ANNEX 1-A

HYDROLOGY STUDIES
AND
PROPOSED OPERATING PLAN

Xeneca Power Development Inc.

Hydrology Review

For

Serpent River Hydropower Site

H331465
Rev. 0
January 8, 2010

Project Report

January 8, 2010

Xeneca Power Development Inc.
Serpent River
Hydrology Review

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Serpent River
Hydrology Review

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1. Introduction

The objective of this report is to develop flow series for the Serpent River at Four Slide Falls and McCarthy Chute that can be used to assess the hydroelectric generating potential of the sites. Flows in the Serpent River have not been measured or monitored in the past at either site, so long term flow series must be synthesized from flow records at other gauge(s) on the Serpent River and/or on other rivers in the region.

This more comprehensive Hydrology Review supercedes the two previous one for McCarthy Chute and one for Four Slide, previously issued on March 31, 2009.

Figure 1 shows the Serpent River Basin at the two hydropower sites. Figure 2 shows the Serpent River Basin, the locations of Water Survey of Canada (WSC) streamflow gauges and the annual average precipitation distribution in the region.

Flow synthesis generally follows these steps:

- Estimation of the expected mean annual runoff at the site
- Definition of the seasonal flow pattern
- Assessing the variability of runoff from year to year
- Synthesis of a long term daily flow record that meets the above parameters.

2. Mean Annual Runoff

Mean annual runoff (MAR) describes how much of the rainfall and snowmelt in the basin drains past the site on average each year. MAR is usually expressed in units of mm over the drainage basin, for ease of comparison with precipitation (rain and snow) and evaporation, which are also expressed in mm.

The estimation of MAR for an ungauged site depends on the extent of regional information available and whether a water level monitoring gauge has been installed at the site. MAR estimation makes use of the following approaches, depending on the level of information available:

- A regional water balance analysis using precipitation and evapotranspiration data.
- Estimation of the long term average flow (LTAF) at a gauge on the same river.
- Regional runoff trends from a network of established streamflow stations.
- Flow synthesis from the gauged record on the same river.

2.1 Regional Water Balance

Where regional flow data is very limited MAR must be estimated from regional isohyets of equal precipitation and estimates of evapotranspiration, which tends to decrease from south to north across Ontario. MAR is then estimated as the difference between long term average precipitation and evapotranspiration.

The streamflow station network around the Serpent River basin is sufficient to avoid using this simplistic approach directly to estimate the MAR at the two hydropower sites. However, a water balance analysis has been used to model the variation in runoff between existing streamflow stations in the Serpent River region. The resulting, calibrated water balance model was then used to estimate the MAR for the project sites. This is described in Section 2.3.

2.2 Long Term Flow in the Serpent River

Flows have been measured at six Water Survey of Canada (WSC) streamflow stations in the Serpent River basin since 1967. Table 1 shows details of the flow records available at these streamflow stations.

Table 1 Serpent River Streamflow Stations

WSC Gauge No.	Serpent River	Drainage Area (km^2)	Complete Years from	Complete Years to	No. of Years of Record
02CD001	At Highway 17	1350	1967	2005	39
02CD002	At Outlet of Dunlop Lake	112	1978	1992	15
02CD003	Below Quirke Lake	322	1978	1992	15
02CD004	Below Pecors Lake	569	1978	1993	16
02CD005	Rochester Creek above Quirke Lake	99.5	1978	1984	7
02CD006	Above Quirke Lake	157	1978	2005	28

Note: Drainage areas were measured using GIS and differ slightly from WSC values for some gauges.

The six river streamflow records in Table 1 have similar basin characteristics and latitudes and have been included in the flow analysis to provide a comparative evaluation of the impacts of location, drainage area, and natural lake regulation that can be used to understand the variation in runoff and flow patterns across the region.

2.3 Regional Runoff

The runoff estimates at the six regional WSC streamflow gauges were analysed to examine runoff trends in the Serpent River basin. Mean annual runoff estimates were adjusted to the 1967 to 2005 period for which complete flow records are available on the Serpent River at Highway 17 [02CD001]. The estimated mean annual runoffs for this period vary from 465 mm below Quirke Lake [02CD003] to 539 mm above Quirke Lake [02CD006]. Thus runoff in the region is fairly uniform, varying by a maximum of only 14% across the six locations analysed.

A simple water balance model was constructed to explain this variation in runoff. Regional runoff and precipitation, together with estimated evaporation loss have been used to calibrate a water balance model for the region.

Long term runoff can be estimated as:

Runoff = Precipitation – Evaporation Loss

Annual average precipitation over each sub-basin can be estimated from Figure 2. Annual average lake evaporation loss in Ontario is well correlated with latitude, as shown in Appendix B, thus:

Annual average lake evaporation = -36.123*Latitude + 2296.6 mm

Basin wide actual evaporation loss is lower than lake evaporation and varies with land use, lake coverage and precipitation, but, in the long term, can be considered as a constant times lake evaporation for a given ground cover and region, i.e.

Annual average evaporation loss = C * Annual average lake evaporation

By accumulating annual average precipitation and evaporation loss for each river basin the runoff can be calculated. The average runoff at the flow monitoring stations can be computed from the flow records, so the constant C can be computed for each river basin.

Table 2 shows the water balance calibration for rivers in the Serpent River region.

Table 2 Water Balance Calibration for the Serpent River Basin

WSC No.	Years of Record	Drainage Area (km^2)	Annual Average Precipitation (mm)	Mean Annual Runoff (mm)	Evaporation Loss Et (mm)	Basin Latitude (°N)	Lake Evaporation Eo (mm)	"C"
02CD001	39	1350	875	480	395	46.36	622	0.63
02CD002	15	112	890	468	422	46.48	618	0.68
02CD003	15	322	887	465	422	46.51	617	0.68
02CD004	16	569	882	511	371	46.44	619	0.60
02CD005	7	99.5	886	508	378	46.52	616	0.61
02CD006	28	157	888	539	349	46.5	617	0.57
"Years" Weighted Average =								0.63

The annual lake evaporation adjustment factor increases with the density of lake coverage in the river basin, because open water is always available to evaporate whereas evaporation from the ground surface depends on soil moisture content, which depletes through the summer when evaporation potential is highest. Most of rivers in the Serpent River region have medium lake coverage and moderate C values.

