quality-control project, with some minor improvements in project design during 1983.

East Poplar River at International Boundary

Table 1 presents the water quality objectives recommended by the IJC and the larger set of objectives recommended to the IJC by the International Poplar River Water Quality Board. The corresponding number of samples collected for the East Poplar River near the International Boundary by governments are also shown in Table 1.

Boron

The two principle data bases (USGS and Environment Canada) report dissolved boron, although it is believed the IJC recommended objective is for total boron. The Committee has taken the position that total and dissolved boron concentrations are essentially equal and is utilizing the more commonly reported dissolved boron for the purpose of monitoring and determining compliance with the IJC recommended objectives.

The long-term five-year moving flow-weighted concentration is presented in Figure 2. Note that each point is plotted as the midpoint of a five-year period, advancing one month at a time throughout the data set, which consist of March to October data. The five-year moving flow-weighted concentrations for boron have not exceeded 1.5 mg/L, which is below the recommended long-term objective of 2.5 mg/L. The sharp decline occurring in 1979 resulted because of the above normal snowmelt runoff in April 1982, which had a boron level of 0.73 mg/L.

The three-month moving flow-weighted concentrations for boron have not exceeded the recommended short-term objective of 3.5 mg/L for any given year as shown in Figure 3. The trend in each annual curve is similar. As autumn approaches, the boron three-month flow-weighted concentrations gradually rise as the

Table 1.--Recommended water-quality objectives and exceedences and the 1982 sampling program (units in milligrams per liter except as otherwise noted).

Constituent	Objective	No. of samples (1982)		
		USA	Canada	Exceedences
<u>Objectives recommended by IJC to governments</u>				
*Boron - total	Note 1	7	18 (Note 5)	Nil
TDS	Note 1	7	18 (Note 5)	Nil
<u>Objectives recommended by Board to IJC</u>				
Aluminum	0.1	5	Nil	Nil
Ammonia - un-ionized	0.2	7	12	Nil
Cadmium - total	0.0012	4	12	Nil
Chromium - total	0.05	4	12	Nil
Copper - dissolved	0.005	5	Nil	Nil
Copper - total	1.0	4	12	Nil
*Fluoride - total	1.5	7	12	Nil
Lead - total	0.03	4	12	Nil
Mercury - dissolved	0.0002	4	12	Note 6
Mercury - whole fish (mg/kg)	0.5	Nil	Nil	Nil (Can)
Nitrate - N	10.0	7	12	Nil
Dissolved oxygen	Note 2	7	12	Nil
Sodium adsorp. ratio	10.0	7	12	Nil
*Sulphate	800.0	7	12	Nil
Zinc - total	0.03	4	12	1/16
Temperature (°C)	Note 3	12	12	Nil
pH	Note 4	7	12	Nil
Coliform - fecal (No./100 mL)	2,000/100 mL	Nil	12	Nil
- total	20,000/100 mL	Nil	12	Nil

*dissolved form of parameter was determined.

Note

1. March to October, long-term average of flow-weighted concentrations should be < 2.5 mg/L for boron, and < 1,000 mg/L for TDS with a maximum flow-weighted concentration not to exceed 3.5 mg/L for boron and 1,500 mg/L for TDS for any three-month period during this time.
2. 5.0 (minimum April 10 to May 15) 4.0 (minimum rest of year).
3. Natural (April 10 to May 15), less than 30 (rest of year).
4. 6.5 (minimum) and less than 0.5 above natural.
5. Total boron data provided by Saskatchewan Environment are included with the Environment Canada dissolved boron values. The respective TDS data bases have also been combined.
6. The USGS mercury data are being authenticated because of potential sample contamination. The USGS data are, therefore, not available for interpretation.

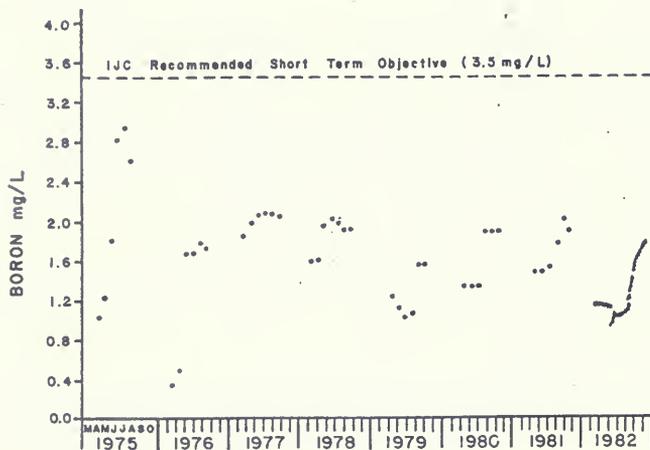
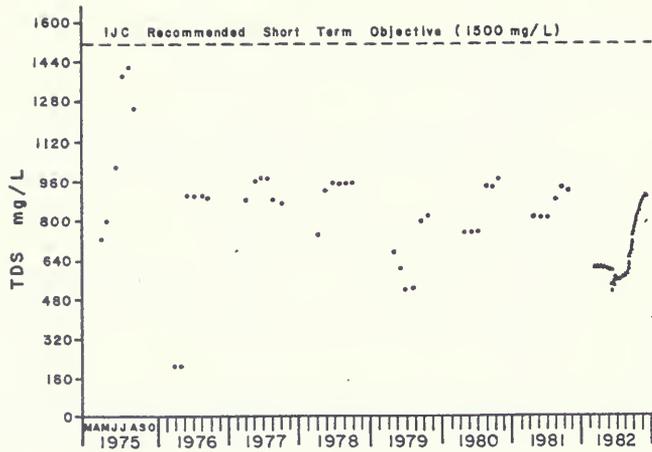


Figure 3: Three-month short-term moving flow weighted concentrations for boron and TDS in the East Poplar River near the International Boundary, computed annually for the period of March to October, 1975 to 1982. *The triangles plotted in 1982 were derived from estimated daily concentrations obtained by regressing with daily conductivities. For the preceding years, the plotted points were derived from the results of the regular sampling program (see text for further details).*

ground-water contribution to streamflow increases. The 1982 calendar year data are also presented using daily boron concentrations estimated using the regression equation: $\text{Boron} = 0.00147 \times \text{Conductivity} - 0.2538$; $r^2 = 0.82$.

Based on sample data, the maximum boron concentration during 1982 for the irrigation period (March through October) was 2.0 mg/L on March 9th. For comparison, the maximum concentration was 1.93 on March 3 and 19, 1982 using the regression equation. The maximum sample concentration of boron for the entire year was 2.2 mg/L on February 11, 1982.

Total Dissolved Solids

The long-term five-year moving average for TDS ranged from 529 to 753 mg/L, never exceeding the recommended long-term objective of 1,000 mg/L (Figure 2). The maximum sample concentration (during the irrigation period) during 1982 was 1,050 mg/L recorded on September 27, whereas the maximum for the entire year was 1,210 mg/L recorded on February 11, 1982.

Based on the available data, the recommended short-term objective of 1,500 mg/L has not been exceeded during 1975 to 1982. The maximum three-month flow-weighted concentrations for the period of record occurred during the period of June to October 1980 when a level of 971 mg/L was measured. During the irrigation period of 1982, the maximum three-month flow-weighted concentration was 905 or 891 mg/L depending on whether the method of computation used sample data or estimated concentrations, respectively. The regression equation for estimating daily total dissolved solids concentrations is:

$$\text{TDS} = 0.6474 (\text{conductivity}) - 4.018; r^2 = 0.94$$

Other Water Quality Characteristics

With the exception of zinc, the multi-purpose objectives recommended by the IJC International Poplar River Water Quality Board for the East Poplar River near the International Boundary were achieved during 1982 (Table 1). The concentration of zinc exceeded the recommended objective of 0.03 mg/L in one of sixteen samples. The mercury content of the river is still uncertain because the two principle data bases do not compare. The Environment Canada data indicated that the mercury content was at or below the analytical detection limit of 0.02 ug/L. The United States Geological Survey data appear

to reflect possible sample contamination and have been withdrawn until their reliability is determined. Investigations into identifying possible sources of contamination are being conducted by the United States Geological Survey. Uranium data obtained by the Environment Canada show that concentrations in the East Poplar River near the International Boundary are typical of background concentrations found in surface waters. The concentrations are below the Canadian Drinking Water Quality Guideline of 20 ug/L.

An assessment of the metal characteristics of the river ecosystem can be improved utilizing collaborative biological data. Environment Canada plans on conducting studies of metals in water, sediment and biota of Cookson Reservoir during 1983. It is interesting to note that during low-flow periods, the East Poplar River water quality is influenced by ground-water inflow in the area immediately below the reservoir. This is substantiated by the higher sulphates in the East Poplar River than what was observed in the reservoir itself during these low-flow periods. A typical example is the August sulphate concentrations of 292 and 108 mg/L at the International Boundary and Cookson Reservoir sites, respectively.

Cookson Reservoir

Samples collected quarterly by Saskatchewan Environment indicate that the TDS content of Cookson Reservoir discharge was predominantly less than 1,000 mg/L. The boron concentrations approached 1.85 mg/L during February and were as low as 0.73 mg/L during May. There was variability in chemical characteristics between the upper and lower ends of the reservoir. The rather sparse data set does not, however, permit an evaluation of the variations between the different sampling sites on the reservoir. No unusual quality characteristics have been observed. Cookson Reservoir remains a Fish-For-Fun zone, largely because no information concerning mercury in fish were collected in 1982. Environment Canada intends to conduct a comprehensive survey during 1983 to determine the levels of mercury (and other metals) in fish, water, and sediment within the reservoir ecosystem.

GROUND WATER QUANTITY

Coal Seam Dewatering Saskatchewan

Data on ground-water levels were exchanged for five piezometers in Saskatchewan near the International Boundary for the purpose of monitoring drawdown due to coal seam dewatering at the Poplar River Mine. A decrease in 1982 of 0.56 meters was observed in piezometer 52, closest to the mine. Levels at the four other piezometers increased from 0.13 to 0.40 meters.

A map of the cone of depression, prepared for the Saskatchewan Department of Environment is shown in Figure 4. Near the mine site the drawdown cone exceeds 20 meters. The cone of depression extends south to about one-half mile of the International Boundary. The Committee will maintain close scrutiny of any expansion of the cone of depression, and in 1983, will endeavor to undertake activities to relate the initial ground-water model to the monitoring results. That is, the Committee recommends that the United States initiate water-level monitoring near the International Boundary south of the point of maximum expansion of the cone of depression. Additional test wells may be required.

Montana

Ten wells which penetrate the following formations were monitored and sampled in the United States portion of the East Poplar River basin near the International Boundary. The wells penetrate the following formations: Alluvium (0-15 meters in thickness); Flaxville (0-26 meters in thickness); Fort Union, including the Hart coal seam, (244 plus meters in thickness); Fox Hills (26-36 meters in thickness); Hell Creek (67-85 meters in thickness). Water level observations were made quarterly. Four of the wells were equipped with continuous water-level recorders.

Small increases and decreases in water levels have occurred in all wells during the two and one-half year observation period, but no trends are noticeable. During April and May 1982, small increases were noted in shallow wells 5, 6, and 10, probably due to above average precipitation. Dewatering of the Hart coal seam north of the International Boundary has, to date, no apparent effect on any of the U.S. observation wells.

