TECHNICAL REPORT TO THE

PPWB COMMITTEE ON HYDROLOGY

NATURAL FLOW

STONY CREEK

AT SASKATCHEWAN - MANITOBA BOUNDARY

JULY 1987

PPWB REPORT #86

PREPARED BY:

THE SECRETARIAT
PRAIRIE PROVINCES WATER BOARD

SYNOPSIS

The average natural flow of Stony Creek at the Saskatchewan-Manitoba boundary for the apportionment periods 1912-13 to 1983-84 is 1 004 dam^3. Average annual consumptive use in the Saskatchewan portion of the basin now amounts to 85 dam^3, 8.5% of the average apportionment flow. The present (1986) level of consumptive use in the Saskatchewan portion of the Stony Creek basin would have exceeded Saskatchewan's 50% share of natural flow in 25 of the 72 years during the period 1912-13 to 1983-84. The average annual quantity of water that would have been delivered to Manitoba in the 47 years when more than 50% of natural flow crossed the boundary would have averaged 670 dam^3, but these deliveries would have taken place in years when the downstream supply of water was not critically low.

The existing hydrometric network does not provide adequate hydrometric coverage for calculating the natural flow of Stony Creek at the Saskatchewan-Manitoba boundary. However, a more accurate estimate of natural flow at the boundary can not be made until hydrometric records of streamflow at the Saskatchewan-Manitoba boundary are obtained. Monitoring of apportionment at the Saskatchewan-Manitoba boundary may not be critical now because the farmers in the area appear to find the natural water storage areas in the main channel sufficient for their needs. Consequently there is almost no evidence of dams being built in the main channel of Stony Creek in Manitoba.

If monitoring is required in future years, a hydrometric station at, or near, the boundary and water use records on the upstream Flynn project are essential to ensure that the natural flow is equitably shared.

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Chapter 1

INTRODUCTION

The Stony Creek natural flow study is one of a series of natural flow studies conducted for the Prairie Provinces Water Board. Following completion of the Prairie Provinces Water Board's natural flow studies of the North Saskatchewan, South Saskatchewan, Saskatchewan, Churchill and Qu'Appelle River basins in 1977, the Board agreed to have other interprovincial basins studied to determine if monitoring of flow for apportionment purposes was required. Eighteen interprovincial basins were initially identified and assigned a priority. Two additional basins, Beaver River and Overflowing River were subsequently added to that list. The Board agreed that the basins would be studied in order of priority as time and funds become available.

This report, entitled "Stony Creek at Saskatchewan-Manitoba Boundary- Natural Flow", describes the basin geography, water use within the basin and the derivation of historic natural flows at the Saskatchewan-Manitoba boundary. The present (1986) level of use is analyzed in conjunction with natural flows to determine the potential for apportionment deficits both now and in the foreseeable future. A procedure that may be used to calculate natural flows in future years is also provided and the adequacy of the existing hydrometric network for the determination of natural flow at the interprovincial boundary is assessed.

Chapter 2

BASIN GEOGRAPHY

Stony Creek originates in a large intermittent slough located in Sec. 35-11-31 WPM, about three kilometres south of Pipestone Creek and eight kilometres north of Jackson Creek. The main channel of Stony Creek runs in a southeasterly direction between Pipestone and Jackson Creeks for some 32 kilometres to the boundary between Saskatchewan and Manitoba. The channel then crosses into the Province of Manitoba at the east boundary of the SE¼ Sec. 10-30 WPM and continues in a southeasterly direction for some 55 kilometres before turning east for some 15 kilometres. Stony Creek then turns north and drains into the Maple lakes. These lakes, in turn, have been drained, following a natural overflow channel, southward to the Souris River. Overflow water from Stony Creek enters the Souris River some 25 kilometres northeast of the Manitoba community of Melita.

The gross and effective drainage area tributary to Stony Creek at the Saskatchewan-Manitoba boundary are 118.1 km^2 and 52.1 km^2 respectively. The total gross and effective drainage area in Saskatchewan are 147.4 km^2 and 62.8 km^2 respectively. Most of the incremental drainage area lies south of the main channel of the creek and joins with the main channel in Twp. 9, Rge. 29 WPM in Manitoba as illustrated in Figure 1. Hydrometric stations have been located on Stony Creek near Sinclair, Broomhill and Bede. The only one currently operated, and the one that this natural flow study is based upon, is located on Stony Creek near Broomhill (05NG019). Its gross and effective drainage areas are 476.3 km^2 and 175.9 km^2 respectively. A Table of gross and effective drainage areas for key points in the Stony Creek Basin is provided in Figure 1.

Stony Creek is classified as an intermittent stream. Snowmelt in the spring contributes to high flows that decline to a gradually diminishing base flow that becomes zero during the summer months. The median natural runoff of Stony Creek at the Saskatchewan-Manitoba boundary for apportionment periods 1912-13 to 1983-84 is 376 dam^3, compared with the mean natural runoff of 1 004 dam^3 (See Table B-5). The large difference between the two figures indicates the extreme variability of runoff in this small drainage basin.

The main channel of Stony Creek, especially in the Manitoba portion of the basin, appears to be a series of sloughs, dugouts and beaver dam impoundments connected by small channels. The land adjacent to the creek is poorly drained with several small potholes and sloughs. The farmers in the area appear to find the "natural" water storage areas in the main channel sufficient both for their agricultural and domestic needs. Consequently, there is almost no evidence of dams being built in the main channel of Stony Creek in Manitoba.

Some of the areas now outside of the effective drainage basin may be drained into Stony Creek at some future time and the natural flow of the stream will be enhanced, so it is pertinent to note that the existing gross drainage area tributary to the boundary is 2.27 times larger than the effective area indicating a large area of potential land drainage.

Chapter 3

BASIN WATER USE

There are no major water use projects located within the effective drainage area of either the Saskatchewan or Manitoba portion of the Stony Creek Basin tributary to the gauging station Stony Creek near Broomhill, but there are three projects that do have an effect on streamflow in the Stony Creek basin. The first two in Saskatchewan, are of recent origin and do not affect historic streamflow.

1. The Flynn Project is a Ducks Unlimited project located in the SE¼ Sec. 28-11-30 WPM. The project was built in 1986. It stores 146.3 dam^3 with a surface area of 31 hectares and uses an estimated 79 dam^3 per year. When the project was visited on September 3, 1986 the reservoir was empty but the dam has been completed and the project was expected to store water starting in 1987. This project controls 24.7 km^2 of effective drainage area (48% of the area tributary to the Saskatchewan-Manitoba boundary).

2. The Dixon Drainage Project is located in the SW¼ Sec. 20-11-30 WPM. It was approved on October 24, 1983 and increased the effective drainage area of Stony Creek by 1.44 square kilometres. The project drains a slough with an area of 28.2 hectares that stores 171.5 dam^3. The drainage works have now been completed and will drain additional water into Stony Creek just above the Flynn project.