The greatest difference in C values is above and below Quirke, demonstrating the greater evaporation losses from lake surfaces. Four Slide Falls site has a drainage area of 593 km^2 and is located a short distance below WSC station 02CD004. Thus the C value for the Four Slide Falls site has assumed to be 0.60, the same as station 02CD004. The McCarthy Chute site has a drainage area of 966 km^2 and is located between stations 02CD004 and 02CD001. The lake coverage between station 02CD004 and McCarthy Chute suggests that the appropriate C value at McCarthy Chute should be between the C values for stations 02CD004 and 02CD001, so a C value of 0.62 was adopted for this site.

Table 3 shows the water balance for the Serpent River at the project sites, based on the above analysis and assumptions.

Table 3 Four Slide Falls and McCarthy Chute Hydropower Sites– Estimated Mean Annual Runoff

Location	Drainage Area (km^2)	Annual Average Precipitation (mm)	Basin Latitude (°N)	Lake Evaporation Eo (mm)	"C"	Evaporation Loss Et (mm)	Mean Annual Runoff (mm)	LTAF (m^3/s)
02CD004	569	882	46.44	619	0.60	371	511	9.22
Four Slide Falls	593	881	46.44	619	0.60	371	510	9.59
McCarthy Chute	966	878	46.41	620	0.62	384	494	15.1
02CD001	1350	875	46.36	622	0.63	395	480	20.5

When the sub-basin areas and MAR values are combined the resulting MAR and LTAF values for the two project sites are:

Four Slide Falls 510 mm and 9.59 m^3/s

McCarthy Chute 494 mm and 15.1 m^3/s

3. Seasonal Flow Pattern

A run-of-river hydroelectric project uses natural river flows, without the benefit of storage regulation through a reservoir. Thus it is important to know not only how much flow passes the dam, but also the distribution and timing of flows. This means that it is important to examine the seasonal flow pattern of streamflow stations that might be considered as a base for simulating a daily flow record at the dam.

Figure 3 shows the seasonal flow patterns for the Serpent River at the Water Survey of Canada streamflow stations. The three gauges above Quirke Lake, the largest water body in the Serpent River basin, show April as the dominant flow month due to snowmelt. However, the two gauges below major lakes, 02CD003 and 02CD004, show significant lake attenuation and the spring peak is spread over April and May. At the mouth of the river, gauge 02CD001, the "flashy" runoff from the less unregulated area below McCarthy Lake restores April to the peak runoff month. Lake storage also means that flows at 02CD004 do not drop as low as at most of the other gauges in late winter and summer months.

The drainage area of the Serpent River at the Four Slide Falls site is only 4.6% larger than at station 02CD004 below Pecors Lake. Thus, the seasonal flow pattern at the Four Slide Falls site is expected to be similar to that below Pecors Lake. The lake coverage in the drainage area between Pecors Lake an McCarthy Chute is similar to that above Pecors Lake, so the seasonal flow pattern at the McCarthy Chute site is also expected to be similar to that at station 02CD004.

4. Annual Flow Variability

The third component of a long term flow record required for generation analysis is flow variability from year to year. The LTAF and the seasonal flow pattern summarize the long term average characteristics of the flow series expected at the dam site. However, these flows will vary from year to year and will influence the generating potential of the site.

Figure 4 shows the variation in mean annual flow for the Serpent River at the gauges in Table 1 from 1967 to 2005, expressed as ratios of the LTAF at each site. For the years when flows are available at all six streamflow stations the annual variation is the same, as would be expected from stations on the same river.

This figure demonstrates the importance of synthesizing a multi-year flow record at the project sites to capture the full range of flow variation that could be expected over the life of the project. The complete records for the period show that sequences of up to three years with below average flow could be expected in the future.

5. Turbinable Flow

The Run-of-River plants proposed for the Serpent River hydropower sites must use river flows as they arrive, without the use of reservoir storage to regulate flows. The principal hydrological tool used to evaluate run-of-river plants is the flow duration curve. This curve ranks all flows from lowest to highest and plots them against the percent of time they are exceeded. This enables the analyst to compute the volume of flow that will pass through the turbine(s) for a given turbine discharge capacity.

Figure 5 shows the flow duration curves for the WSC streamflow stations with flows expressed as ratios of the LTAF at each site.

The similarity in seasonal variation in flows is reflected in the flow duration curves. The natural flow in Rochester Creek [02CD005] shows wider variation than the regulated flows in the Serpent River. The Serpent River below Dunlop Lake at the head of the basin shows evidence of restricted releases, but otherwise the flow duration curves are very similar. Flows are less than the LTAF for $\pm$65% of the year because a large part of the annual runoff is the result of snowmelt, which generally occurs in only two to four months of the year.

The flow duration curves at the two project sites would be expected to have a similar shape to station 02CD004.

6. Long Term Daily Flow Synthesis

Synthesis of a long term daily flow series at an ungauged site requires selection of an historic streamflow record that has the same characteristics as those expected at the dam to prorate to the site. From the above hydrology review the Serpent River below Pecors Lake [02CD004] appears to be the best candidate for a representative from which to synthesize flow series at the project sites.

6.1 WSC Station 02CD004 Flow Extension

Flows were measured at station between 1967 and 1994 but, as Table 4 shows, the streamflow station record at this station is incomplete, with only 16 complete years of record, which would miss the lowest flow cycle on record, from 1998 to 2001. This period is important in considering potential income streams for the project.