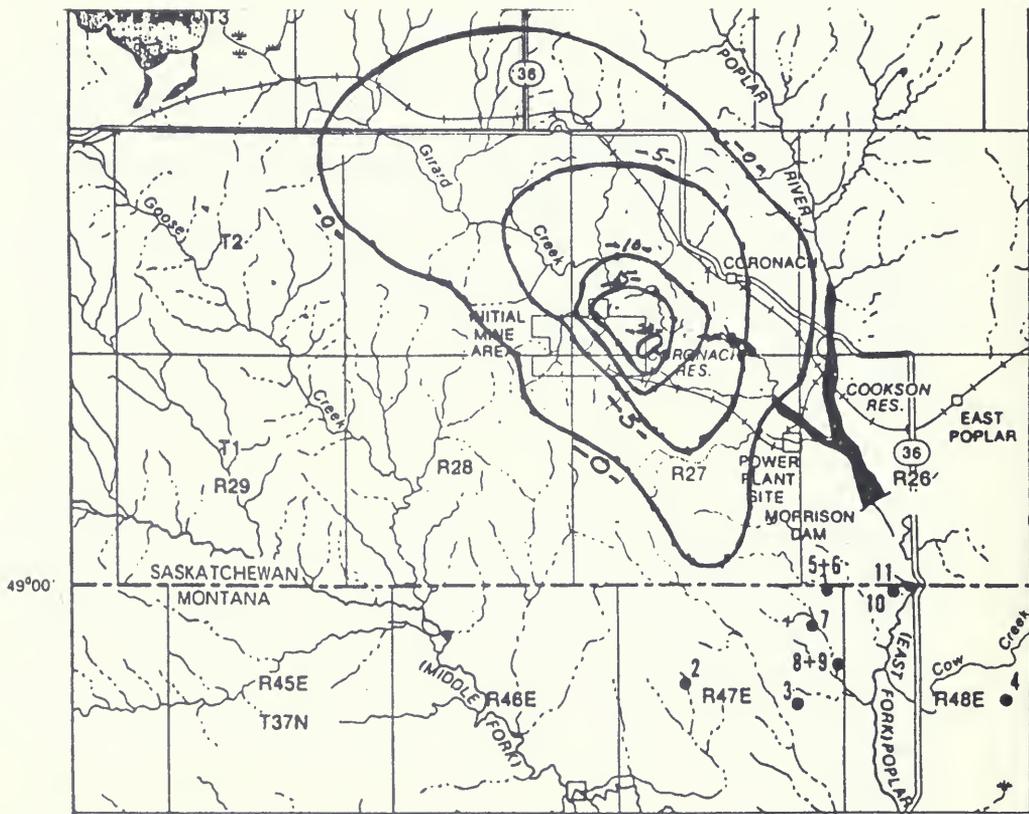


Figure 4 : Map showing water level decline in meters in the Hart Coalseam as of December 1982.

GROUND WATER QUALITY

Montana

The ten observation wells on the United States side of the International Boundary have been sampled during October on an annual basis since 1980. Wells 2, 3, and 4 have a casing diameter of 3.8 centimeters and this small diameter has precluded adequate pumping for obtaining a reliable sample. Thus, analytical results from these wells are considered unreliable and have not been included in characterization of the water quality. Wells 5-11 have larger diameter casings and sufficient pumping prior to sample collection was possible to provide reliable water-quality results.

Throughout the sampling period the wells had little change in their major ion water chemistry (Figure 5). Wells 6 and 7, from the Hart coal seam, were similar in major ion chemistry with the cations dominated by calcium and magnesium with sodium contributing less than 30 percent of the total. The anions were strongly dominated by bicarbonate. Total dissolved solids concentrations were near 500 mg/L and boron concentrations were near 0.8 mg/L. Water from alluvial wells 5, 7, and 8 had similar chemical compositions as those from the Hart coal seam, especially with respect to anion ratios and TDS concentrations. The cation ratios and boron concentrations were slightly more diverse. Waters from wells that penetrate the Fort Union and Fox Hills-Hell Creek aquifers (wells 9 and 11, respectively) had a sodium bicarbonate type water. The total dissolved solids concentrations from both wells was near 900 mg/L and the boron concentrations were slightly higher than 1.8 mg/L.

Concentrations of nitrate nitrogen were usually low except for alluvial well number 5 where the 3 samples (1980, 1981, and 1982) ranged from 1.81 to 7.58 mg/L. The maximum concentration was below 10 mg/L which is the recommended upper limit for domestic water supplies. Fluoride concentrations were always less than 1 mg/L except for well number 11 where concentrations up to 3.1 mg/L were measured.

Trace element concentrations from all samples met drinking-water standards. But, the following elements showed slightly higher concentrations in the wells listed as compared to the average of all wells.

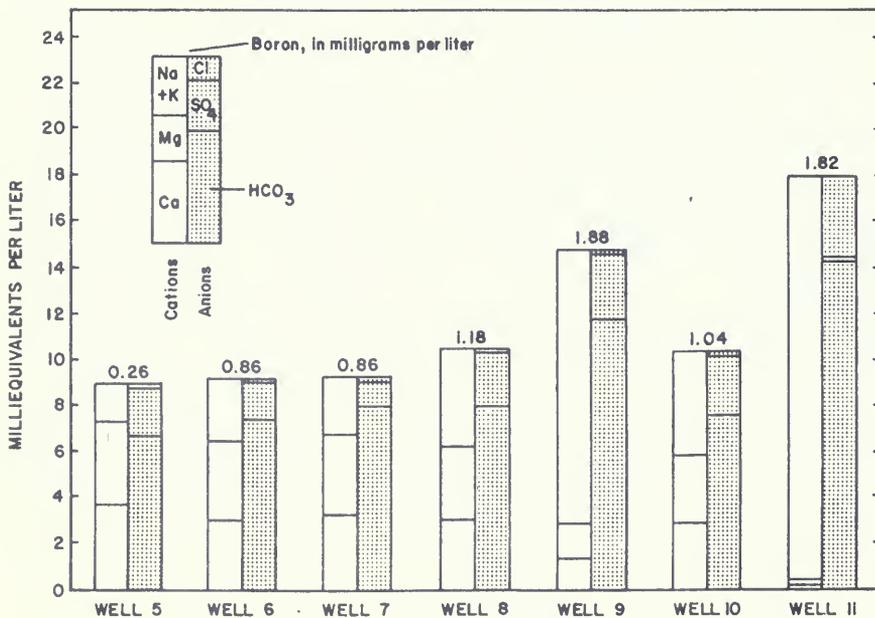


Figure 5 : Average concentrations of major ions and boron from selected observation wells in the United States portion of the East Poplar River basin (data are composites from 1980, 1981, and 1982).

Arsenic - well no. 10: concentration 11.4 microgram per liter (ug/L)
Copper - well no. 5: concentration 41 ug/L
- well no. 7; concentration 48 ug/L
- well no. 11; concentration 110 ug/L
Mercury - well no. 5; concentration .24 ug/L
Selenium - well no. 5; concentration 10 ug/L
Zinc - well no. 5; concentration 1,070 ug/L

All uranium values were near detection levels in 1982.

Saskatchewan

Ground-water quality was determined in 14 of the 18 piezometers included in the monitoring schedule. The remaining four piezometers were dry at the time of sampling (October). Scatter diagrams of concentrations plotted linearly against time were used to interpret all available data. The following parameters showed wide concentration variability in seven or more piezometers: specific conductivity, calcium, iron, arsenic, copper, aluminum, lead, zinc, color, and total dissolved solids.

Piezometer C712B (Station 2a in oxidized till) showed increasing trends from seven parameters: barium, calcium, chloride, sulphate, strontium, uranium, and vanadium. Piezometer C726B (Station 8a in mottled till) showed increased concentrations for four parameters: barium, conductivity, manganese, and lead. Piezometer C726E also showed increased concentrations for five parameters: calcium, lithium, magnesium, total alkalinity and total hardness. These three piezometers are located next to the ash lagoons and the changes may be due to seepage. However, the values fluctuate too much to allow any conclusion to be made at this time.

The question of sampling, analytical precision, and variability of the local ground-water quality was raised by the Poplar River Bilateral Monitoring Committee in its 1981 Annual Report. A follow-up investigation by the Saskatchewan Power Corporation was undertaken in 1982. The data are still variable and it is not clear whether the results represent the natural state of ground-water quality or are the result of problems in sampling handling, or methods at the laboratories. It is proposed, therefore, that the Committee conduct more investigations in 1982 into the question of data variability.

ASH LAGOON QUALITY AND QUANTITY

Seepage calculation for ash lagoons No. 1 and 2, and the polishing pond were made in the fourth quarter of 1982 and subsequently reviewed by the consultant who developed the initial calculations, Thomas A. Prickett, P. Eng., of Urbana, Illinois. The effect of No. 2 lagoon was considered since approximately 0.5 meters of water now covers the bottom of this lagoon. Total seepage from the lagoons (including polishing ponds) was calculated to be 0.182 liters/second. Flow to Cookson Reservoir from the oxidized till adjacent to the polishing pond was zero. The leachate front has advanced 0.65 meters since the pond was first filled. The leachate flow in the Empress formation to the Poplar River was zero. The leachate front in the Empress formation has now advanced to a point 261.0 meters to the south of the ash lagoons.

Permeability of the liners has remained in the same order of magnitude (10^{-9} cm/s) as originally calculated by T. A. Prickett. This was confirmed by computed lower seepage rates.

The concentrations of the ions in the ash lagoons and polishing ponds were expected to increase with time. This did not occur for all ions. The concentrations of 11 parameters increased in the polishing pond water, whereas 5 parameters in the ash lagoons increased in concentration. These measurements provide a basis for comparing future changes in adjacent ground-water quality. All samples should be filtered so as to minimize the effect that suspended particles may have on the analyses. In addition, the Committee recommends split samples be collected and analyzed annually by United States and Canadian laboratories. In recognizing the importance that fly-ash quality has on

water quality, the Committee also recommends that samples of the ash in the ponds be analyzed on an annual basis.

Parameters that increased in concentration in the ash lagoons were: boron, fluoride, molybdenum, and strontium. The pH also increased. In addition, increased concentrations were observed in the polishing pond for barium, chloride, selenium, sodium, sulphate, and vanadium.

Ground-water elevations were monitored in 66 piezometers in the vicinity of the ash lagoons and in the area southward to the International Boundary. Six wells were dry at the time of measurement in October 1982.

Increased ground-water elevations were observed in 52 piezometers and decreased elevations were observed for six piezometers (6a₄, 8a₃, 8c₁, 8c₂, 9b₂ and C534). The range of increases were 0.11 to 1.6 meters in the till and 0.1 to 0.85 meters in the Empress formation. The water level decline was most pronounced in piezometers 8c₁ (4.31 meters) and 9b₂ (4.08 meters) and are anomalously large considering the water level readings reported for the third quarter of 1982. These two piezometers are reported to have low recovery characteristics.

AIR QUALITY

Montana

The State of Montana continued to operate three air monitoring sites in the Poplar River area of Montana during 1982. The parameters monitored include: sulphur dioxide, Beta scattering coefficient, total suspended particulates, sulphates and nitrates.

During 1982, sulphur dioxide concentrations remained below both Montana and United States ambient air-quality standards. The maximum one-hour concentration of 6.0 parts per hundred million (pphm) was recorded at the International Boundary site during September. This concentration is approximately one-eighth of the Montana standard. The highest 24-hour concentration of 2.0 pphm occurred in March, also at the International Boundary site. The Montana 24-hour sulphur dioxide standard is 10 pphm. A comparison of sulphur dioxide concentrations with Class II Prevention of Significant Deterioration increment, demonstrates that the 24-hour concentration is the averaging time which consumes the most increment. The 2.0 pphm 24-hour average at the International Boundary site would consume 57 percent of the available increment.

The Montana 24-hour standard for total suspended particulates was exceeded on May 5, 1982. On that date a concentration of 234 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) was recorded at the International Boundary site. An examination of the sample and Montana meteorological data indicated that May 5, 1982 was characterized by high winds, which resulted in excessive wind-blown dust off agricultural fields. This concentration also exceeded the United States secondary standard but did not exceed the health-based primary standard.

Although several 24-hour concentrations of total suspended particulates exceeded the Class II Prevention of Significant Deterioration increment, it is likely that the Saskatchewan power plant is only a minor contributor. The major source of particulates is fugitive dust from agricultural fields and unpaved roads.