There is only one project in the Manitoba portion of Stony Creek basin. The "Jago" Ducks Unlimited Project located in the SE¼ Sec. 27-5-28 WPM. It was licensed in 1971 for waterfowl conservation and uses an estimated 16 dam^3 per year. In allocating water use from the "Jago" project to the flows of Stony Creek, it was assumed that all of the water would be diverted in the month of April. There are three additional Ducks Unlimited Projects located downstream from the Stony Creek gauging station. Two are connected with the "Mosquito" project and the third with the "CARR" project. All three are licensed for waterfowl conservation purposes and they need about 300 dam^3 to operate effectively. These projects do not affect inflow to the gauging station but are an indication of developed uses in the downstream portion of the basin.

A field trip was made to this area on September 3-4, 1986 as described in Appendix C. Two additional small dams were identified in Saskatchewan which are on a small tributary to the creek in Sec. 28-10-30 WPM, and use an estimated total of six dam^3.

There were no unauthorized dams in Manitoba although there were several sloughs in the channel of the creek. Therefore, the total historic water use would be 22 dam^3 per year at the gauging station and the present use flow at the Saskatchewan-Manitoba boundary (assuming that the Flynn Project is operable) would be 85 dam^3 per year as shown in Table A-1.

Chapter 4

NATURAL FLOW CALCULATIONS

Natural flow, the quantity of water that would have been recorded under natural conditions prior to the effect of human intervention, was derived for Stony Creek using the project depletion method to adjust recorded flow. This method is described in detail in Prairie Provinces Water Board Report No. 48 entitled "Determination of Natural Flow For Apportionment Purposes".

The only hydrometric station currently operated in the basin, Stony Creek near Broomhill (05NG019), was established in 1965 and has been operated on a seasonal basis from 1965 until the present time. An array showing recorded monthly flows for this station is shown in Table B-1. Recorded flows at this site were adjusted to natural flows and the resultant monthly streamflow array was extended to cover the 73-year historic period 1912 to 1984 using regression equations. Natural flows were then transferred to the Saskatchewan-Manitoba boundary using a ratio based on effective drainage areas tributary to the two sites.

Historic upstream minor water uses within the effective drainage area of the Stony Creek basin are as shown in Table A-1. They were determined, on an annual basis, as a function of estimated water use from licensed and unlicensed projects and include project evaporative losses. The actual water uses would have varied from year to year because of variations in net evaporation and inflow. Both of the water use projects considered in Table A-1 are within the effective drainage area of Stony Creek basin and are above the hydrometric station. The estimated annual water uses for projects located

above the hydrometric gauging station were added to the recorded monthly mean flows at the gauging station. When recorded flow at the gauging station was negligible it was assumed that upstream water use would not have had any effect on streamflow at the gauging station because the water would have been trapped in one of the many in-channel storage areas between the point of use and the hydrometric station. Thus, no adjustment was made for use in 1973, 1977, 1978, 1980, 1981 and 1984. The resulting natural monthly mean flow for the station was used to produce the array of natural monthly mean flows for the years 1967 to 1984 inclusive as shown in Table B-2.

Several reports defining natural streamflow estimates of tributaries to the Assiniboine and Souris Rivers have already been prepared. These include PPWB reports on the Antler, Gainsborough, Graham and Pipestone Creeks and the comprehensive report prepared by the Souris River Basin Board entitled "Souris River Basin Study - Natural Flow Report". These reports have examined all practical alternatives that might be used to extend streamflow on watercourses of this type. Consequently, it was decided, in producing this report, to base the extended period of record on the natural flow reports previously made for these adjacent creeks where extensive work has already been done to estimate monthly natural streamflow. Both the period of time covered by these reports and the type of creeks being studied were sufficiently similar that it could be reasonably assumed that streamflow would also be similar.

A series of step-wise multiple regressions were made to relate Stony Creek to natural flow estimates for Graham, Pipestone, Gainsborough and Antler Creeks respectively to determine which of these four creeks were most representative of streamflows on Stony Creek. The best regression used Graham Creek alone and extended natural flow estimates using the natural streamflow estimates for that creek. Hence, a description of the regressions used to generate the natural flow estimates for Graham creek is included in this chapter.

The extended record for Graham Creek near Melita was based on a multiple regression analysis with streamflow from Souris River above Minot (5117500), Moose Mountain Creek near Oxbow (05ND004), and Long Creek near Estevan (05NB001). Missing hydrometric records were estimated by assigning priorities to the regression equations. Monthly natural flows for Graham Creek near

Melita for the winter months December, January and February were assumed to be nil for all years and missing monthly records for March were assumed to be nil unless daily temperature records indicated sufficient melting to start streamflow in the Graham Creek basin. When this occurred, missing monthly natural flows for Graham Creek were estimated from a graphical monthly correlation with March flows of the Souris River near Minot. Missing monthly natural flows for November were estimated by extrapolating the recession limb of the annual hydrograph based on an analysis of recorded daily flows for October at the Graham Creek hydrometric gauging station.

The regressions used to relate Graham Creek to streamflow on Stony Creek are shown in Table B-3. The months of July, August and September were grouped together to provide sufficient values to derive a reasonable regression equation. This grouping was necessary because there were several zero flow values recorded in these months. The regression equation uses synthesized estimates of Graham Creek at the boundary but these estimates, for the period that the regressions are made, are based on recorded flow adjusted to natural flow at the gauging station multiplied by a constant value. The extensions to cover the entire study period are based both on the natural flow of Graham Creek and on the estimates made to extend the Graham Creek records. The resulting estimate of monthly natural flow of Stony Creek near Broomhill from 1912 to 1983 inclusive is shown in Table B-4.

Natural flows at the Saskatchewan-Manitoba boundary were based entirely on the natural flows derived for Stony Creek at the hydrometric station. The transfer of natural flow arrays from the hydrometric station to the interprovincial boundary used a direct relationship based on the two effective drainage areas:

$$Q_{\text{boundary}} = Q_{\text{gauging station}} \times \frac{52.1}{175.9}$$

Monthly natural flow for Stony Creek at the Saskatchewan-Manitoba boundary for the period 1912-13 to 1983-84 is shown in Table B-5.

The estimates made for Stony Creek both at the gauging station and at the boundary are based on flow estimates for Graham Creek at the Saskatchewan-

Manitoba boundary. The estimates provide a reasonable portrayal of the manner in which this creek might have fluctuated during the period 1912 to 1984 inclusive. Caution is recommended, however, in using estimated values for individual years or months as being indicative of historic flows. These values may be used in dealing with this interprovincial stream to provide preliminary answers concerning potential streamflow that might be available for use. They should not, however, be interpreted as individually accurate estimates of monthly flow in any specific month. Caution should also be exercised when using this data base for other studies that may require a more detailed or realistic streamflow data base.