Table 4 Mean Monthly Flows (in m^3/s) for the Serpent River below Pecors Lake (02CD004)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1967										2.5	8.7		
1968					15.7	9.7	7.4	5.2	7.5	9.8	7.7		
1969				14.3	18.9	11.4	11.0	6.6					
1970					18.3	28.4	9.8	5.0	5.6	12.1	14.2		
1971						11.2	5.6	3.0	2.0	1.4	1.3		
1972						9.1	3.3	2.5	7.1	5.8	5.5		
1973							6.8	7.1	5.4	2.8	1.7		
1974			Missing Data						1.0	0.4	4.7		
1975													
1976													
1977									0.7	7.6	20.4	16.7	
1978	9.5	5.3	3.8	7.1	21.5	11.7	5.3	3.0	2.9	14.7	10.5	8.0	8.6
1979	6.2	4.9	12.4	35.6	35.9	13.7	11.5	7.3	4.9	6.6	20.1	18.3	14.8
1980	12.2	8.5	5.5	18.1	20.4	8.4	5.0	3.1	2.7	3.1	4.2	4.1	7.9
1981	3.3	3.6	6.8	27.8	14.0	8.9	7.2	3.0	2.0	2.3	2.6	3.0	7.0
1982	3.9	3.3	4.4	18.0	29.0	9.3	4.1	2.2	4.0	11.2	17.7	18.6	10.5
1983	17.0	9.6	10.2	24.5	22.5	19.5	6.1	2.1	1.0	3.1	6.2	9.0	10.9
1984	7.6	6.4	6.7	15.3	13.9	8.5	5.9	3.8	4.2	5.4	17.2	17.2	9.3
1985	13.2	7.7	7.8	22.4	30.7	11.1	5.4	4.4	3.6	3.9	8.5	10.7	10.8
1986	6.6	4.9	5.3	19.5	14.2	8.1	4.9	4.8	4.4	6.7	7.4	5.5	7.7
1987	4.4	3.9	4.4	10.1	7.4	5.9	4.2	1.8	0.7	0.6	1.2	4.0	4.0
1988	5.8	5.5	5.0	32.2	19.8	8.1	2.7	2.1	2.1	6.5	28.1	24.1	11.8
1989	12.1	7.1	5.4	16.3	21.4	10.2	4.7	1.5	0.4	0.1	0.9	1.7	6.8
1990	2.6	3.1	7.3	14.2	18.5	13.7	8.3	3.9	1.5	2.3	6.2	12.8	7.9
1991	7.7	5.0	6.5	29.5	19.6	6.5	2.5	1.4	1.0	3.9	13.8	18.2	9.6
1992	11.5	7.1	6.1	13.0	23.3	7.7	4.4	3.3	6.9	8.8	13.3	14.0	10.0
1993	9.8	6.3	4.4	14.4	25.3	17.6	10.8	5.3	5.4	11.9	14.1	13.2	11.6
1994	8.8	6.6	6.1	10.5	16.9	10.6	7.5	4.2	4.9				
Mean	8.4	5.8	6.4	19.0	20.4	11.3	6.3	3.8	3.4	5.6	9.8	11.7	9.3

To overcome these gaps in the 02CD004 record and extend the record it was decided to synthesize daily flows for the missing periods from the 02CD001 flow records continuously available during the 39-year period 1967-2005.

The drainage area of 02CD004 the Serpent River below Pecors Lake is 42% of the drainage area at 02CD001 the Serpent River at Highway 17. Inflows between Pecors Lake and Highway 17 are less attenuated by large lakes than at 02CD004 and are therefore more responsive and “peaky” than the flows at 04CD004. As a result a direct comparison of daily flows at the two streamflow stations does not result in meaningful correlations.

The effect of lake attenuation on the timing of flows was largely removed by comparing flows on a monthly basis. A multiple linear regression analysis was undertaken between mean monthly flows, month by month, yielding twelve regression equations of the form:

$$02CD004 = a.02CD001 + b$$

The multiple regression coefficients [R] for these twelve monthly equations varied from 0.85 in August to 0.96 in January, with an average of 0.91; so the fitted equations have a good level of significance.

These equations were applied on a daily basis to infill missing values and extend the flow series below Pecors Lake to 39 years, 1967-2005. Using the monthly equations on a daily basis will not capture the variable lag times between the gauges and may not correspond exactly to the timing of the missing flows. However, a shift of a few days is not important in generation analysis.

The infilled flow record for the Serpent River below Pecors Lake shown in Table 5 has a LTAF of 9.22 m^3/s and an MAR of 511 mm, the same as the MAR in Table 1.