The annual geometric and arithmetic means for total suspended particulates returned to the low levels experienced prior to 1981; a drought year that was associated with frequent dust storms. The Montana Air Quality Bureau considers that the 1982 values are close to normal. These particulates are also well below Montana and United States ambient air-quality standards. In addition, the sulphate and nitrate levels were low and typical of remote unpolluted areas. Visibility measurements taken at the International Boundary site show an average Beta scattering coefficient of 1.9×10^{-5} per meter for 1982. Although the Poplar River area is designated Class II under the Prevention of Significant Deterioration increment program, the average scattering coefficient of 1.9×10^{-5} per meter is well below the Montana standard of 3×10^{-5} per meter, which applies only to pristine Class I areas.

Saskatchewan

Ambient sulphur dioxide monitoring began near Coronach in July 1979. To date a few detectable concentrations have been recorded at this site. The highest concentration recorded in 1982 was 3.9 ppm on June 4, which is below Saskatchewan Environment's one-hour air-quality standard of 17 ppm.

The 24-hour average suspended particulate concentrations in Coronach exceeded Saskatchewan Environment's air-quality standards on three occasions in 1982.

Weather information for the three days indicates that strong winds were blowing from a northerly direction. The power plant was not likely the source of these elevated levels, but quite probably dust from fields north of the monitoring site was responsible. The 1982 annual geometric mean concentration for suspended particulates was below the Saskatchewan standard of 70 ug/m^3 .

In-stack monitoring results have shown variability due to plant operation and difficulties and changes in coal quality. In addition, considerable monitor downtime was experienced during the year; however, instrument serviceability has improved in the last half of 1982.

On the occasions when bunker oil was used as a fuel at the plant, unusually high stack opacities were the result. This is attributed to a coating effect which the oil has on the precipitator. Daily average opacities have generally ranged from 20 to 40 percent, with the lowest values occurring during uninterrupted coal firing. The SPC has an ongoing program of precipitator tuning and experimentation with electrode and plate rapping sequences which has improved the performances of the unit. Precipitator efficiency was measured at greater than 99 percent in June of 1982.

In-stack nitrogen oxides concentrations remained relatively constant, averaging about 700 milligrams per cubic meter (mg/m^3). Daily average sulphur dioxide concentrations have ranged from about 2000 mg/m^3 to about 4000 mg/m^3 , corresponding to changes in the sulphur content of the coal. The relationship of sulphur dioxide emissions to the firing with bunker oil is being investigated.

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 quantity 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
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. Co-Chairmen 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 Co-chairman will be responsible for transmitting to his counterpart Co-chairman 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 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 sections 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. TERM 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

CANADA - UNITED STATES

March 8, 1983

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 SCHEDULE

CANADA

STREAMFLOW MONITORING

Responsible Agency: Environment Canada

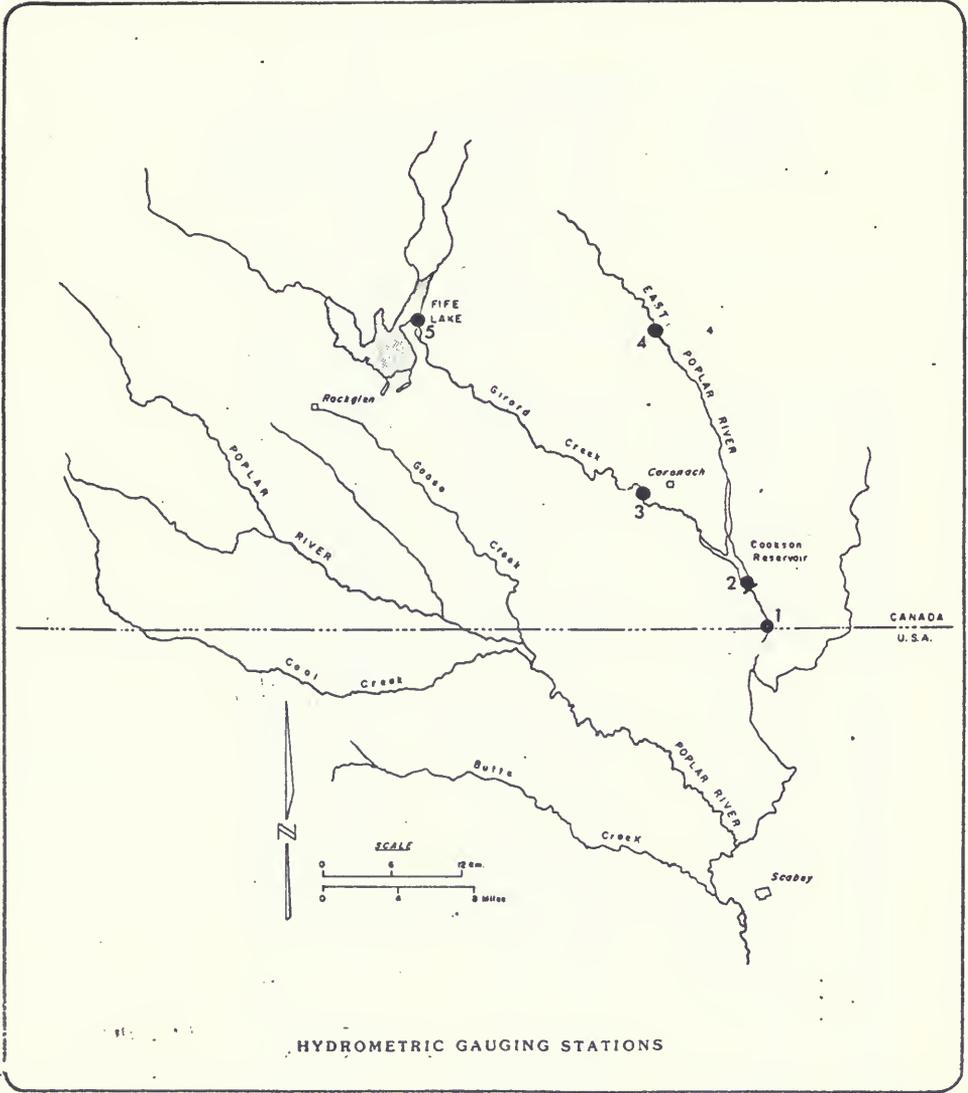
Daily mean discharge or levels and instantaneous monthly extremes as normally published in surface water data publications.

<u>No. on Map</u>	<u>Station No.</u>	<u>Station Name</u>
1.	11AE003 (06178500)	East Poplar River at International Boundary
2.	11AE013	Cookson Reservoir near Coronach
3.	11AE015	Girard Creek near Coronach
4.	11AE014	East Poplar River above Cookson Reservoir

Responsible Agency: Saskatchewan Environment

5. * Fife Lake Overflow

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



HYDROMETRIC GAUGING STATIONS

SURFACE WATER QUALITY MONITORING

Sampling Locations

Responsible Agency: Saskatchewan Environment

No. on Map	Station No.	Station Name
1	01SK02000002	Fife Lake Overflow
2	00SK02000012	Girard Creek South of Town of Coronach
3	05SK02000008	Upper End of Cookson Reservoir at Highway 36
4	05SK02000004	Cookson Reservoir near Dam
5	00SK02000003	East Poplar River at culvert immediately below Cookson Reservoir

Responsible Agency: Environment Canada

6	O0SA11AE0008	East Poplar River at International Boundary
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Parameters

Responsible Agency: Saskatchewan Environment

ESQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station					
			No: 1	2	3	4	5	
10151	Alkalinity-pheno	Pot. Titration	OF	Q	Q	Q	Q	Q
10101	Alkalinity-tot	Pot. Titration	OF	Q	Q	Q	Q	Q
13002	Aluminum Total	AA-direct		A	A	A	A	A
33004	Arsenic-tot	AA		A	A	A	A	A
06201	Bicarbonates	Calculated	OF	Q	Q	Q	Q	Q
05106	Boron-diss	Colourimetric	W	Q	Q	Q	Q	Q
48002	Cadmium-tot	AA-Solvent extract		A	A	A	A	A
20103	Calcium	AA	OF	Q	Q	Q	Q	Q
06051	Carbon-tot Inorg	IR	OF	Q	Q	Q	Q	Q
06001	Carbon-tot Org	Calculated	OF	Q	Q	Q	Q	Q
06301	Carbonates	Calculated	OF	Q	Q	Q	Q	Q
17203	Chloride	Colourimetric	OF	Q	Q	Q	Q	Q
06711	Chlorophyll 'a'	Colourmetry		Q	Q	Q	Q	Q
24002	Chromium-tot	AA-direct		A	A	A	A	A
36012	Coliform-fec	MF	OF	Q	Q	Q	Q	Q
36002	Coliform-tot	MF	OF	Q	Q	Q	Q	Q
02041	Conductivity	Wheatstone Bridge	W	Q	Q	Q	Q	Q
29005	Copper-tot	AA-Solvent extract		A	A	A	A	A
09107	Fluoride	Specific ion electrode		A	A	A	A	A
82002	Lead-tot	AA-Solvent extract		A	A	A	A	A
12102	Magnesium	AA-direct	OF	Q	Q	Q	Q	Q
80011	Mercury-tot	Flameless AA		A	A	A	A	A
42001	Molybdenum	AA-direct		A	A	A	A	A
07015	N-TKN	Colourimetric	OF	Q	Q	Q	Q	Q
10401	NFR	Gravimetric	OF	Q	Q	Q	Q	Q
10501	NFR(F)	Gravimetric	OF	Q	Q	Q	Q	Q
28002	Nickel-total	AA-Solvent extraction	OF	Q	Q	Q	Q	Q
07110	Nitrate + NO ₂	Colourimetric	OF	Q	Q	Q	Q	Q
06521	Oil and Grease			A	A	A	A	A
08102	Oxygen-diss	Meter	OF	Q	Q	Q	Q	Q
15406	Phosphorus-tot	Colourimetric	OF	Q	Q	Q	Q	Q
19103	Potassium	Auto analyser	OF	Q	Q	Q	Q	Q
34005	Selenium-Ext			A	A	A	A	A
11103	Sodium	Auto analyser	OF	Q	Q	Q	Q	Q
16306	Sulphate	Colourimetric	OF	Q	Q	Q	Q	Q
10451	TDS	Gravimetric	OF	Q	Q	Q	Q	Q
0206YZ	Temperature		OF	Q	Q	Q	Q	Q
23002	Vanadium-tot	AA-Solvent extract		A	A	A	A	A
30005	Zinc-tot	AA-Solvent extract		A	A	A	A	A
10301	pH	Electrometric	W	Q	Q	Q	Q	Q