Chapter 5

PRESENT USE

FLOW CALCULATIONS

An analysis was made to determine whether present (1986) uses of Stony Creek at the Saskatchewan-Manitoba boundary would have been less than 50% of the natural flow under the terms of the 1969 Master Agreement on Apportionment for the periods 1912-1913 to 1983-1984. A monthly array of uses was created assuming that the uses current in 1986 had applied to the entire recorded and estimated historic period. The estimated water uses within the effective drainage area of the Stony Creek basin upstream of the interprovincial boundary were determined as listed in Table A-1. It should be noted that the estimated annual water uses would vary from year to year because of variable net evaporation and because of the limitation of restricting annual water use in any year to available inflow.

Current water uses upstream of the Saskatchewan-Manitoba boundary were combined to form an array of monthly uses. When the natural flow was zero before the uses were subtracted, it was assumed that the uses would also be zero, and no positive allowance was made for the potential increase in streamflow due to drainage from the Dixon project. The array of adjusted monthly uses was then subtracted from natural flow at the interprovincial boundary to provide an estimate of annual flows at the present level of use (see Table B-6). These monthly flows represent the flow that would have been recorded at the Saskatchewan-Manitoba boundary during the period 1912-1913 to 1983-84 had the present 1986 level of use been in effect for the entire period. An array of one-half of the natural flow at the interprovincial boundary was subtracted from this annual array of natural flows adjusted for present use. The residual

annual flows (shown in Table B-6) provide a picture of the balance of flow situation of this creek for the 1912-13 to 1983-84 apportionment periods. Based on this table, Saskatchewan would not have passed 50% of the natural flow of the Stony Creek at the interprovincial boundary in 25 of the 72 apportionment periods. Manitoba would have received an average flow volume of 670 dam^3 in the 47 years when estimated flow volumes were in excess of it's 50% share, but these surpluses would have occurred in years when water supplies were plentiful.

It may be reasonably argued that, since the Flynn project only controls 47.6% of the effective drainage area tributary to the Manitoba boundary, it will always use less than 50% of the natural flow rising in Saskatchewan. If unit yields throughout the Saskatchewan portion of the basin are consistent, the argument is valid. A second argument may be that the Dixon drainage project will supplement streamflow, making up for some of the anticipated deficits in streamflow created by the Flynn project. These arguments can only be refuted or confirmed by monitoring consumptive uses on the Flynn project, outflow from the Dixon project and streamflow at the boundary.

At some time in the future, the procedure for determining whether both provinces receive their equitable share of Stony Creek water may become a problem. Both the Dixon project and the Ducks Unlimited Flynn project are relatively large developments in a small drainage basin. It would be interesting to note how these two projects perform for the next few years by monitoring water use during each spring runoff. The information could then be used to decide whether these users are retaining more than Saskatchewan's share of Stony Creek water.

Chapter 6

PROCEDURE FOR FUTURE CALCULATION OF NATURAL FLOWS

If it becomes necessary to formally monitor the apportionment of streamflow of Stony Creek at the interprovincial boundary, natural flow calculations would have to be made on a regular basis to ensure that Manitoba receives its share of the flow. The natural flow of Stony Creek could be computed using the project depletion method based on the generalized equation:

$$Q_{natural\ flow} = Q_{recorded\ flow} + Net\ depletion$$

The net depletion of streamflow from upstream projects may be computed as the sum of the withdrawal for consumptive uses plus net evaporation plus changes in reservoir storage over the specified time interval. Natural flow at the interprovincial boundary would then be determined using the methodology developed in this section. As of August 1986, the upstream projects identified in this basin are as shown in Table A-1. These projects should be checked again prior to formal monitoring of apportionment and a further check should be made to determine whether additional projects have been added in the basin since 1986. The amount of water added to the effective drainage area of the basin by the Dixon Drainage Project, each year, should also be documented.

The existing gauging station, Stony Creek near Broomhill, can not adequately define natural and recorded streamflow at the boundary between Saskatchewan and Manitoba. When it becomes necessary to monitor flows in the basin, a gauging station must be established on Stony Creek at, or near, the Saskatchewan-Manitoba boundary to monitor the streamflow that actually crosses the boundary and major upstream uses should be monitored.

Chapter 7

CONCLUSIONS

AND RECOMMENDATIONS

CONCLUSIONS:

1. The existing hydrometric network is not adequate for calculating the natural flows of Stony Creek at the Saskatchewan-Manitoba boundary. A more accurate estimate of natural flows at the boundary is needed if apportionment is to be monitored.

2. The average annual consumptive water use in the Saskatchewan portion of the Stony Creek basin represents 8.5% of the average apportionment flow of 1 004 dam^3 or 22.6% of the median apportionment flow of 376 dam^3.

3. Under present (1986) conditions, less than 50% of the natural flow of Stony Creek at the Saskatchewan-Manitoba boundary would have been passed to Manitoba in 25 of the 72 years studied. The volume of water that would have been delivered to Manitoba in excess of 50% of natural flow during years of excess flow would have averaged 670 dam^3.

RECOMMENDATIONS:

1. Based on the present (1986) level of development in the Saskatchewan portion of the Stony Creek basin, the Board may wish to consider monitoring of apportionment at this time although downstream uses are minimal.

2. If it is decided to monitor apportionment, a hydrometric gauging station should be established at the Saskatchewan-Manitoba boundary.

3. Annual records of water use at the Flynn project and drainage from the Dixon project should be maintained to ascertain the net change in water balance due to these two Saskatchewan projects.

Chapter 8

ACKNOWLEDGEMENTS

The Stony Creek natural flow study was prepared by Mr. R.B. Godwin, Executive Director of the Prairie Provinces Water Board. The final text was subsequently reviewed by the Committee on Hydrology Members. Their editorial and technical comments are appreciated.

A special note of thanks is extended to Mrs. Glenda Mason for her work in preparing the numerous drafts of this text, to Mr. Gordon Smith for his help in the computerized aspects of this study and to Mr. Ken Born in his drafting assistance in preparation of the report. Similarly, the help of Mr. A.J. Chen in finalizing the text is also recognized.

APPENDICES

APPENDIX A

WATER USES

TABLE A-1

STONY CREEK NEAR BROOMHILL (05NG019)
WATER USE PROJECTS WITHIN THE EFFECTIVE DRAINAGE AREA

Location	Use	Estimated Use (dam^3)	Reservoir Capacity (dam^3)	Year Licensed	Map Location
Saskatchewan					
1. SE¼ Sec. 8-11-30 WPM (Flynn Poject)	Wildlife (Ducks Unlimited	79	164.3	1986	S-1
2. SE¼ Sec. 28-10-30 WPM	Unknown	2 *	3 *	Unauthorized	S-3
3. NE¼ Sec. 01-10-30 WPM	Unknown	4 *	12 *	Unauthorized	S-4
Manitoba					
1. SE¼ Sec. 26-5-28 WPM (Clark Project)	Wildlife (Ducks Unlimited)	16	80	1971	S-5

* Estimated

Note:

Estimated use at the gauging station
Stony Creek near Broomhill (1967-71 = 6 dam^3)
(1972-84 = 22 dam^3).