Table 5 Infilled and Extended Mean Monthly Flows for the Serpent River below Pecors Lake (02CD004)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1967	11.5	8.1	5.3	29.1	45.1	11.9	5.2	3.6	2.0	2.5	8.7	11.5	12.1
1968	10.6	6.6	5.4	18.5	15.7	9.7	7.4	5.2	7.5	9.8	7.7	10.0	9.5
1969	10.4	10.5	5.8	14.3	18.9	11.4	11.0	6.6	2.3	4.6	11.7	9.4	9.7
1970	6.0	4.5	4.3	9.1	18.3	28.4	9.8	5.0	5.6	12.1	14.2	16.7	11.2
1971	9.1	6.5	6.7	20.4	29.3	11.2	5.6	3.0	2.0	1.4	1.3	12.6	9.1
1972	9.4	7.1	5.6	18.4	50.3	9.1	3.3	2.5	7.1	5.8	5.5	5.3	10.8
1973	8.2	8.7	9.8	13.5	23.4	10.8	6.8	7.1	5.4	2.8	1.7	5.7	8.7
1974	7.1	6.6	4.8	20.1	25.4	11.8	6.7	2.4	1.0	0.4	4.7	5.7	8.1
1975	8.1	7.5	5.1	13.1	36.2	15.7	10.0	3.0	1.2	0.5	1.9	10.7	9.4
1976	6.6	5.1	5.3	27.8	22.2	8.1	3.2	1.2	0.4	0.2	0.3	1.0	6.8
1977	1.2	1.3	6.9	23.1	13.4	5.1	1.8	0.6	0.7	7.6	20.4	16.7	8.2
1978	9.5	5.3	3.8	7.1	21.5	11.7	5.3	3.0	2.9	14.7	10.5	8.0	8.6
1979	6.2	4.9	12.4	35.6	35.9	13.7	11.5	7.3	4.9	6.6	20.1	18.3	14.8
1980	12.2	8.5	5.5	18.1	20.4	8.4	5.0	3.1	2.7	3.1	4.2	4.1	7.9
1981	3.3	3.6	6.8	27.8	14.0	8.9	7.2	3.0	2.0	2.3	2.6	3.0	7.0
1982	3.9	3.3	4.4	18.0	29.0	9.3	4.1	2.2	4.0	11.2	17.7	18.6	10.5
1983	17.0	9.6	10.2	24.5	22.5	19.5	6.1	2.1	1.0	3.1	6.2	9.0	10.9
1984	7.6	6.4	6.7	15.3	13.9	8.5	5.9	3.8	4.2	5.4	17.2	17.2	9.3
1985	13.2	7.7	7.8	22.4	30.7	11.1	5.4	4.4	3.6	3.9	8.5	10.7	10.8
1986	6.6	4.9	5.3	19.5	14.2	8.1	4.9	4.8	4.4	6.7	7.4	5.5	7.7
1987	4.4	3.9	4.4	10.1	7.4	5.9	4.2	1.8	0.7	0.6	1.2	4.0	4.0
1988	5.8	5.5	5.0	32.2	19.8	8.1	2.7	2.1	2.1	6.5	28.1	24.1	11.8
1989	12.1	7.1	5.4	16.3	21.4	10.2	4.7	1.5	0.4	0.2	0.9	1.7	6.8
1990	2.6	3.1	7.3	14.2	18.5	13.7	8.3	3.9	1.5	2.3	6.2	12.8	7.9
1991	7.7	5.0	6.5	29.5	19.6	6.5	2.5	1.4	1.0	3.9	13.8	18.2	9.6
1992	11.5	7.1	6.1	13.0	23.3	7.7	4.4	3.3	6.9	8.8	13.3	14.0	10.0
1993	9.8	6.3	4.4	14.4	25.3	17.6	10.8	5.3	5.4	11.9	14.1	13.2	11.6
1994	8.8	6.6	6.1	10.5	16.9	10.6	7.5	4.2	4.9	4.5	7.5	8.4	8.1
1995	6.9	4.9	5.8	12.6	28.7	17.4	7.0	4.3	5.5	4.3	11.6	9.2	9.9
1996	7.9	9.9	5.7	15.1	38.3	14.8	7.6	11.3	10.1	9.6	12.5	15.0	13.2
1997	11.5	8.9	5.6	22.1	40.1	10.6	4.8	2.5	1.6	0.9	5.3	4.5	9.9
1998	3.7	3.6	4.6	22.6	9.1	8.6	5.8	2.1	1.0	1.4	5.3	9.6	6.4
1999	8.7	11.1	5.9	12.8	7.9	6.4	4.6	3.1	1.3	1.1	2.0	4.9	5.8
2000	7.1	6.2	10.1	8.3	6.7	5.1	2.4	1.3	0.5	0.2	0.4	1.1	4.1
2001	1.9	2.6	4.6	26.6	23.5	11.6	3.4	1.3	3.9	15.4	18.7	20.6	11.2
2002	11.2	6.8	7.7	23.8	27.6	12.1	5.6	3.0	1.3	3.4	4.2	6.5	9.4
2003	6.1	3.6	4.7	14.2	23.6	16.7	6.3	4.6	3.8	7.2	22.6	23.6	11.5
2004	9.7	4.9	5.9	19.3	31.8	16.3	10.3	4.0	1.8	2.5	8.6	15.5	10.9
2005	13.2	8.6	4.8	13.9	10.4	5.3	2.3	1.6	0.7	0.4	3.3	10.1	6.2
Mean	8.2	6.2	6.1	18.6	23.1	11.2	5.9	3.5	3.1	4.9	9.0	10.7	9.2

6.2 Flow Series Synthesis at the Project Sites

Having infilled and extended the daily flow series for the Serpent River below Pecors Lake [02CD004] to 39 years from 1967 to 2005, it was then used to synthesize daily flow series at each hydropower project site by pro-rating by the ratio of the LTAF, i.e.

Daily flow at Four Slide Falls = 9.59/9.22 x Daily flow at station 02CD004

and

Daily flow at McCarthy Chute = 15.1/9.22 x Daily flow at station 02CD004

Before the flows were synthesized using the infilled and extended 02CD004 record it was screened for statistical stationarity using DATSCRN, a software package from the International Institute for Land Reclamation and Improvement (ILRI), Wagenigan, The Netherlands, 1991. The 1967 - 2005 period does not exhibit any non-stationary at the 5% significance level, and can be considered representative of flows in the Serpent River.

7. Results

The principal output of this hydrology review is a 39-year, daily flow series that can be used in the generation potential analysis of Four Slide Falls and McCarthy Chute hydropower projects. These datasets are too large to include in this report, but the following characteristics of the flow series are reproduced here to confirm their adherence to the objectives stated throughout the report:

- Table 6 A monthly flow summary table at Four Slide Falls
- Table 7 A monthly flow summary table at McCarthy Chute
- Figure 6 Seasonal flow patterns at the project sites
- Figure 7 An annual flow variation diagram for the project sites
- Figure 8 Daily flow duration curves for the project sites.

In addition to the above Hatch has prepared Flow Metrics for the Four Slide Falls and McCarthy Chute sites using the synthesized 39-year daily flow series.

The Flow Metrics sheets have been attached as Appendix A. The relationship between average annual lake evaporation and latitude in Ontario is presented in Appendix B.

Note: The flow series derived for the project site is intended for generation potential analysis and should not be used for final flood design or low flow evaluations. Detailed flood and low flow analyses should be undertaken at the project design stage.

8. Conclusions and Recommendations

This detailed Hydrology Review confirms the previous estimates of the hydrologic resource at the McCarthy Chute and Four Slide sites.

No additional analyses are recommended at this time in support of the energy generation analysis for the McCarthy Chute and Four Slide sites.

As noted in Section 7, detailed flood and low flow analyses should be undertaken in the Environmental Assessment and Design Phases of the project.