* Computer storage and retrieval system - Saskatchewan Environment

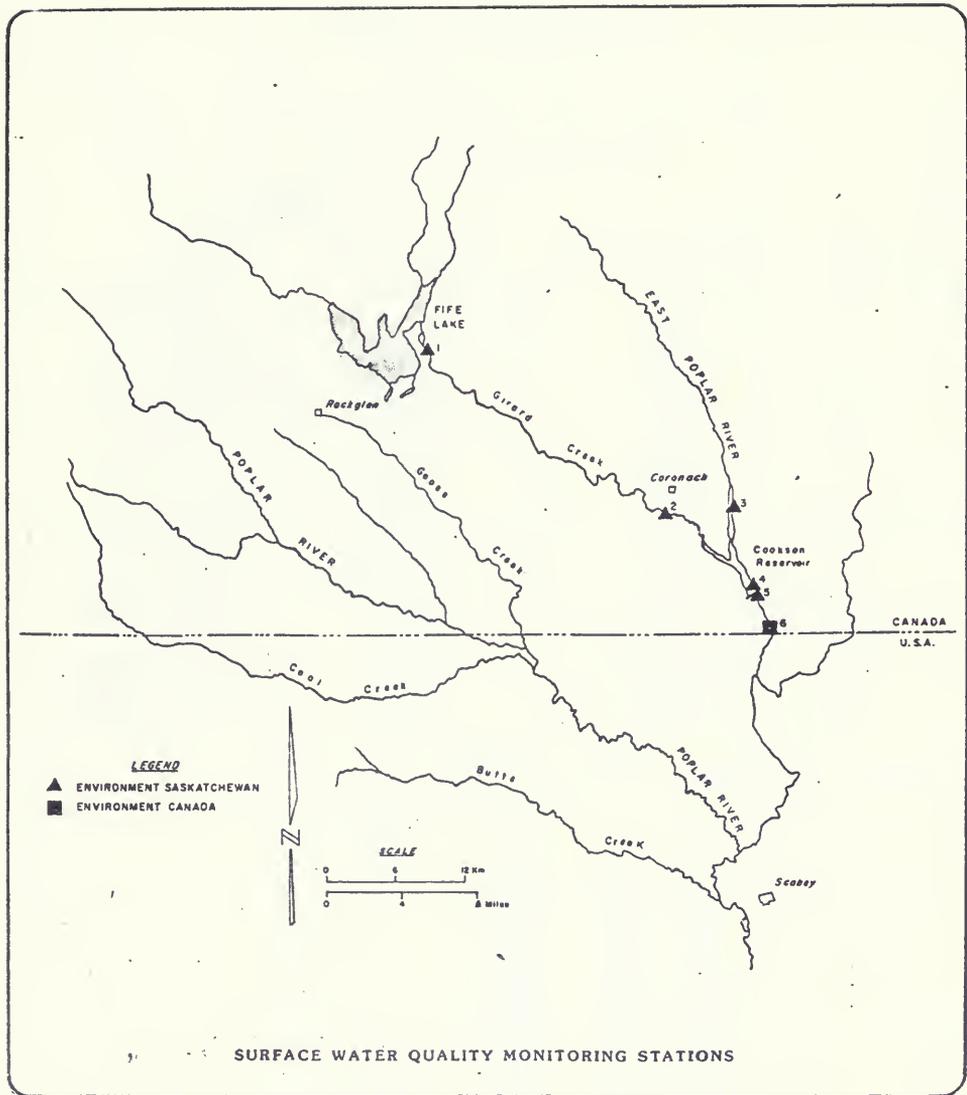
Symbols: W - Weekly during overflow; OF - once during each period of overflow greater than 2 weeks' duration; Q - quarterly; A - annually in the fall; AA - atomic absorption; IR - infrared; Pot - potentiometric; NFR - nonfiltrable residue NFRF - nonfiltrable residue, fixed.

PARAMETERS (Continued)

Responsible Agency: Environment Canada

NAQUADAT* Code	Parameter	Analytical Method	Sampling Frequency Station No: 6
10151	Alkalinity-pheno	Potentiometric	M
10101	Alkalinity-tot	Potentiometric	M
13302	Aluminum-Diss.	AA	M
07569	Ammonia-Free	Calculated	M
07506	Ammonia-total	Electrometric	M
33104	Arsenic-diss	Flameless AA	M
56020	Barium-tot	AA	M
06201	Bicarbonates	Calculated	M
05105	Boron-diss	Carminic Acid	M
48020	Cadmium-tot	AA Acid H ₂ O ₂	M
20103	Calcium	AA-direct*	M
06401	Carbon Dioxide	Calculated	M
06902	Carbon-partic	Elemental Analyzer	M
06002	Carbon-tot Org	UV Digestion	M
06301	Carbonates	Calculated	M
17206	Chloride	Colourimetric	M
06711	Chlorophyll a	Spectrophotometric	M
24302	Chromium-Ext	AA-direct	M
27020	Cobalt-tot	AA Acid H ₂ O ₂	M
36012	Coliform-fec	MF	M
35002	Coliform-tot	MF	M
02011	Colour	Comperator	M
02041	Conductivity	Wheatstone Bridge	M
29020	Copper-tot	AA-Acid H ₂ O ₂	M
80011	Copper-tot	UV-Colourimetric	M
06604	Cyanide	Electrometric	M
09105	Fluoride	Calculated	M
10602	Hardness	Calculated	M
08501	Hydroxide	Calculated	M
25104	Iron-diss	AA-direct	M
82020	Lead-tot	AA-Acid H ₂ O ₂	M
12102	Magnesium	AA-direct*	M
25104	Manganese-diss	AA-direct	M
03011	Mercury-tot	Flameless AA	M
07902	N-particulate	Elemental Analyzer	M
07651	N-tot diss	UV Colourimetric	M
10401	NFR	Gravimetric	M
28020	Nickel-total	AA-Acid H ₂ O ₂	M
07110	Nitrate	Colourimetric	M
07603	Nitrogen-tot	Calculated	M
180XX	Organo Chlorines	GC	M
08101	Oxygen-diss	Whinkler	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
18601	Pyridine Herbicides	GC	M
11201	SAR	Calculated	M
00210	Sat Index	Calculated	M
34102	Selenium-diss	Flameless AA	M
14105	Silica	Colourimetric	M
11103	Sodium	Flame Emission	M
00211	Stab Index	Calculated	M
16306	Sulphate	Colourimetric	M
00202	TDS	Calculated	M
02061	Temperature	Alcohol	M
02073	Turbidity	Nephelometric	M
23020	Vanadium-tot	AA-Acid H ₂ O ₂	M
30020	Zinc-tot	AA-Acid H ₂ O ₂	M
10301	pH	Electrometric	M
92111	Uranium	Fluorometric	A

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



GROUNDWATER QUALITY MONITORING

Sampling Locations

Responsible Agency: Saskatchewan Environment

Sampling Frequency: Annually

<u>Station</u>	<u>SPC Piezometer No.</u>	<u>Sampling Elevation (m)</u>	<u>Station Description</u>
8a	C726A	746.338	unoxidized till
	C726B	751.040	mottled till
	C726C	752.739	oxidized till
	C726D	755.543	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
C533	C533	740.441	empress gravel
C534	C534	753.499	till
18	C741	735.153	empress gravel
19	C735	753.789	empress gravel
21	C742	741.800	empress gravel

Groundwater

Parameters

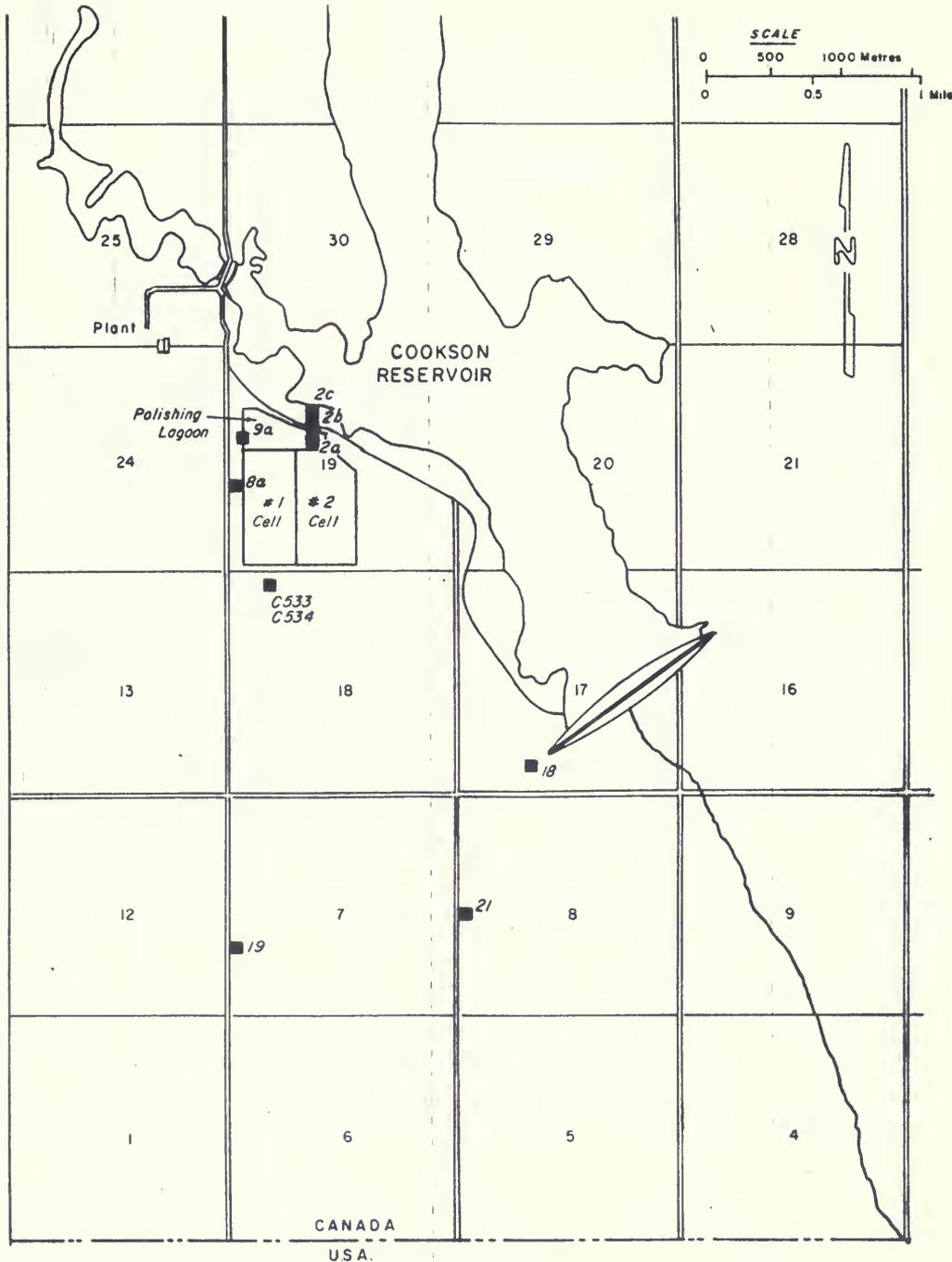
Responsible Agency: Saskatchewan Environment

<u>ESQUADAT* Code</u>	<u>Parameter</u>	<u>Analytical Method</u>	<u>Sampling Frequency Station No:</u>
10101	Alkalinity-tot	Pot-Titration	A
13002	Aluminum	AA-HNO ₃	3
33004	Arsenic	Flameless AA	A
56001	Barium	AA-HNO ₃	A
06201	Bicarbonates	Calculated	A
05106	Boron-diss	Colourimetric	3
48002	Cadmium	AA-HNO ₃	3
20103	Calcium	AA-direct	A
06301	Carbonates	Calculated	A
17203	Chloride	Colourimetric	A
24002	Chromium	AA-HNO ₃	A
27002	Cobalt	AA-HNO ₃	A
02011	Colour	Comparator	A
02041	Conductivity	wheatstone Bridge	3
29005	Copper		A
09107	Fluoride	Electrometric	A
26004	Iron	AA-HNO ₃	A
82002	Lead	AA-HNO ₃	3
12102	Magnesium	AA-direct	A
25004	Manganese		A
80011	Mercury	Flameless AA	A
42001	Molybdenum	AA-HNO ₃	A
10301	pH	Electrometric	3
19103	Potassium		A
34005	Selenium-tot	Colourimetric	A
14101	Silica	Colourimetric	A
11103	Sodium	Flame Emission	A
38001	Strontium	AA-HNO ₃	3
16306	Sulphate	Colourimetric	3
10451	TDS	Gravimetric	3
92115	Uranium	Fluorometry	3
23002	Vanadium	AA-HNO ₃	A
97025	Water Level		A
30005	Zinc	AA-HNO ₃	A

* Computer Storage and Retrieval System - Saskatchewan Environment
 Symbols: AA - atomic absorption; A - Annually; 3 - three times
 Note - all ions are dissolved.