Estimated Use at the Saskatchewan-Manitoba boundary (1986)
(assuming the Flynn Project to be operable) = 85 dam^3.

PPWB FILE J 203

APPENDIX B

NATURAL AND RECORDED FLOWS

TABLE B-1

STONY CREEK NEAR BROOMHILL (05NG019)
RECORDED FLOW - m^3/s

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	CU.DAMS
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-	-	-	-	-	-	-
1916	-	-	-	-	-	-	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	-	-	-	-	-	-	-
1918	-	-	-	-	-	-	-	-	-	-	-	-	-
1919	-	-	-	-	-	-	-	-	-	-	-	-	-
1920	-	-	-	-	-	-	-	-	-	-	-	-	-
1921	-	-	-	-	-	-	-	-	-	-	-	-	-
1922	-	-	-	-	-	-	-	-	-	-	-	-	-
1923	-	-	-	-	-	-	-	-	-	-	-	-	-
1924	-	-	-	-	-	-	-	-	-	-	-	-	-
1925	-	-	-	-	-	-	-	-	-	-	-	-	-
1926	-	-	-	-	-	-	-	-	-	-	-	-	-
1927	-	-	-	-	-	-	-	-	-	-	-	-	-
1928	-	-	-	-	-	-	-	-	-	-	-	-	-
1929	-	-	-	-	-	-	-	-	-	-	-	-	-
1930	-	-	-	-	-	-	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-	-	-	-	-	-	-
1932	-	-	-	-	-	-	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-	-	-	-	-	-	-
1936	-	-	-	-	-	-	-	-	-	-	-	-	-
1937	-	-	-	-	-	-	-	-	-	-	-	-	-
1938	-	-	-	-	-	-	-	-	-	-	-	-	-
1939	-	-	-	-	-	-	-	-	-	-	-	-	-
1940	-	-	-	-	-	-	-	-	-	-	-	-	-
1941	-	-	-	-	-	-	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-	-	-	-	-	-	-
1943	-	-	-	-	-	-	-	-	-	-	-	-	-
1944	-	-	-	-	-	-	-	-	-	-	-	-	-
1945	-	-	-	-	-	-	-	-	-	-	-	-	-
1946	-	-	-	-	-	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-	-	-	-	-	-
1951	-	-	-	-	-	-	-	-	-	-	-	-	-
1952	-	-	-	-	-	-	-	-	-	-	-	-	-
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1954	-	-	-	-	-	-	-	-	-	-	-	-	-
1955	-	-	-	-	-	-	-	-	-	-	-	-	-
1956	-	-	-	-	-	-	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	-	-	-	-	-	-	-
1958	-	-	-	-	-	-	-	-	-	-	-	-	-
1959	-	-	-	-	-	-	-	-	-	-	-	-	-
1960	-	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	0.00	1.12	0.06	0.08	0.11	0.08	0.15	0.17	-	-	-
1966	-	-	0.24	0.97	0.42	0.01	0.03	0.00	0.00	0.00	-	-	-
1967	-	-	0.00	0.18	0.21	0.00	0.00	0.00	0.00	0.00	-	-	-
1968	-	-	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1969	-	-	0.00	2.32	0.37	0.00	0.73	0.02	0.00	0.00	-	-	-
1970	-	-	0.00	2.99	1.86	0.10	0.02	0.00	0.00	0.00	-	-	-
1971	-	-	0.00	0.14	0.03	0.20	0.07	0.00	0.00	0.00	-	-	-
1972	-	-	0.84	0.95	0.10	0.03	0.00	0.00	0.00	0.00	-	-	-
1973	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1974	-	-	0.00	4.90	0.73	0.18	0.02	0.00	0.00	0.00	-	-	-
1975	-	-	0.00	4.51	1.33	0.42	0.04	0.00	0.45	0.43	-	-	-
1976	-	-	0.00	14.50	0.48	0.29	0.04	0.00	0.00	0.00	-	-	-
1977	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1978	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1979	-	-	0.00	0.95	0.47	0.03	0.00	0.00	0.00	0.00	-	-	-
1980	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1981	-	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1982	-	-	0.00	0.52	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1983	-	-	0.00	1.14	0.08	0.00	0.00	0.00	0.00	0.00	-	-	-
1984	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
MIN	-	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
MAX	-	0.01	0.84	14.50	1.86	0.42	0.73	0.08	0.45	0.43	-	-	-
MEAN	-	0.01	0.06	1.76	0.31	0.07	0.05	0.00	0.03	0.03	-	-	-