Table 6 Synthesized Mean Monthly Flows (in m^3/s) in the Serpent River at Four Slide Falls

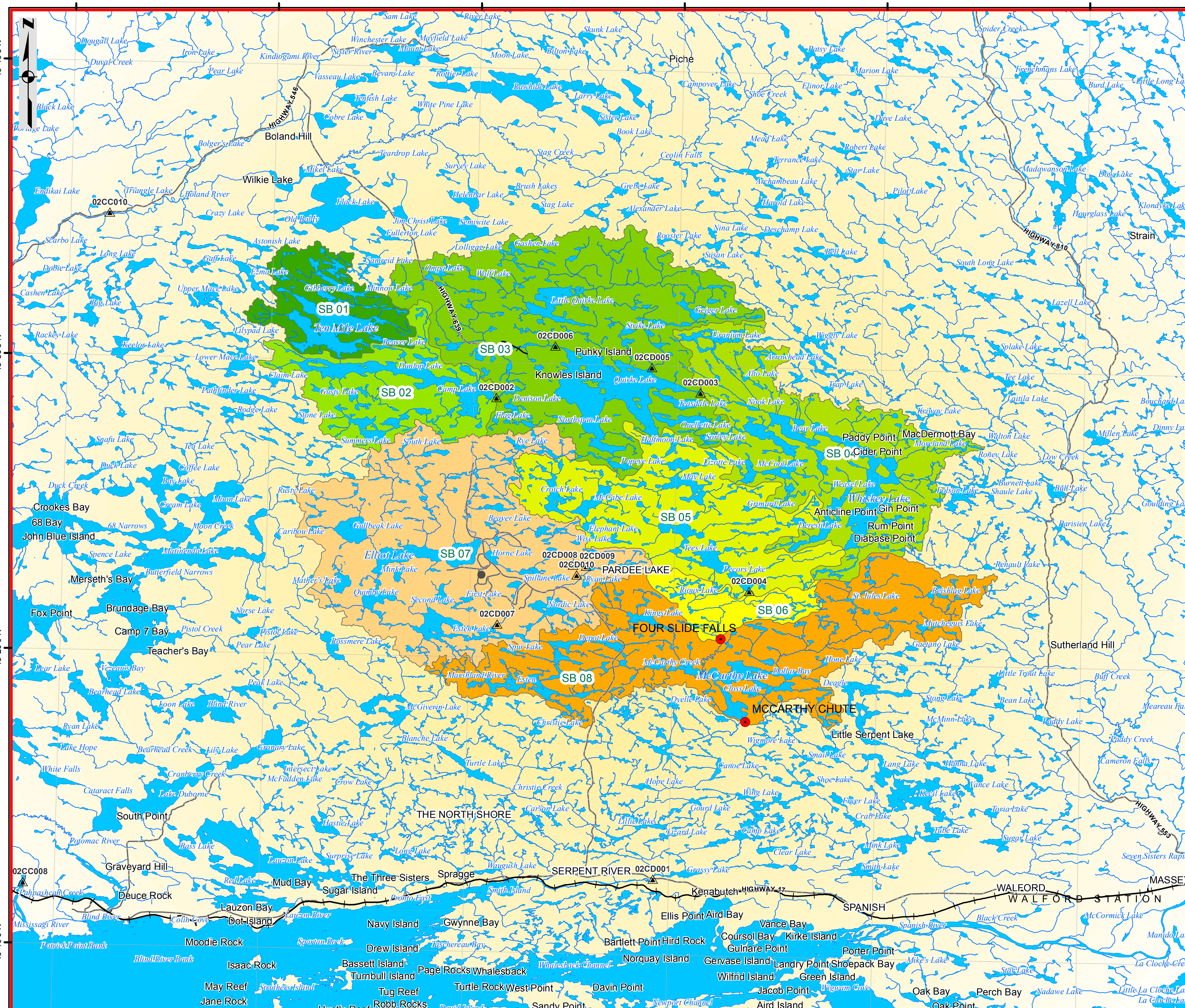
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1967	11.9	8.5	5.5	30.2	46.9	12.4	5.4	3.8	2.1	2.6	9.0	12.0	12.6
1968	11.0	6.9	5.6	19.2	16.4	10.1	7.7	5.4	7.8	10.2	8.0	10.4	9.9
1969	10.8	10.9	6.0	14.9	19.6	11.9	11.5	6.8	2.4	4.7	12.2	9.8	10.1
1970	6.3	4.7	4.5	9.4	19.1	29.5	10.2	5.2	5.8	12.6	14.8	17.3	11.6
1971	9.5	6.8	6.9	21.2	30.5	11.7	5.8	3.1	2.1	1.5	1.4	13.1	9.5
1972	9.8	7.4	5.8	19.1	52.3	9.5	3.4	2.6	7.4	6.1	5.7	5.6	11.2
1973	8.5	9.0	10.2	14.0	24.3	11.2	7.1	7.4	5.6	2.9	1.8	5.9	9.0
1974	7.4	6.9	5.0	20.9	26.4	12.2	7.0	2.5	1.0	0.4	4.9	5.9	8.4
1975	8.4	7.8	5.3	13.6	37.6	16.3	10.4	3.1	1.3	0.5	2.0	11.1	9.8
1976	6.8	5.3	5.5	28.9	23.1	8.5	3.3	1.2	0.4	0.2	0.3	1.1	7.0
1977	1.2	1.3	7.2	24.0	13.9	5.3	1.9	0.6	0.7	7.9	21.2	17.3	8.6
1978	9.9	5.5	3.9	7.4	22.4	12.2	5.5	3.1	3.0	15.3	10.9	8.3	9.0
1979	6.4	5.1	12.9	37.0	37.3	14.3	11.9	7.5	5.1	6.8	20.9	19.0	15.4
1980	12.7	8.9	5.7	18.8	21.2	8.8	5.2	3.2	2.8	3.2	4.4	4.2	8.2
1981	3.4	3.8	7.1	28.9	14.6	9.3	7.5	3.1	2.0	2.4	2.7	3.1	7.3
1982	4.1	3.5	4.5	18.7	30.2	9.7	4.3	2.2	4.1	11.7	18.4	19.3	10.9
1983	17.7	10.0	10.6	25.5	23.3	20.3	6.4	2.2	1.1	3.2	6.5	9.3	11.3
1984	7.9	6.7	7.0	15.9	14.5	8.8	6.2	3.9	4.4	5.6	17.9	17.9	9.7
1985	13.7	8.0	8.1	23.3	31.9	11.6	5.7	4.5	3.8	4.1	8.9	11.2	11.2
1986	6.9	5.1	5.5	20.3	14.8	8.5	5.1	5.0	4.6	7.0	7.7	5.7	8.0
1987	4.6	4.0	4.6	10.5	7.7	6.2	4.4	1.8	0.7	0.6	1.2	4.1	4.2
1988	6.0	5.7	5.2	33.5	20.6	8.4	2.8	2.2	2.2	6.8	29.2	25.0	12.3
1989	12.6	7.3	5.6	16.9	22.2	10.6	4.9	1.6	0.4	0.2	0.9	1.8	7.1
1990	2.7	3.2	7.6	14.8	19.2	14.2	8.6	4.0	1.6	2.4	6.4	13.4	8.2
1991	8.0	5.2	6.8	30.7	20.4	6.7	2.6	1.5	1.1	4.1	14.3	18.9	10.0
1992	12.0	7.3	6.3	13.5	24.2	8.0	4.6	3.4	7.2	9.1	13.9	14.6	10.4
1993	10.2	6.5	4.6	15.0	26.3	18.3	11.2	5.5	5.6	12.4	14.6	13.8	12.0
1994	9.2	6.9	6.4	10.9	17.6	11.0	7.8	4.4	5.1	4.7	7.8	8.7	8.4
1995	7.1	5.1	6.1	13.2	29.9	18.1	7.3	4.4	5.8	4.5	12.0	9.5	10.3
1996	8.2	10.3	5.9	15.7	39.8	15.4	7.9	11.8	10.5	10.0	13.0	15.6	13.7
1997	11.9	9.2	5.8	23.0	41.7	11.1	5.0	2.6	1.7	1.0	5.5	4.7	10.3
1998	3.9	3.7	4.8	23.5	9.4	8.9	6.1	2.1	1.1	1.5	5.5	10.0	6.7
1999	9.1	11.6	6.1	13.3	8.2	6.7	4.7	3.2	1.4	1.1	2.1	5.1	6.0
2000	7.3	6.4	10.5	8.6	7.0	5.3	2.5	1.4	0.5	0.2	0.5	1.1	4.3
2001	1.9	2.7	4.8	27.6	24.5	12.1	3.6	1.3	4.1	16.0	19.4	21.4	11.6
2002	11.7	7.1	8.0	24.7	28.7	12.6	5.9	3.1	1.3	3.6	4.3	6.7	9.8
2003	6.3	3.7	4.9	14.8	24.5	17.4	6.6	4.8	4.0	7.5	23.5	24.5	11.9
2004	10.1	5.1	6.2	20.1	33.0	17.0	10.7	4.2	1.9	2.6	8.9	16.1	11.4
2005	13.8	8.9	5.0	14.5	10.8	5.6	2.4	1.7	0.8	0.4	3.4	10.5	6.5
Mean	8.5	6.5	6.4	19.4	24.0	11.7	6.2	3.6	3.2	5.1	9.4	11.1	9.6