R. 27

R. 26



GROUNDWATER QUALITY MONITORING

GROUNDWATER PIEZOMETERS TO MONITOR

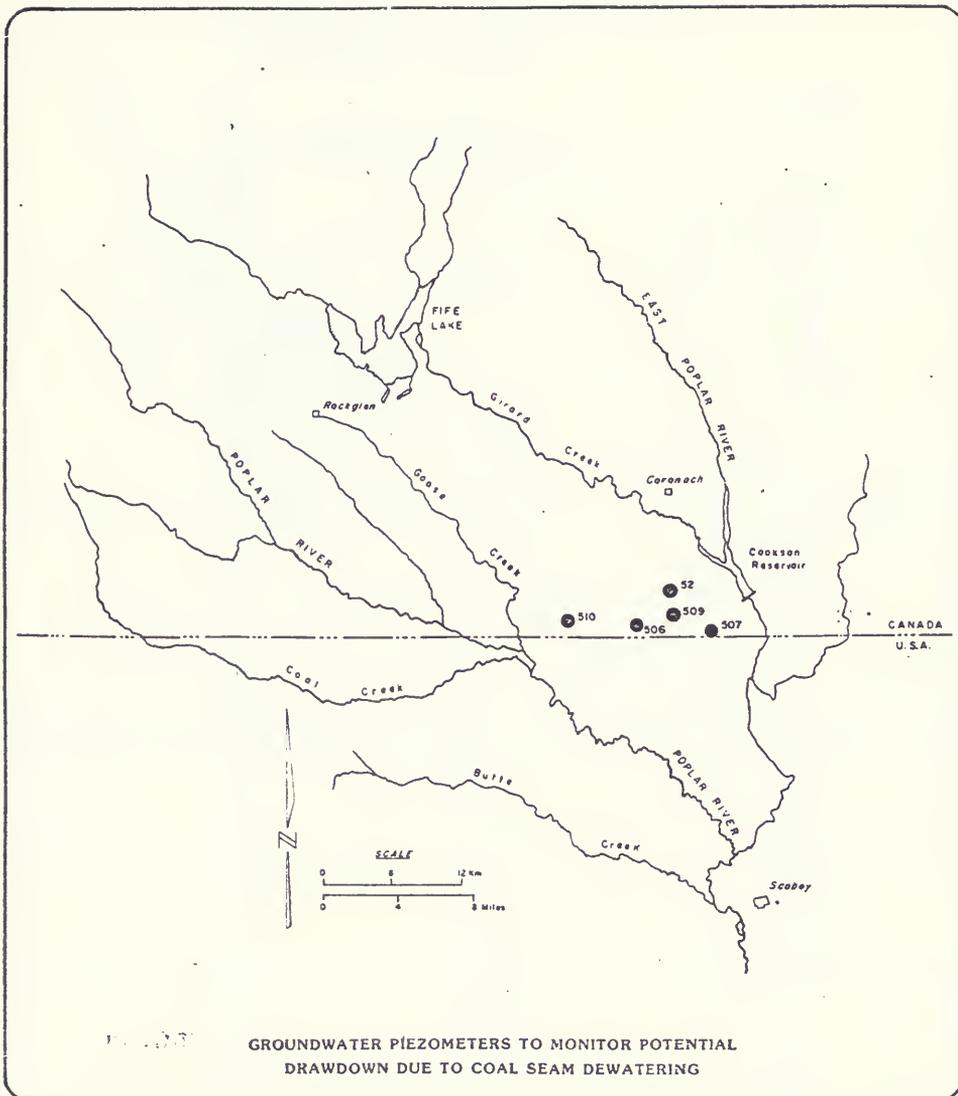
POTENTIAL DRAWDOWN DUE TO COAL

SEAM DEWATERING

Responsible Agency: Saskatchewan Environment

Measurement Frequency: Quarterly

<u>SPC Piezometer No.</u>	<u>Location</u>	<u>Sampling Elevation (m)</u>	<u>Perforation Zone (depth in metres)</u>
52	NW14-1-27W3	738.43	43 - 49 (in coal)
506	SW4-1-27 W3	748.27	81 - 82 (in coal)
507	SW6-1-26 W3	725.27	34 - 35 (in coal)
509	NW11-1-27W3	725.82	76 - 77 (in coal)
510	NW1-1-28 W3	769.34	28 - 29 (in layered coal and clay)



GROUNDWATER PIEZOMETER LEVEL MONITORING - ASH LAGOON AREA

SCHEDULE A - PIEZOMETERS IN TILL

Responsible Agency: Saskatchewan Environment

Frequency of Measurement

Piezometer

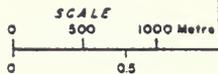
1a	All piezometer levels are measured quarterly
1b	
1c	
2a ₁	
2a ₂	
2a ₃	
2a ₄	
2b ⁴	
2c	
3a	
3b	
3c	
6a ₁	
6a ₂	
6a ₃	
6a ₄	
7a ₁	
7a ₂	
7a ₃	
7a ₄	
C534	
8a ₁	
8a ₂	
8a ₃	
8a ₄	
8b ₁	
8b ₂	
8b ₃	
8b ₄	
8c ₁	
8c ₂	
8c ₃	
8c ₄	
8d ₁	
8d ₂	
8d ₃	
8d ₄	
9a ₁	
9a ₂	
9a ₃	
9a ₄	
9b ₁	
9b ₂	
9b ₃	
9b ₄	

R. 27

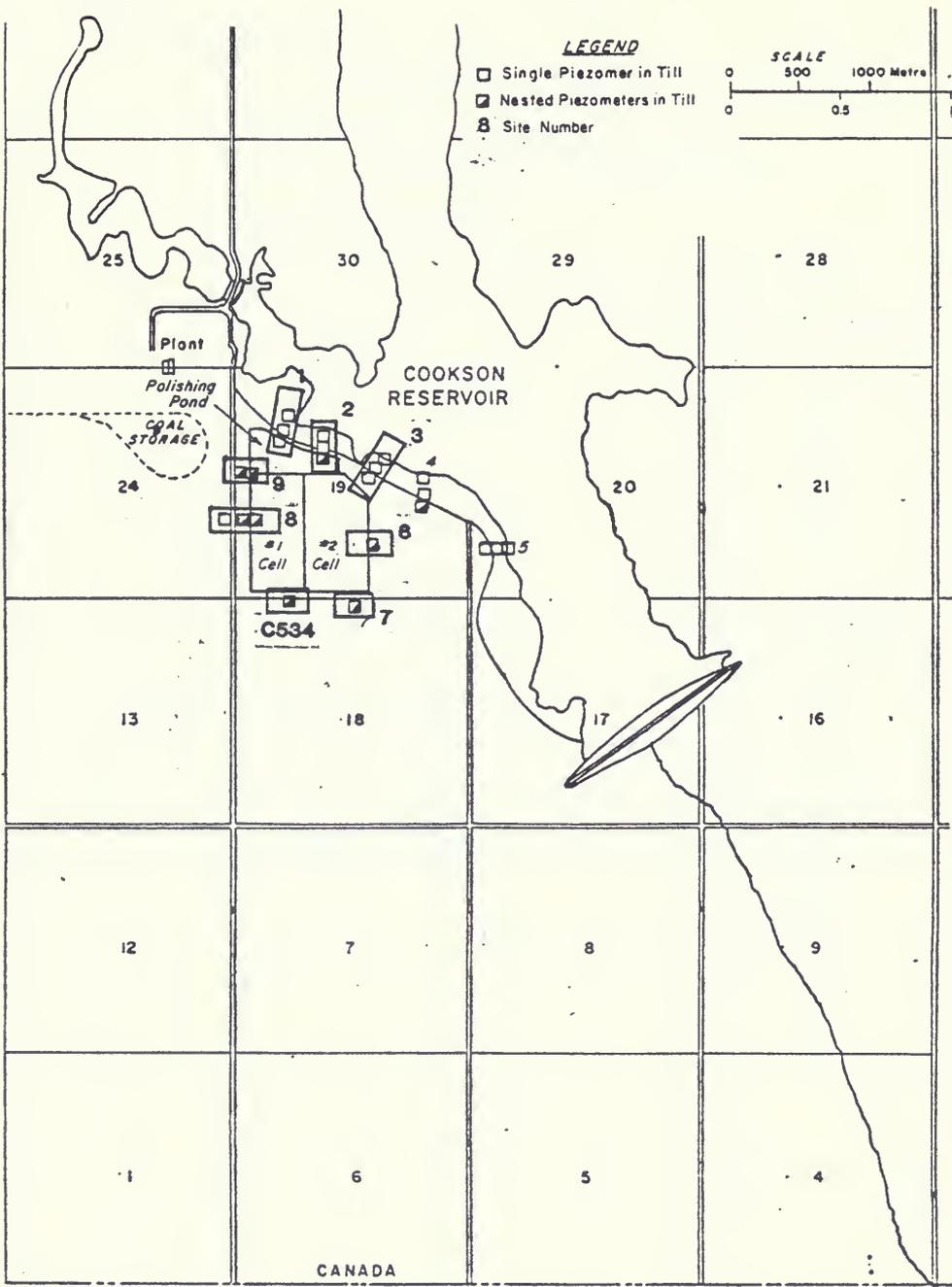
R. 26

LEGEND

- Single Piezometer in Till
- ▣ Nested Piezometers in Till
- 8 Site Number



Mile



CANADA
USA.

POPLAR RIVER POWER STATION, ASH LAGOON MONITORING STUDY

**PIEZOMETER INSTALLATION SITES
SCHEDULE "A" - PIEZOMETERS IN TILL**

GROUNDWATER PIEZOMETER LEVEL MONITORING - ASH LAGOON AREA AND
INTERNATIONAL BOUNDARY AREA

SCHEDULE B - PIEZOMETERS IN EMPRESS GRAVEL

Responsible Agency: Saskatchewan Environment

Frequency of Measurement

Piezometer

Immediate Ash Lagoon Area

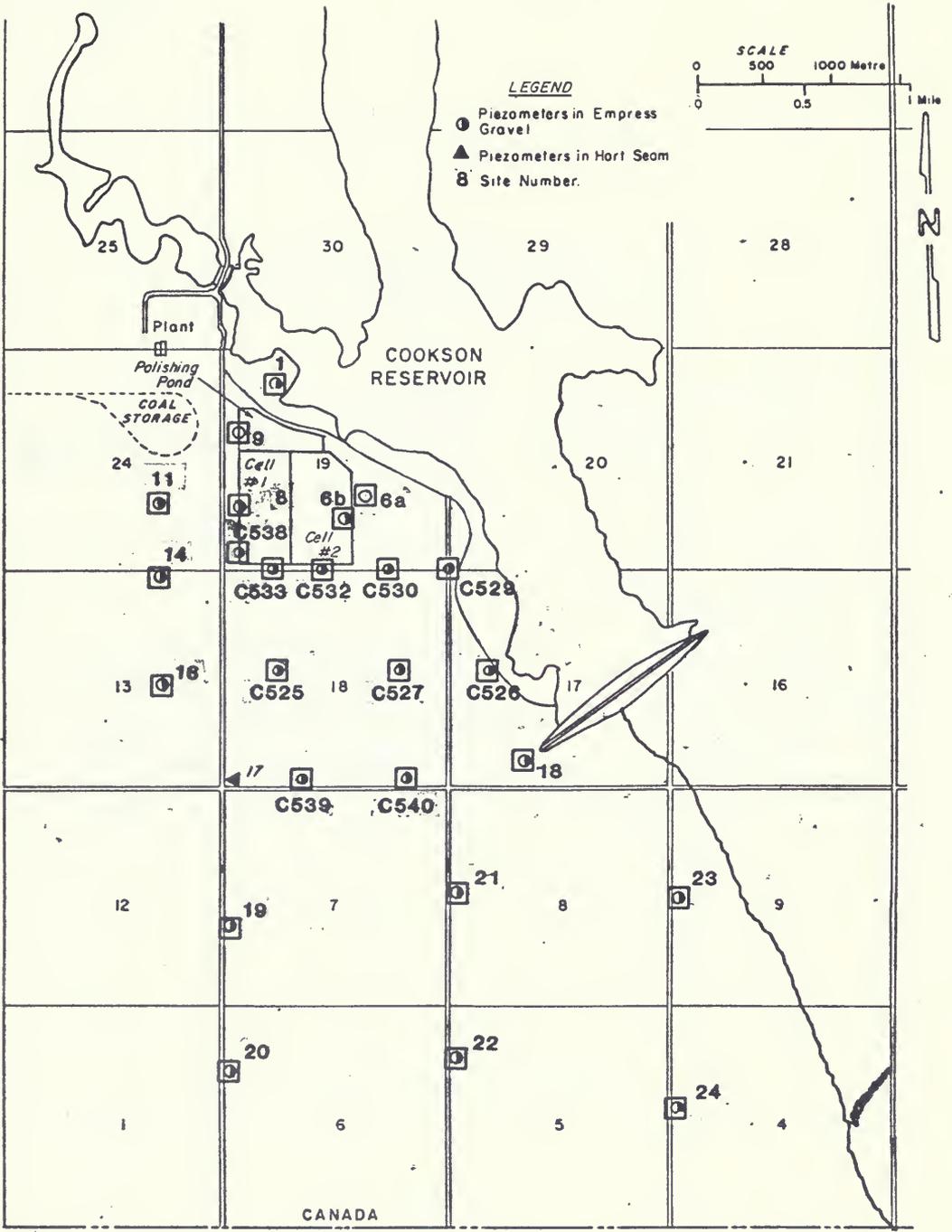
1	All piezometer levels are measured quarterly
6a	
6b	
C529	
C530	
C532	
C533	
C538	
8	
9	