PPWB FILE A5N G19

TABLE B-2

STONY CREEK NEAR BROOMHILL (05NG019)
NATURAL FLOW - m^3/s

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	CU.DAMS
1912	-	-	-	-	-	-	-	-	-	-	-	-	-
1913	-	-	-	-	-	-	-	-	-	-	-	-	-
1914	-	-	-	-	-	-	-	-	-	-	-	-	-
1915	-	-	-	-	-	-	-	-	-	-	-	-	-
1916	-	-	-	-	-	-	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	-	-	-	-	-	-	-
1918	-	-	-	-	-	-	-	-	-	-	-	-	-
1919	-	-	-	-	-	-	-	-	-	-	-	-	-
1920	-	-	-	-	-	-	-	-	-	-	-	-	-
1921	-	-	-	-	-	-	-	-	-	-	-	-	-
1922	-	-	-	-	-	-	-	-	-	-	-	-	-
1923	-	-	-	-	-	-	-	-	-	-	-	-	-
1924	-	-	-	-	-	-	-	-	-	-	-	-	-
1925	-	-	-	-	-	-	-	-	-	-	-	-	-
1926	-	-	-	-	-	-	-	-	-	-	-	-	-
1927	-	-	-	-	-	-	-	-	-	-	-	-	-
1928	-	-	-	-	-	-	-	-	-	-	-	-	-
1929	-	-	-	-	-	-	-	-	-	-	-	-	-
1930	-	-	-	-	-	-	-	-	-	-	-	-	-
1931	-	-	-	-	-	-	-	-	-	-	-	-	-
1932	-	-	-	-	-	-	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	-	-	-	-	-	-
1934	-	-	-	-	-	-	-	-	-	-	-	-	-
1935	-	-	-	-	-	-	-	-	-	-	-	-	-
1936	-	-	-	-	-	-	-	-	-	-	-	-	-
1937	-	-	-	-	-	-	-	-	-	-	-	-	-
1938	-	-	-	-	-	-	-	-	-	-	-	-	-
1939	-	-	-	-	-	-	-	-	-	-	-	-	-
1940	-	-	-	-	-	-	-	-	-	-	-	-	-
1941	-	-	-	-	-	-	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-	-	-	-	-	-	-
1943	-	-	-	-	-	-	-	-	-	-	-	-	-
1944	-	-	-	-	-	-	-	-	-	-	-	-	-
1945	-	-	-	-	-	-	-	-	-	-	-	-	-
1946	-	-	-	-	-	-	-	-	-	-	-	-	-
1947	-	-	-	-	-	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-	-	-	-	-	-
1950	-	-	-	-	-	-	-	-	-	-	-	-	-
1951	-	-	-	-	-	-	-	-	-	-	-	-	-
1952	-	-	-	-	-	-	-	-	-	-	-	-	-
1953	-	-	-	-	-	-	-	-	-	-	-	-	-
1954	-	-	-	-	-	-	-	-	-	-	-	-	-
1955	-	-	-	-	-	-	-	-	-	-	-	-	-
1956	-	-	-	-	-	-	-	-	-	-	-	-	-
1957	-	-	-	-	-	-	-	-	-	-	-	-	-
1958	-	-	-	-	-	-	-	-	-	-	-	-	-
1959	-	-	-	-	-	-	-	-	-	-	-	-	-
1960	-	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	-	-	-	-	-	-	-	-	-	-	-	-
1965	-	-	0.00	1.12	0.06	0.08	0.11	0.08	0.15	0.17	-	-	-
1966	-	-	0.24	0.97	0.42	0.01	0.03	0.00	0.00	0.00	-	-	-
1967	-	-	0.00	0.19	0.21	0.00	0.00	0.00	0.00	0.00	-	-	-
1968	-	-	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1969	-	-	0.00	2.32	0.37	0.00	0.73	0.02	0.00	0.00	-	-	-
1970	-	-	0.00	2.99	1.86	0.10	0.02	0.00	0.00	0.00	-	-	-
1971	-	-	0.00	0.14	0.03	0.20	0.07	0.00	0.00	0.00	-	-	-
1972	-	-	0.84	0.96	0.10	0.03	0.00	0.00	0.00	0.00	-	-	-
1973	-	-	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1974	-	-	0.00	4.91	0.73	0.18	0.02	0.00	0.00	0.00	-	-	-
1975	-	-	0.00	4.52	1.33	0.42	0.04	0.00	0.45	0.43	-	-	-
1976	-	-	0.00	14.51	0.48	0.29	0.04	0.00	0.00	0.00	-	-	-
1977	-	-	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1978	-	-	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1979	-	-	0.00	0.96	0.47	0.03	0.00	0.00	0.00	0.00	-	-	-
1980	-	-	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1981	-	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1982	-	-	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
1983	-	-	0.00	1.15	0.08	0.00	0.00	0.00	0.00	0.00	-	-	-
1984	-	-	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
MIN	-	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-
MAX	-	0.01	0.84	14.51	1.86	0.42	0.73	0.08	0.45	0.43	-	-	-
MEAN	-	0.01	0.06	1.77	0.31	0.07	0.05	0.00	0.03	0.03	-	-	-

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TABLE B-3

STONY CREEK NEAR BROOMHILL (05NG019)
REGRESSION EQUATIONS USED TO ESTIMATE NATURAL MONTHLY MEAN FLOW

Month[1]	Years	Regression Equation	Correlation Coefficient	Standard Error of Estimate[2]	Priority Number
Mar.	1912-64	$\log Q_E = -0.092225 + 0.985193 \log GNF02$	0.86	0.67	1
Apr.	1912-64	$\log Q_E = 0.813807 + 1.076450 \log GNF02$	0.96	0.31	1
May	1912-64	$\log Q_E = 0.497539 + 1.123336 \log GNF02$	0.88	0.86	1
June	1912-64	$\log Q_E = 0.408298 + 1.114597 \log GNF02$	0.88	0.72	1
July Aug. Sept.	1912-64	$\log Q_E = 0.530624 + 1.100183 \log GNF02$	0.67	0.87	1
Oct.	1912-64	$\log Q_E = 0.544114 + 1.155586 \log GNF02$	0.82	0.62	1

1 November to February set to zero.

2 Standard error of estimate expressed as a percentage of mean of the dependent variable for the regressed period.

LIST OF SYMBOLS

GNF02 = Natural flow of Graham Creek at the Saskatchewan-Manitoba boundary (As published in PPWB Report # 62).

Q_E = Natural flow of Stony Creek near Broomhill station C5NG19.

NOTE: All regressions are based on recorded flow adjusted to natural flow (the boundary flows (GNF02) are estimated by multiplying natural monthly streamflow at station 05NF008 by a constant). The estimated flows shown in Table B-4 for the period 1912-84 are based on these regressions.