Table 7 Synthesized Mean Monthly Flows (in m^3/s) in the Serpent River at McCarthy Chute

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
1967	18.8	13.3	8.7	47.7	73.9	19.5	8.5	5.9	3.3	4.1	14.2	18.9	19.8
1968	17.4	10.9	8.8	30.2	25.8	15.9	12.1	8.5	12.3	16.1	12.6	16.4	15.6
1969	17.1	17.1	9.5	23.5	30.9	18.7	18.1	10.7	3.7	7.5	19.2	15.4	15.9
1970	9.9	7.5	7.1	14.9	30.1	46.5	16.0	8.2	9.1	19.8	23.2	27.3	18.3
1971	15.0	10.7	10.9	33.4	48.0	18.4	9.1	5.0	3.3	2.3	2.1	20.6	14.9
1972	15.4	11.7	9.1	30.1	82.5	14.9	5.4	4.1	11.7	9.6	9.0	8.8	17.7
1973	13.4	14.2	16.1	22.1	38.3	17.7	11.1	11.6	8.8	4.6	2.9	9.3	14.2
1974	11.7	10.8	7.9	33.0	41.6	19.3	11.0	4.0	1.6	0.7	7.7	9.3	13.2
1975	13.3	12.3	8.3	21.5	59.3	25.7	16.4	4.9	2.0	0.8	3.1	17.5	15.5
1976	10.8	8.4	8.6	45.6	36.4	13.3	5.2	1.9	0.6	0.3	0.5	1.7	11.1
1977	2.0	2.1	11.3	37.9	21.9	8.4	3.0	0.9	1.1	12.4	33.4	27.3	13.5
1978	15.6	8.7	6.2	11.7	35.3	19.2	8.6	4.9	4.8	24.1	17.2	13.1	14.2
1979	10.1	8.1	20.3	58.3	58.8	22.5	18.8	11.9	8.0	10.8	33.0	30.0	24.3
1980	20.0	14.0	9.0	29.6	33.4	13.8	8.2	5.0	4.4	5.0	6.9	6.7	13.0
1981	5.3	5.9	11.1	45.6	23.0	14.6	11.8	4.9	3.2	3.7	4.2	4.9	11.5
1982	6.4	5.5	7.2	29.5	47.6	15.2	6.8	3.5	6.5	18.4	29.0	30.5	17.2
1983	27.9	15.8	16.7	40.1	36.8	32.0	10.0	3.4	1.7	5.1	10.2	14.7	17.9
1984	12.4	10.5	11.1	25.0	22.8	13.9	9.7	6.2	6.9	8.9	28.2	28.3	15.3
1985	21.6	12.6	12.8	36.8	50.3	18.2	8.9	7.1	6.0	6.5	14.0	17.6	17.7
1986	10.9	8.1	8.7	31.9	23.3	13.3	8.0	7.8	7.2	11.0	12.2	9.0	12.6
1987	7.2	6.4	7.3	16.5	12.2	9.7	6.9	2.9	1.2	1.0	1.9	6.5	6.6
1988	9.5	9.0	8.2	52.8	32.5	13.2	4.4	3.5	3.5	10.7	46.1	39.5	19.3
1989	19.9	11.6	8.8	26.7	35.0	16.7	7.7	2.5	0.7	0.3	1.5	2.8	11.2
1990	4.3	5.0	12.0	23.3	30.2	22.5	13.6	6.3	2.5	3.8	10.1	21.0	12.9
1991	12.7	8.1	10.7	48.4	32.2	10.6	4.1	2.3	1.7	6.5	22.6	29.8	15.8
1992	18.9	11.6	9.9	21.3	38.2	12.6	7.2	5.3	11.3	14.3	21.9	23.0	16.3
1993	16.1	10.3	7.3	23.6	41.5	28.9	17.7	8.7	8.8	19.5	23.1	21.7	19.0
1994	14.5	10.8	10.0	17.1	27.8	17.4	12.2	6.9	8.0	7.4	12.3	13.8	13.2
1995	11.3	8.0	9.5	20.7	47.1	28.5	11.4	7.0	9.1	7.1	19.0	15.0	16.2
1996	12.9	16.3	9.3	24.7	62.7	24.3	12.4	18.6	16.5	15.7	20.5	24.6	21.6
1997	18.8	14.5	9.2	36.2	65.7	17.4	7.9	4.1	2.6	1.5	8.6	7.4	16.2
1998	6.1	5.8	7.6	37.1	14.9	14.1	9.5	3.4	1.7	2.3	8.6	15.8	10.6
1999	14.3	18.2	9.6	20.9	13.0	10.6	7.5	5.1	2.1	1.8	3.3	8.1	9.5
2000	11.6	10.2	16.5	13.6	11.1	8.4	3.9	2.1	0.8	0.4	0.7	1.7	6.7
2001	3.1	4.3	7.6	43.6	38.6	19.0	5.6	2.1	6.4	25.2	30.6	33.8	18.4
2002	18.4	11.2	12.6	38.9	45.3	19.8	9.2	4.9	2.1	5.6	6.8	10.6	15.5
2003	9.9	5.9	7.7	23.3	38.6	27.4	10.4	7.6	6.3	11.7	37.1	38.6	18.8
2004	16.0	8.1	9.7	31.7	52.1	26.7	16.9	6.6	3.0	4.1	14.1	25.4	17.9
2005	21.7	14.0	7.9	22.8	17.1	8.7	3.7	2.6	1.2	0.7	5.4	16.5	10.2
Mean	13.4	10.2	10.0	30.6	37.8	18.4	9.7	5.7	5.0	8.0	14.8	17.5	15.1