West of Ash Lagoon Area

11
14
16

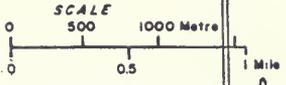
South of Ash Lagoon Area

C525
C526
C527
C539
C540
18
19
20
21
22
23
24



LEGEND

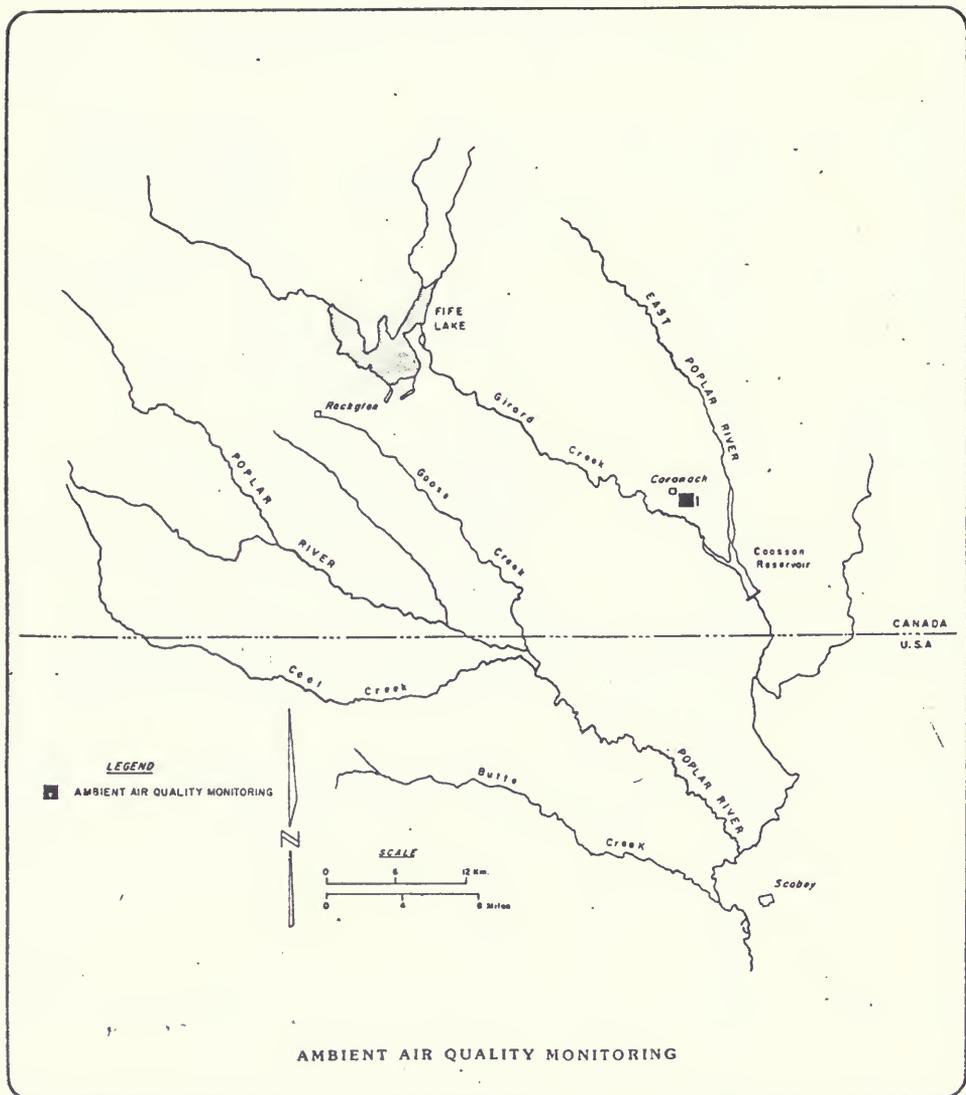
- Piezometers in Empress Gravel
- ▲ Piezometers in Hort Seam
- 8 Site Number.



POPLAR RIVER POWER STATION WASH LAGOON MONITORING STUDY

PIEZOMETER INSTALLATION SITES

SCHEDULE "B" PIEZOMETERS IN EMPRESS GRAVEL



SOURCE EMISSION MONITORING

Responsible Agency: Saskatchewan Environment

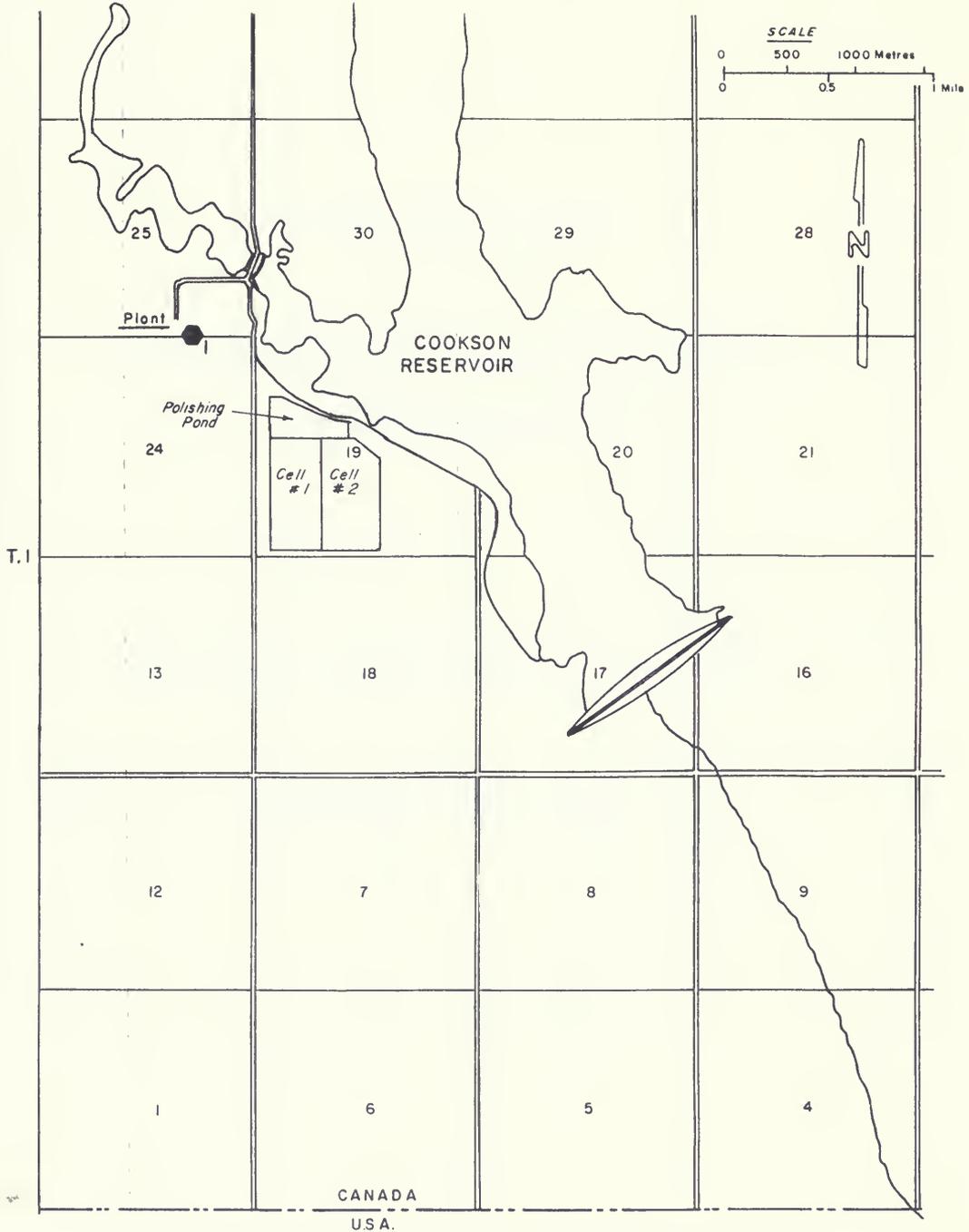
<u>No. on Map</u>	<u>Station Location</u>	<u>Parameters</u>	<u>Sampling Frequency</u>
1	At Poplar River Power Plant	Sulfur Dioxide Nitrogen Dioxide, Opacity.	Continuous reported as Hourly Averages

METHODS

Sulfur Dioxide	Saskatchewan Environment - Permit to operate R197R1, 15 January 1982, Ultraviolet Absorption
Nitrogen Dioxide	Saskatchewan Environment - Permit to operate R197R1, 15 January 1982, Chemiluminescence
Opacity	Saskatchewan Environment - Permit to operate R197R1, 15 January 1982, Optical