TABLE B-4

STONY CREEK NEAR BROOMHILL (05NG019)
NATURAL FLOW FOR EXTENDED PERIOD - m^3/s

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	CU.DAMS
1912	0.00	0.00	0.00	0.37	0.18	0.03	0.00	0.00	0.00	0.00	0.00	0.00	1520.5
1913	0.00	0.00	0.00	0.42	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1181.8
1914	0.00	0.00	0.01	0.34	0.06	0.05	0.01	0.00	0.00	0.00	0.00	0.00	1244.5
1915	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	118.5
1916	0.00	0.00	0.00	1.11	0.17	0.06	0.03	0.01	0.00	0.00	0.00	0.00	3580.3
1917	0.00	0.00	0.00	0.47	0.14	0.04	0.01	0.00	0.00	0.00	0.00	0.00	1723.7
1918	0.00	0.00	0.01	0.09	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	397.6
1919	0.00	0.00	0.00	0.79	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2183.7
1920	0.00	0.00	0.00	0.56	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1856.2
1921	0.00	0.00	0.00	0.05	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00	235.2
1922	0.00	0.00	0.00	0.97	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2784.5
1923	0.00	0.00	0.00	1.03	0.10	0.03	0.06	0.06	0.00	0.00	0.00	0.00	3391.0
1924	0.00	0.00	0.00	0.16	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	542.7
1925	0.00	0.00	0.01	2.23	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5994.5
1926	0.00	0.00	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	134.6
1927	0.00	0.00	0.00	1.37	0.21	0.07	0.02	0.00	0.00	0.02	0.00	0.00	4397.9
1928	0.00	0.00	0.01	1.39	0.08	0.02	0.02	0.09	0.00	0.00	0.00	0.00	4184.0
1929	0.00	0.00	0.00	0.04	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	182.3
1930	0.00	0.00	0.01	0.19	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	874.3
1931	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.6
1932	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	91.4
1933	0.00	0.00	0.01	0.17	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	691.6
1934	0.00	0.00	0.00	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	157.2
1935	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	165.0
1936	0.00	0.00	0.00	0.31	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	835.1
1937	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	88.2
1938	0.00	0.00	0.02	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	281.0
1939	0.00	0.00	0.04	0.34	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	1059.6
1940	0.00	0.00	0.00	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	196.6
1941	0.00	0.00	0.00	0.20	0.05	0.02	0.00	0.00	0.00	0.00	0.00	0.00	708.3
1942	0.00	0.00	0.00	0.42	0.04	0.03	0.00	0.01	0.00	0.00	0.00	0.00	1307.8
1943	0.00	0.00	0.02	2.91	0.04	0.10	0.02	0.00	0.00	0.00	0.00	0.00	8000.2
1944	0.00	0.00	0.00	0.03	0.00	0.06	0.10	0.00	0.00	0.00	0.00	0.00	506.4
1945	0.00	0.00	0.01	0.15	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	493.0
1946	0.00	0.00	0.03	0.47	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1320.0
1947	0.00	0.00	0.01	0.37	0.00	0.09	0.10	0.01	0.00	0.00	0.00	0.00	1528.3
1948	0.00	0.00	0.00	2.17	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7146.9
1949	0.00	0.00	0.00	2.28	0.03	0.15	0.00	0.00	0.00	0.00	0.00	0.00	6391.2
1950	0.00	0.00	0.00	1.35	0.52	0.08	0.10	0.31	0.12	0.04	0.00	0.00	6668.3
1951	0.00	0.00	0.00	4.43	1.45	0.04	0.00	0.00	0.00	0.00	0.00	0.00	15502.5
1952	0.00	0.00	0.01	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1264.7
1953	0.00	0.00	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	193.8
1954	0.00	0.00	0.01	0.01	0.00	0.14	0.16	0.03	0.00	0.00	0.00	0.00	892.8
1955	0.00	0.00	0.00	3.42	0.33	0.05	0.01	0.00	0.00	0.00	0.00	0.00	9897.1
1956	0.00	0.00	0.00	3.79	0.14	0.03	0.01	0.00	0.00	0.00	0.00	0.00	10288.3
1957	0.00	0.00	0.02	0.13	0.03	0.04	0.01	0.11	0.15	0.01	0.00	0.00	1294.2
1958	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1113.7
1959	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	90.2
1960	0.00	0.00	0.03	0.85	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2305.5
1961	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.4
1962	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	29.3
1963	0.00	0.00	0.03	0.03	0.00	0.33	0.01	0.00	0.00	0.00	0.00	0.00	1067.6
1964	0.00	0.00	0.11	1.36	0.36	0.05	0.01	0.00	0.00	0.00	0.00	0.00	4927.6
1965	0.00	0.00	0.00	1.12	0.06	0.08	0.11	0.08	0.15	0.17	0.00	0.00	4605.5
1966	0.00	0.00	0.24	0.97	0.42	0.01	0.03	0.00	0.00	0.00	0.00	0.00	4377.5
1967	0.00	0.00	0.00	0.19	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1053.5
1968	0.00	0.00	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	283.5
1969	0.00	0.00	0.00	2.32	0.37	0.00	0.73	0.02	0.00	0.00	0.00	0.00	9005.7
1970	0.00	0.00	0.00	2.99	1.86	0.10	0.02	0.00	0.00	0.00	0.00	0.00	13050.7
1971	0.00	0.00	0.00	0.14	0.03	0.20	0.07	0.00	0.00	0.00	0.00	0.00	1176.3
1972	0.00	0.00	0.84	0.96	0.10	0.03	0.00	0.00	0.00	0.00	0.00	0.00	5085.0
1973	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.0
1974	0.00	0.00	0.00	4.91	0.73	0.18	0.02	0.00	0.00	0.00	0.00	0.00	15195.8
1975	0.00	0.00	0.00	4.52	1.33	0.42	0.04	0.00	0.45	0.43	0.00	0.00	18809.5
1976	0.00	0.00	0.00	14.51	0.48	0.29	0.04	0.00	0.00	0.00	0.00	0.00	39758.4
1977	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.0
1978	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.0
1979	0.00	0.00	0.00	0.96	0.47	0.03	0.00	0.00	0.00	0.00	0.00	0.00	3812.9
1980	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.0
1981	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.6
1982	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1382.8
1983	0.00	0.00	0.00	1.15	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3207.0
1984	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.4
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.0
MAX	0.00	0.01	0.84	14.51	1.86	0.42	0.73	0.31	0.45	0.43	0.00	0.00	39758.4
MEAN	0.00	0.00	0.02	1.00	0.16	0.04	0.03	0.01	0.01	0.01	0.00	0.00	3343.3

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Note: Shaded area denotes natural flow data derived by regression analysis.

TABLE B-5

STONY CREEK AT THE SASKATCHEWAN-MANITOBA BOUNDARY
NATURAL FLOW - m^3/s

	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	CU.DAMS
1912-13	0.11	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	450.4
1913-14	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	355.7
1914-15	0.10	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	362.9
1915-16	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.7
1916-17	0.33	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1060.5
1917-18	0.14	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	519.6
1918-19	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	108.7
1919-20	0.23	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	646.8
1920-21	0.17	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	549.8
1921-22	0.02	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	69.7
1922-23	0.29	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	824.8
1923-24	0.30	0.03	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1004.4
1924-25	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	164.5
1925-26	0.66	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1771.0
1926-27	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	39.3
1927-28	0.40	0.06	0.02	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	1307.8
1928-29	0.41	0.02	0.01	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1234.2
1929-30	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.7
1930-31	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	253.3
1931-32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.7
1932-33	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.3
1933-34	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	198.6
1934-35	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	46.2
1935-36	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.3
1936-37	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	246.4
1937-38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	42.3
1938-39	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	93.8
1939-40	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	285.5
1940-41	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	57.3
1941-42	0.06	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	209.8
1942-43	0.13	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	399.9
1943-44	0.86	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2355.7
1944-45	0.01	0.00	0.02	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	153.4
1945-46	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	162.7
1946-47	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	378.3
1947-48	0.11	0.00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	443.5
1948-49	0.64	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2115.7
1949-50	0.68	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1892.2
1950-51	0.40	0.16	0.03	0.03	0.09	0.03	0.01	0.00	0.00	0.00	0.00	0.00	1975.1
1951-52	1.31	0.43	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4598.1
1952-53	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	374.6
1953-54	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	58.0
1954-55	0.00	0.00	0.04	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	257.7
1955-56	1.01	0.10	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2931.5
1956-57	1.12	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	3063.8
1957-58	0.04	0.01	0.01	0.00	0.03	0.04	0.00	0.00	0.00	0.00	0.00	0.03	435.5
1958-59	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	275.3
1959-60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	33.9
1960-61	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	661.6
1961-62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.8
1962-63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	32.4
1963-64	0.01	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	373.6
1964-65	0.40	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1376.0
1965-66	0.33	0.02	0.02	0.03	0.02	0.04	0.05	0.00	0.00	0.00	0.00	0.07	1552.2
1966-67	0.29	0.12	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1108.6
1967-68	0.05	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	385.0
1968-69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.0
1969-70	0.69	0.11	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2666.7
1970-71	0.89	0.55	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3865.6
1971-72	0.04	0.01	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	1011.7
1972-73	0.28	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	842.9
1973-74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.5
1974-75	1.45	0.22	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4501.0
1975-76	1.34	0.39	0.12	0.01	0.00	0.13	0.13	0.00	0.00	0.00	0.00	0.00	5571.4
1976-77	4.30	0.14	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11776.4
1977-78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.5
1978-79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.5
1979-80	0.29	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1129.4
1980-81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.4
1981-82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.5
1982-83	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	409.6
1983-84	0.34	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	951.5
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.5
MAX	4.30	0.55	0.12	0.22	0.09	0.13	0.13	0.00	0.00	0.00	0.00	0.25	11776.4
MEAN	0.30	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1003.7

PPWB FILE GSM NG19

TABLE B-6

STONY CREEK AT THE SASKATCHEWAN-MANITOBA BOUNDARY
ANNUAL NATURAL FLOW AT THE PRESENT (1986)
LEVEL OF USE AND RESULTANT DEFICITS IN ANNUAL FLOW - dam^3

APPORTIONMENT PERIOD	NATURAL FLOW	FLOW AT THE PRESENT LEVEL OF USE	50% OF NATURAL FLOW	ANNUAL SURPLUS IN FLOW
1912-13	450	365	225.0	140.0
1913-14	356	271	178.0	93.0
1914-15	363	278	181.5	96.5
1915-16	35	0	17.5	-17.5
1916-17	1061	976	530.5	445.5
1917-18	520	435	260.0	175.0
1918-19	109	24	54.5	-30.5
1919-20	647	562	323.5	238.5
1920-21	550	465	275.0	190.0
1921-22	70	0	35.0	-35.0
1922-23	825	740	412.5	327.5
1923-24	1004	919	502.0	417.0
1924-25	165	80	82.5	-2.5
1925-26	1771	1686	885.5	800.5
1926-27	39	0	19.5	-19.5
1927-28	1308	1223	654.0	569.0
1928-29	1234	1149	617.0	532.0
1929-30	60	0	30.0	-30.0
1930-31	253	168	126.5	41.5
1931-32	10	0	5.0	-5.0
1932-33	33	0	16.5	-16.5
1933-34	199	114	99.5	14.5
1934-35	46	0	23.0	-23.0
1935-36	48	0	24.0	-24.0
1936-37	246	161	123.0	38.0
1937-38	42	0	21.0	-21.0
1938-39	94	9	47.0	-38.0
1939-40	286	201	143.0	58.0
1940-41	57	0	28.5	-28.5
1941-42	210	125	105.0	20.0
1942-43	400	315	200.0	115.0
1943-44	2356	2271	1178.0	1093.0
1944-45	153	68	76.5	-8.5
1945-46	163	78	81.5	-3.5
1946-47	378	293	189.0	104.0
1947-48	444	359	222.0	137.0
1948-49	2116	2031	1058.0	973.0
1949-50	1892	1807	946.0	861.0
1950-51	1975	1890	987.5	902.5
1951-52	4598	4513	2299.0	2214.0
1952-53	375	290	187.5	102.5
1953-54	58	0	29.0	-29.0
1954-55	258	173	129.0	44.0
1955-56	2932	2847	1466.0	1381.0
1956-57	3064	2979	1532.0	1447.0
1957-58	436	351	218.0	133.0
1958-59	275	190	137.5	52.5
1959-60	34	0	17.0	-17.0
1960-61	662	577	331.0	246.0
1961-62	8	0	4.0	-4.0
1962-63	32	0	16.0	-16.0
1963-64	374	289	187.0	102.0
1964-65	1376	1291	688.0	603.0
1965-66	1552	1467	776.0	691.0
1966-67	1109	1024	554.5	469.5
1967-68	385	300	192.5	107.5
1968-69	11	0	5.5	-5.5
1969-70	2667	2582	1333.5	1248.5
1970-71	3866	3781	1933.0	1848.0
1971-72	1012	927	506.0	421.0
1972-73	843	758	421.5	336.5
1973-74	7	0	3.5	-3.5
1974-75	4501	4416	2250.5	2165.5
1975-76	5571	5486	2785.5	2700.5
1976-77	11776	11691	5888.0	5803.0
1977-78	7	0	3.5	-3.5
1978-79	7	0	3.5	-3.5
1979-80	1129	1044	564.5	479.5
1980-81	14	0	7.0	-7.0
1981-82	7	0	3.5	-3.5
1982-83	410	325	205.0	120.0
1983-84	952	867	476.0	391.0

APPENDIX C

FIELD TRIP TO STONY CREEK BASIN - SEPTEMBER 3-4, 1986

A field trip was made to Stony Creek on September 3 and 4, 1986. Those present on the field trip were:

Bruce Godwin, Prairie Provinces Water Board
Tony Moser, Saskatchewan Water Corporation
Tim Jansen, Saskatchewan Water Corporation
Rick Bowering, Manitoba Department of Natural Resources

The location of each of the projects described in this appendix is also plotted on Figure 1. There are four projects in the Saskatchewan portion of Stony Creek basin. The largest is the Ducks Unlimited Flynn Project (see S-1 in figure 1) in the SE¼ Sec. 8-11-30 WPM. Approval was given to build the project on March 4, 1986 and it was finished in the fall of 1986. The dam stores an estimated 146.3 dam^3 at fsl and was built with the cooperation of the farmer that owns the land. It is reported that future use by the project will average 79 dam^3 per year.

The Dixon Project (S-2) in the SW¼ Sec. 20-11-30 WPM is a drainage project. It adds 1.44 km^2 of drainage to Stony Creek, draining a slough with a surface area of 28.2 hectares and an estimated capacity of 171.5 dam^3 through an 1 860 metre drainage ditch. The project (drainage project #56) was completed on October 24, 1983.

There are two small dams (S-3); one in the SE¼ Sec. 28-10-30 WPM and the second immediately downstream in the NE¼ Sec. 21-10-30 WPM. They are very old and stable. Both dams are ripraped. The upstream dam stores an estimated three dam^3 of water and the downstream dam an estimated 12 dam^3. Estimated uses are, two dam^3 and four dam^3, respectively.

Based on air photo interpretation and an examination of 1:50 000 topographic maps, several sites were identified as possible dams. Field inspection verified that they were natural sloughs or potholes located in the drainage channel.

There was no evidence of any other man-made dams. There was one location (S-4) in the NE¼ Sec. 1-10-30 WPM where two dugouts, built adjacent to the channel, maintain a water supply on a year-round basis for stockwater purposes, but the channel itself has not been dammed and dugouts have been excluded in estimating natural flow.