R.27

R.26



SOURCE EMISSION MONITORING

POPLAR RIVER

COOPERATIVE MONITORING
ARRANGEMENT

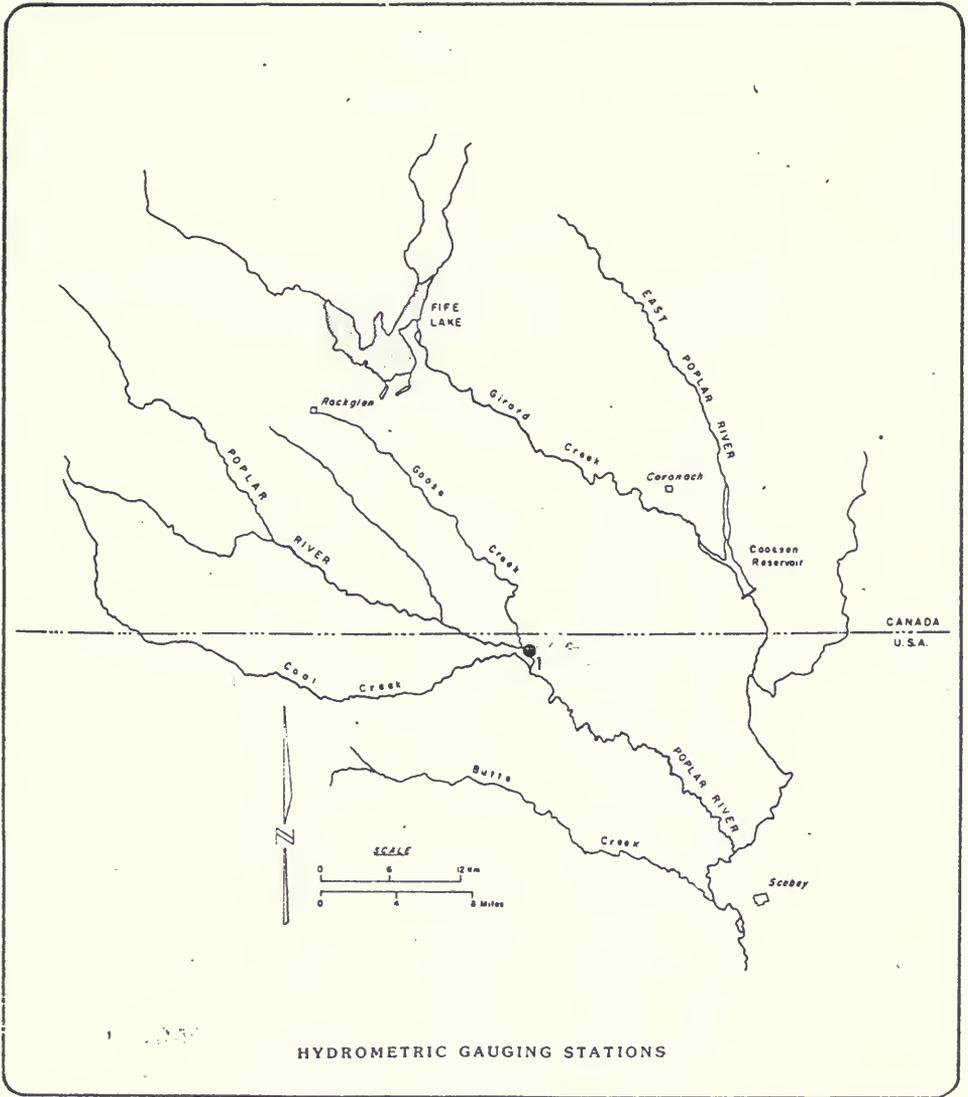
TECHNICAL MONITORING SCHEDULE

UNITED STATES

STREAMFLOW MONITORING

Responsible Agency: United States Geological Survey

<u>No. on Map</u>	<u>Station Number</u>	<u>Station Name</u>
1	06178000 (11AE008)	Poplar River at International Boundary



SURFACE WATER QUALITY MONITORING

Station Location

Responsible Agency: U.S. Geological Survey

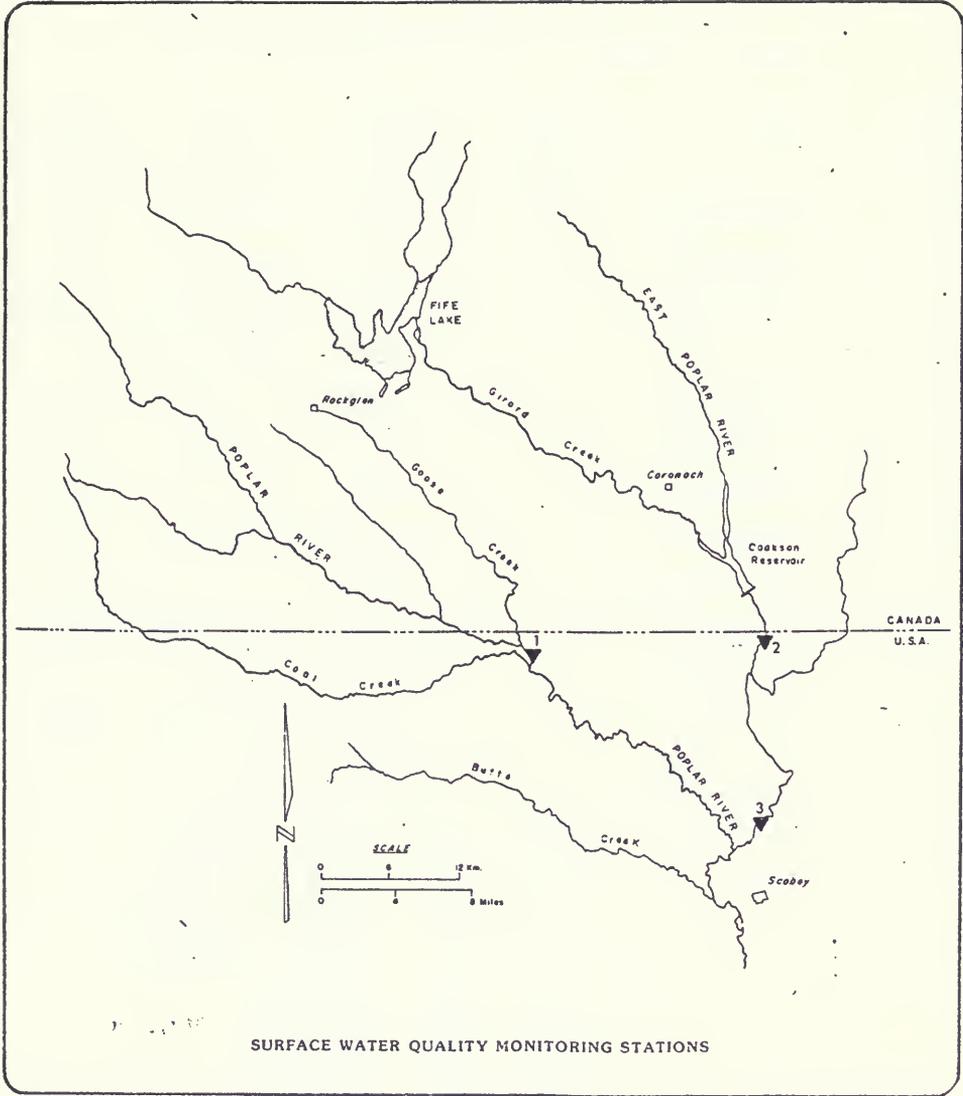
No. on Map	USGS Station No.	Station Name
1	06178000	Poplar River at International Boundary
2	06178500	East Poplar River at International Boundary
3	06179000	East Poplar River near Scobey

PARAMETERS

Code	Parameter	Analytical Method	Sampling Frequency		
			No:	1	2
00410	Alkalinity-field	Elect. Titration	N	BM	M
90410	Alkalinity-lab	Elect. Titration	N	BM	M
01106	Aluminum-diss	AA	SA	SA	SA
NA	Ammonia-free	Calculated	N	BM	N
00610	Ammonia-Total	Colorimetric	N	BM	N
00615	Ammonia-Org N-tot	Colorimetric	N	BM	N
01000	Arsenic-diss	Flameless AA	SA	SA	SA
01002	Arsenic-tot/rec	Flameless AA	A	A	A
01010	Beryllium-diss	AA	SA	SA	SA
01012	Beryllium-tot/rec	AA-peroxulfate	A	A	A
01020	Boron-diss	Colorimetric	N	BM	M
01025	Cadmium-diss	AA	A	A	A
01027	Cadmium-tot/rec	AA-peroxulfate	A	A	A
00915	Calcium	AA	N	BM	M
00860	Carbon-tot Org	Wet Oxidation	N	BM	M
00940	Chloride	Colorimetric	N	BM	M
01030	Chromium-diss	AA	SA	SA	SA
01034	Chromium-tot/rec	AA-peroxulfate	A	A	A
00080	Color	Electrometric, visual	N	BM	M
00093	Conductivity	Wheatstone bridge	N	D	M
01040	Copper-diss	AA	SA	SA	SA
01042	Copper-tot/rec	AA-peroxulfate	A	A	A
00061	Discharge-tot	—	N	BM	M
00095	Fluoride	Electrometric	N	BM	M
01044	Iron-diss	AA	N	BM	N
01045	Iron-tot/rec	AA-peroxulfate	A	A	A
01049	Lead-diss	AA	SA	SA	SA
01051	Lead-tot/rec	AA-peroxulfate	A	A	A
00925	Magnesium	AA	N	BM	M
01056	Manganese-diss	AA	SA	SA	SA
01055	Manganese-tot/rec	AA-peroxulfate	A	A	A
71890	Mercury-diss	Flameless AA	SA	SA	SA
71900	Mercury-tot/rec	AA-peroxulfate	N	BM	M
01154	NFE	Gravimetric	N	BM	M
01085	Nickel-diss	AA	SA	SA	SA
01067	Nickel-tot/rec	AA-peroxulfate	A	A	A
00815	Nitrate-Tot	Ion Chromatography	N	BM	M
00830	Nitrate - Micrits	Colorimetric	N	BM	M
00300	Oxygen-diss	Winkler/meter	N	BM	M
70507	P-Ortho-tot	Colorimetric	N	BM	M
00400	pH	Electrometric	N	BM	X
00465	Phosphorus-tot	Colorimetric	N	BM	N
00935	Potassium	AA	N	BM	N
00931	SAB	Calculated	N	BM	N
01145	Selenium-diss	AA	SA	SA	SA
01145	Selenium-tot/rec	AA-peroxulfate	A	A	A
00955	Silica	Colorimetric	N	BM	M
00930	Sodium	AA	N	BM	M
00945	Sulfate	Colorimetric	N	BM	M
70301	TDS	Calculated	N	BM	N
00010	Temp Water	Toluene/moelcor	N	C	M
00020	Temp Air	Toluene	N	BM	M
00076	Turbidity	Nephelometric	N	BM	N
01090	Zinc-diss	AA	SA	SA	SA
01092	Zinc tot/rec	AA-peroxulfate	A	A	A

*Computer storage and retrieval system - USGS

Symbolic: C - continuous; D - daily; M - monthly; BM - every two months; A - annually at high flow; SA - semi-annually at low and high flow; AA - atomic absorbance; tot - total; rec - recoverable; diss - dissolved



SURFACE WATER QUALITY MONITORING STATIONS

GROUND WATER QUALITY MONITORING

Station Locations

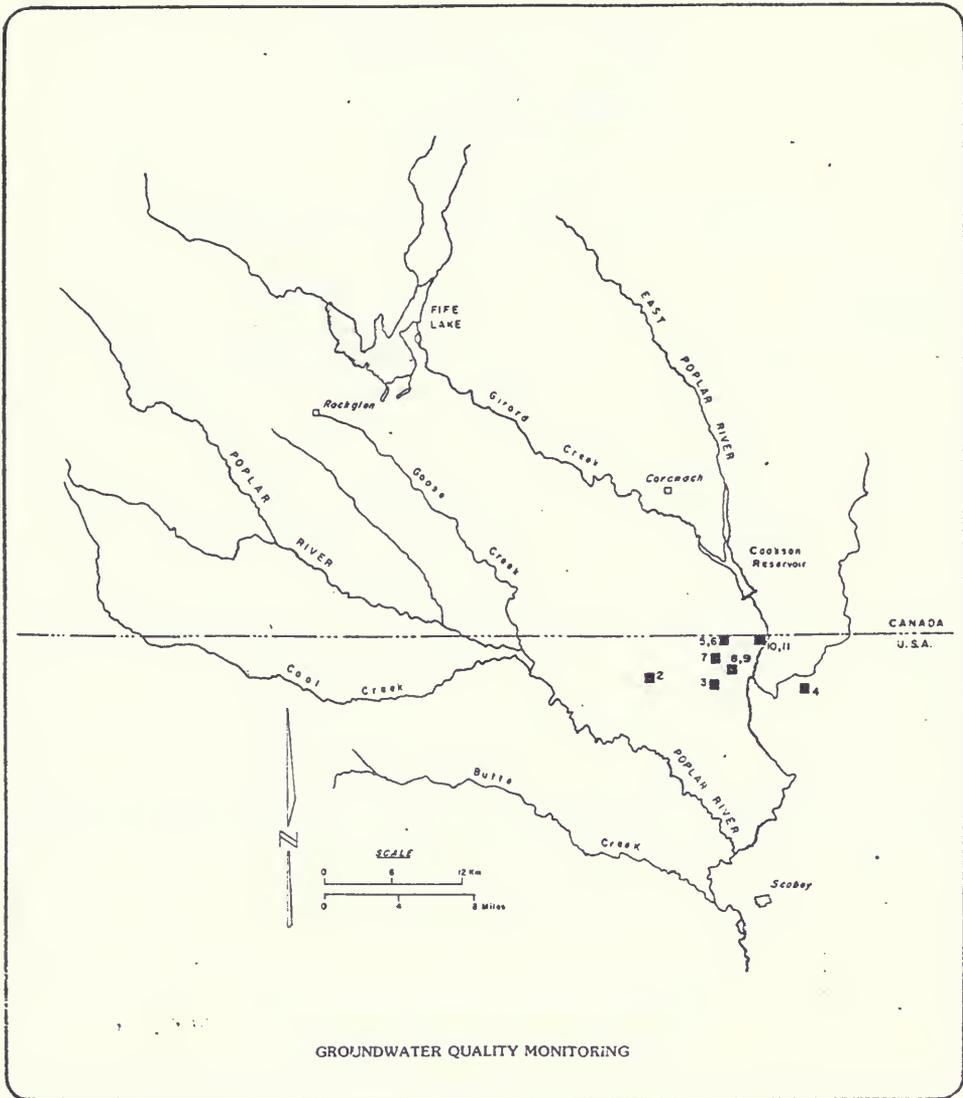
Responsible Agency: United States Geological Survey

Map Number	Well Location	Total Depth m	Casing Diameter (cm)	Aquifer	Perforation Zone (m)
2	37N47E17DABB	116	3.8 PVC	Hart Coal	76-79
3	37N47E23AADD	165	3.8 PVC	Hart Coal	33-36
4	37N48E23BBCC	122	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

Parameters

Storet Code *	Parameter	Analytical Method	Sampling Frequency Station No.
00440	Bicarbonates	Electrometric Titration	Sample collection is semi-annually for all locations identified above.
01020	Boron-diss	Emission Plasma ICP	
00915 00445	Calcium Carbonates	Emission Plasma 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 01040	Conductivity Copper-diss	Wheatstone Brdg 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	
00915	Potassium	Emission Plasma, ICP	
01145	Selenium-diss	AA	
00955	Silica	Emission Plasma, ICP	
00930	Sodium	Emission Plasma, ICP	
01060	Strontium-diss	Emission Plasma, ICP	
00445	Sulphate	Ion Chromatography	
22703	Uranium	Fusion Fluorometric	
00190	Zinc-diss	Emission Plasma, ICP	
70301	TDS	Calculated	

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



GROUNDWATER LEVELS TO MONITOR
POTENTIAL DRAWDOWN DUE TO
COAL SEAM DEWATERING

Responsible Agency: United States Geological Survey

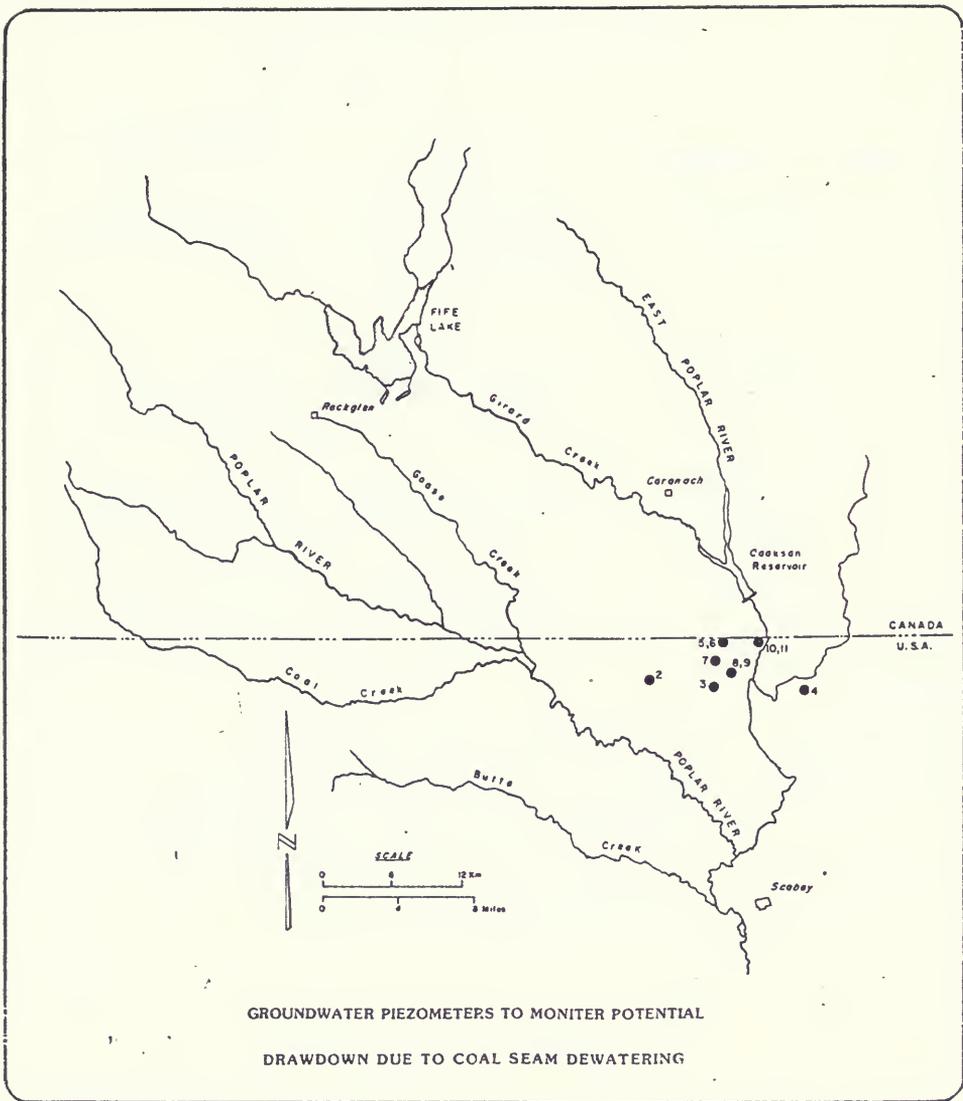
No. on Map

2 to 11

Sampling

Determine water levels
quarterly

Note: All wells will be monitored on a quarterly basis for levels in 1982.



GROUNDWATER PIEZOMETERS TO MONITER POTENTIAL
DRAWDOWN DUE TO COAL SEAM DEWATERING

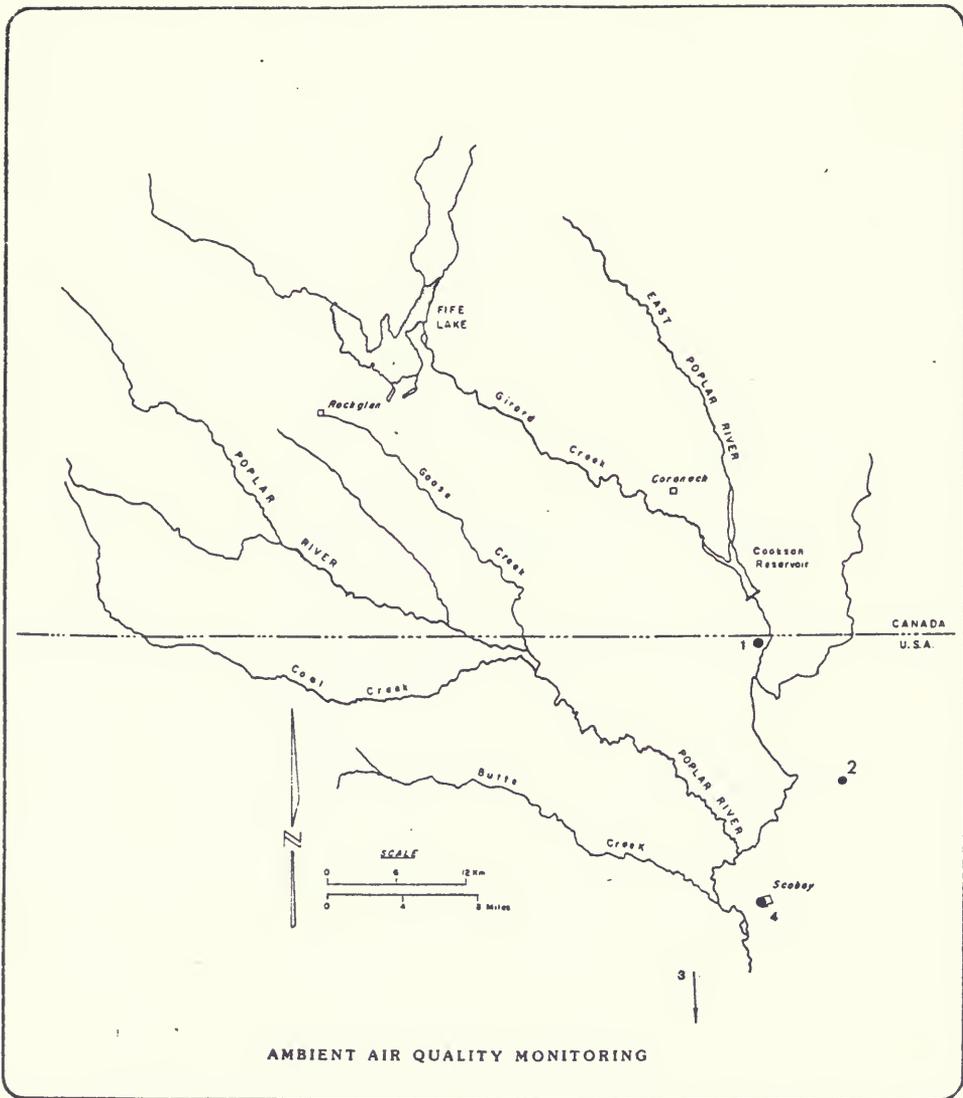
AMBIENT AIR QUALITY MONITORING

Responsible Agency: State of Montana
Air Quality Bureau

<u>No. on Map</u>	<u>Location</u>	<u>Parameters</u>	<u>Sampling Frequency and Reporting</u>
1	International Boundary	Sulfur Dioxide, Total Suspended Particles, Visibility Wind, Speed and Direction	Hourly averages Summary statistics (24-hour for TSP)
2	Hanrahan	Sulfur Dioxide, Total Suspended Particles	Hourly averages Summary statistics (24-hour for TSP)
3	Ft. Peck Reservation	Sulfur Dioxide Total Suspended Particles	Hourly averages Summary statistics (24-hour for TSP)
4	Scobey	Total Suspended Particles	24-hour average for TSP

METHODS

Sulfur Dioxide	EPA Equivalent Method EQSA-0276-009
Total Suspended	EPA Reference Method CFR Title 40 Part 50 Appendix B (State of Montana QA Manual Section 1.1.10 and 1.2.10) 24-hour sample once/6 days
Visibility	State of Montana QA Manual Section 1.1.7 and 1.2.7 (Nephelometer) - continuous



ANNEX 3

METRIC CONVERSIONS

METRIC CONVERSION FACTORS

ac-ft	=	1,233.5 m ³ = 1.2335 dam ³
ac	=	4047 m ³ = 0.4047 ha
C ⁰	=	1.8 F ⁰
cm	=	0.3937 in.
cm ²	=	0.155 in ²
dam ³	=	1000 m ³ = 0.8107 ac-ft
ft ³	=	28.3171 × 10 ⁻⁴ m ³
ha	=	10,000 m ² = 2.471 ac
hm	=	100 m = 328.08 ft
hm ³	=	1 × 10 ⁶ m ³
Igpm	=	0.0631 L/s
in	=	2.54 cm
kg	=	2.20462 lb = 1.1 × 10 ⁻³ tons
km	=	0.62137 miles
km ²	=	0.3861 mi ²
L	=	0.3532 ft ³ = 0.21997 I. gal. = 0.36420 U.S. gal
L/s	=	0.035 cfs = 13.193 Igpm = 15.848 U.S. gpm
m	=	3.2808 ft
m ²	=	10.7638 ft ²
m ³	=	1000 L = 35.3144 ft ³ = 219.97 I. gal = 264.2 U.S. gal
m ³ /s	=	35.314 cfs
mm	=	0.04 ft
tonne	=	1000 kg = 1.1023 ton (short)
U.S.gpm	=	0.0758 L/s