There was only one project a licensed dam (S-5) in the SE¼ Sec. 26-5-28 WPM in the Manitoba portion of the Stony Creek drainage basin that would have an effect upon natural flow at the hydrometric station, Stony Creek near Broomhill (5NG019). It is listed in Manitoba records as 70-19, and stores 16 dam^3. Uses are an estimated four dam^3 of water annually. There was a series of natural reservoirs for some 13 kilometres of channel bed in townships 5 and 6, ranges 27 and 28. They appeared at first glance to be small stockwater reservoirs but had no downstream control or spillway and thus were classed as natural ponds.

Numerous other sites along Stony Creek were examined to determine whether dams had been built to control water in Stony Creek. There were several sloughs in the main channel, but no additional dams were found.

On Stony Creek, as on Jackson Creek, there appeared to be an underlying seam of gravel throughout the entire length of the creek in Manitoba. That gravel layer carried and maintained water at, or close to, the surface along the

entire watercourse. The result was a series of sloughs that remain full all year round. The farmers take advantage of this condition and use the water without having to build dams.

In Stony Creek, particularly, there appeared to be large areas that, in future years, could effectively be drained into the creek. Such drainage might measurably increase streamflow volumes particularly in the Manitoba portion of the drainage basin. There were also potentially large areas in the headwaters portion of Stony Creek, above the recently completed Ducks Unlimited project, that could be effectively drained in future years.

It has been assumed, in studies based on the results of this field trip, that historic natural streamflow at the boundary between Saskatchewan and Manitoba would be 6 dam^3 larger per year than recorded flows. Starting in the spring of 1987, this figure should rise to 85 dam^3 as the Ducks Unlimited Flynn project stores water in the Stony Creek basin. These estimates of use have made no allowance for upstream drainage in the basin. Similarly, historic streamflow at the station near Broomhill should be incremented by 22 dam^3 per year to allow for the licensed and unlicensed projects in the tributary basin. The validity of incrementing recorded flow at the gauging station by 22 dam^3 to allow for upstream uses in Saskatchewan is open to question. Upstream uses in Saskatchewan will probably have an effect on flow at the interprovincial boundary because they are close to that boundary. There is some question, however, as to whether that effect would be felt at the Broomhill hydrometric station some 45 kilometres downstream because of the numerous sloughs located within the main channel of Stony Creek in Manitoba.

DRAINAGE AREAS

STONY CREEK DRAINAGE BASIN

	Gross Area (km^2)	Effective Area (km^2)
Stony Creek near Sinclair (05NG018)	294.7	126.4
Stony Creek near Broomhill (05NG019)	476.3	175.9
Stony Creek near Bede (05NG004)	629.9	223.3
Area Tributary to Stony Creek at the Saskatchewan-Manitoba Boundary	118.1	52.1
Incremental Area in Saskatchewan, Tributary to Stony Creek downstream from the Saskatchewan-Manitoba Boundary	29.3	10.7
Total Area of Stony Creek Basin at the Saskatchewan-Manitoba Boundary	147.4	62.8

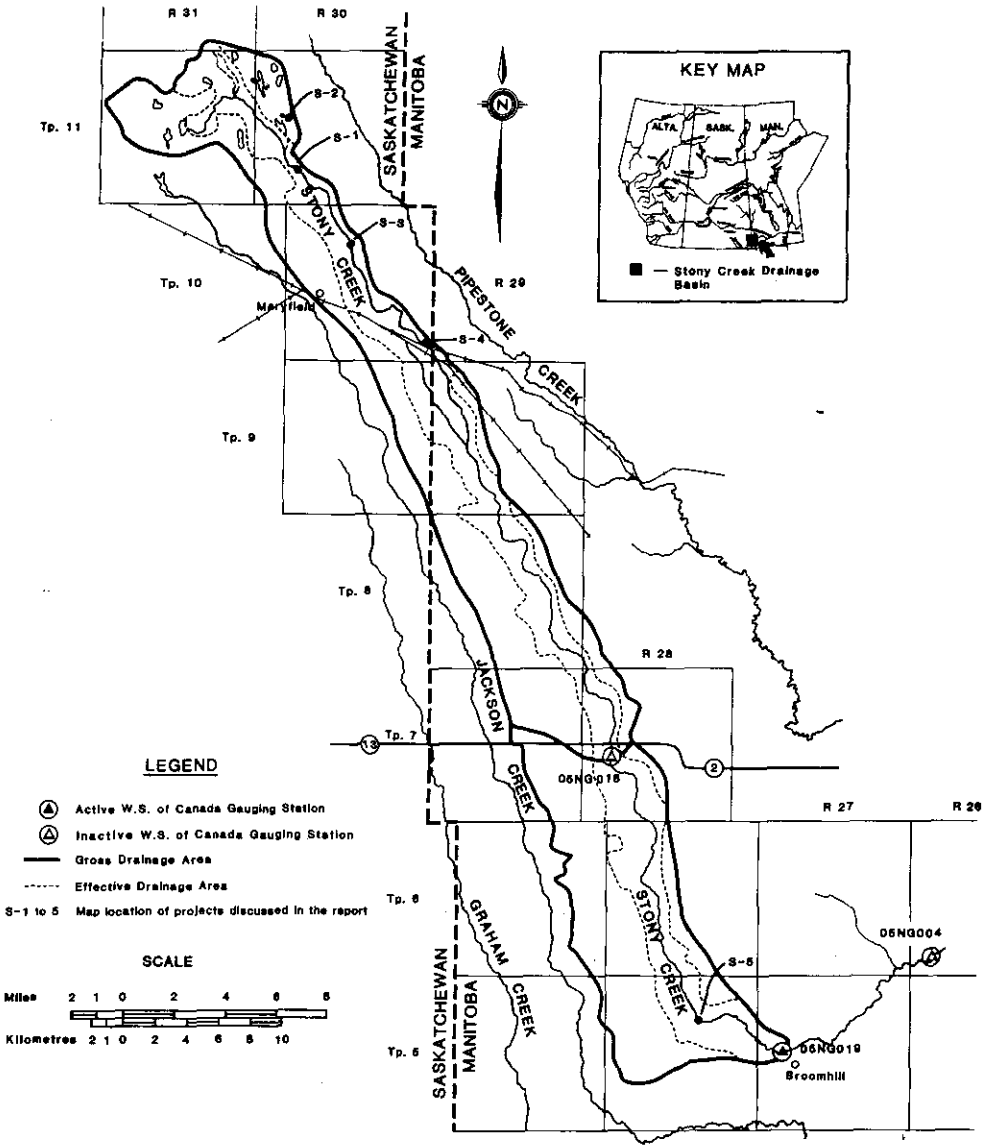

FIGURE 1 LOCATION MAP OF STONY CREEK BASIN