Mark Orton
MO:ll

FIGURES



NOTES:

1. MAPPING INFORMATION SHOWN ON THE DRAWING HAS BEEN DERIVED FROM THE DIGITAL DATA FROM MNR DATABASE
2. PROJECTED COORDINATE SYSTEM IS NAD 1983, UTM ZONE 17N.

LEGEND

- WATER BODIES
- SUB-BASINS
- PROJECT(S) LOCATION
- GAUGING STATION

SUB BASIN ID	DRAINAGE	AREA (km^2)
SB 01	TEN MILE LAKE	46
SB 02	DUNLOP LAKE; GAUGE 02CD002	66
SB 03	QUIRKE LAKE; GAUGE 02CD003	210
SB 04	WHISKEY LAKE	133
SB 05	PECORS LAKE; GAUGE 02CD004	114
SB 06	FOUR SLIDE FALLS	24
SB 07	ELLIOT LAKE	206
SB 08	MCCARTHY CHUTE	167

DRAINAGE AREA SUMMARY:

LOCATION	AREA (km^2)
GAUGE 02CD002	112
GAUGE 02CD003	322
GAUGE 02CD004	569
FOUR SLIDE FALLS	593
MCCARTHY CHUTE	966

Xeneca Power Development Inc.

0 1 : 250,000 10 Kms

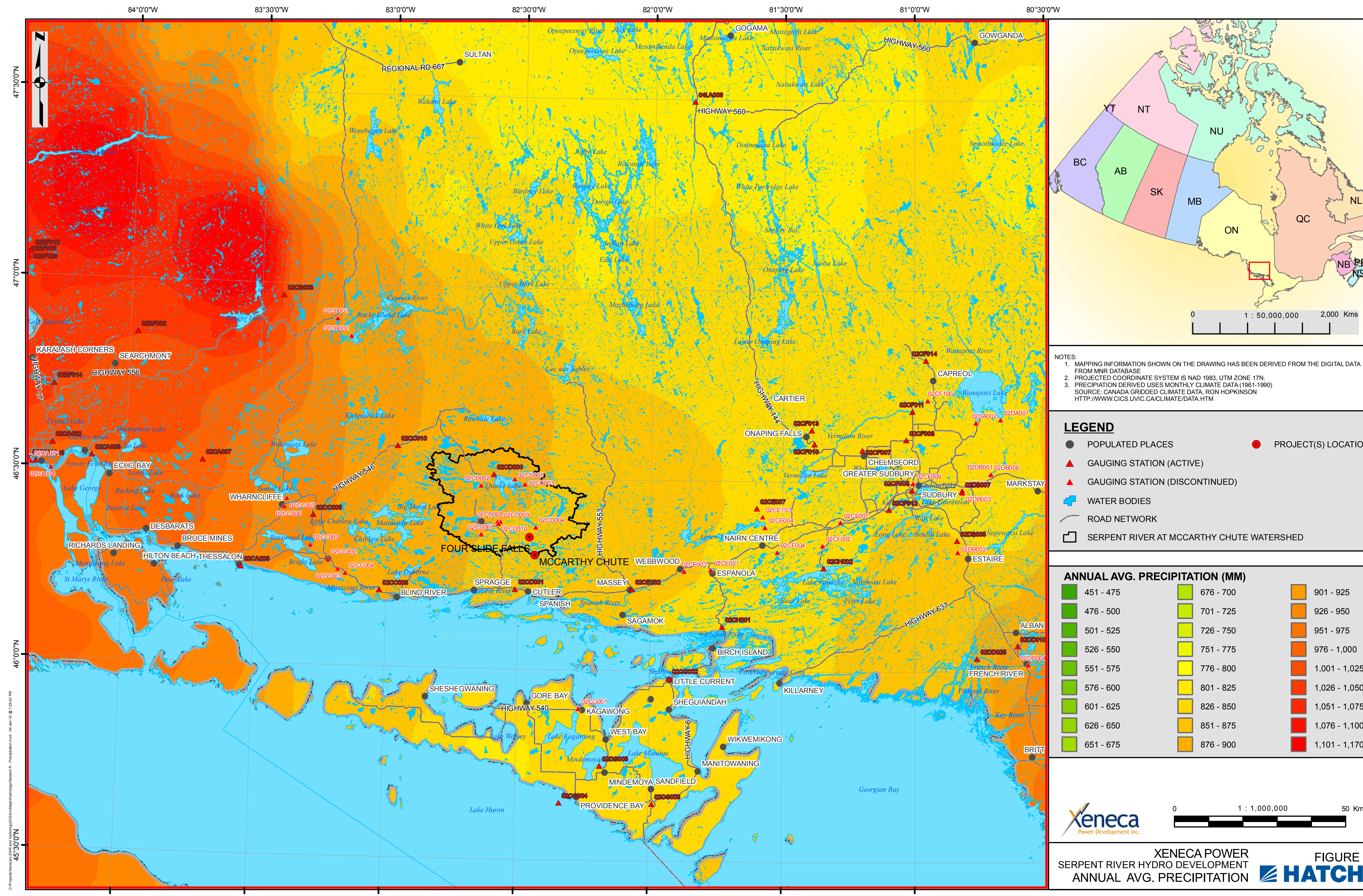
XENECA POWER

SERPENT RIVER HYDRO DEVELOPMENT

MCCARTHY CHUTE WATERSHED

FIGURE 1

HATCH



XENECA POWER
SERPENT RIVER HYDRO DEVELOPMENT
ANNUAL AVG. PRECIPITATION

FIGURE 2

HATCH

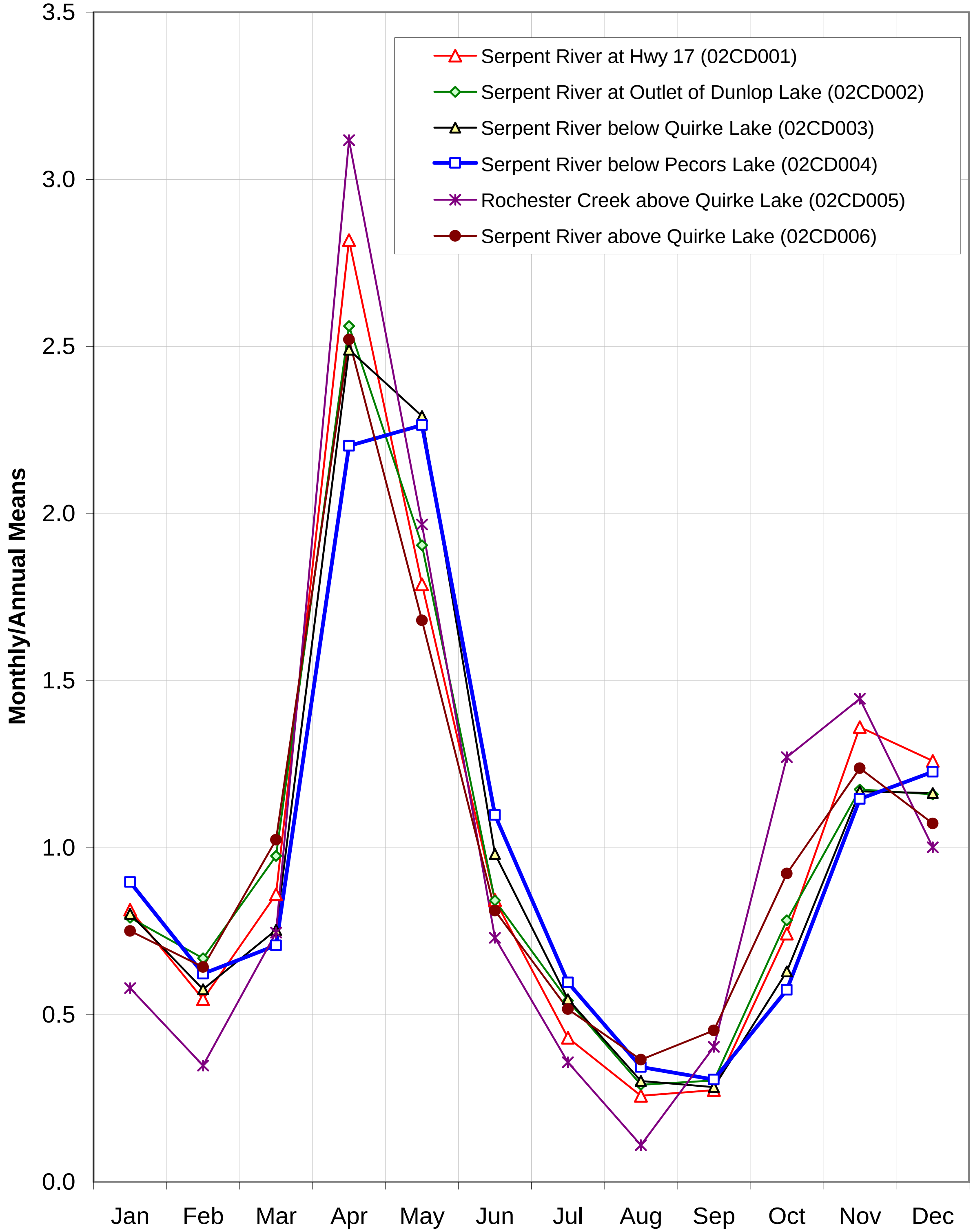


Figure 3
Xeneca Power
Serpent River Hydro Development
Seasonal Flow Patterns

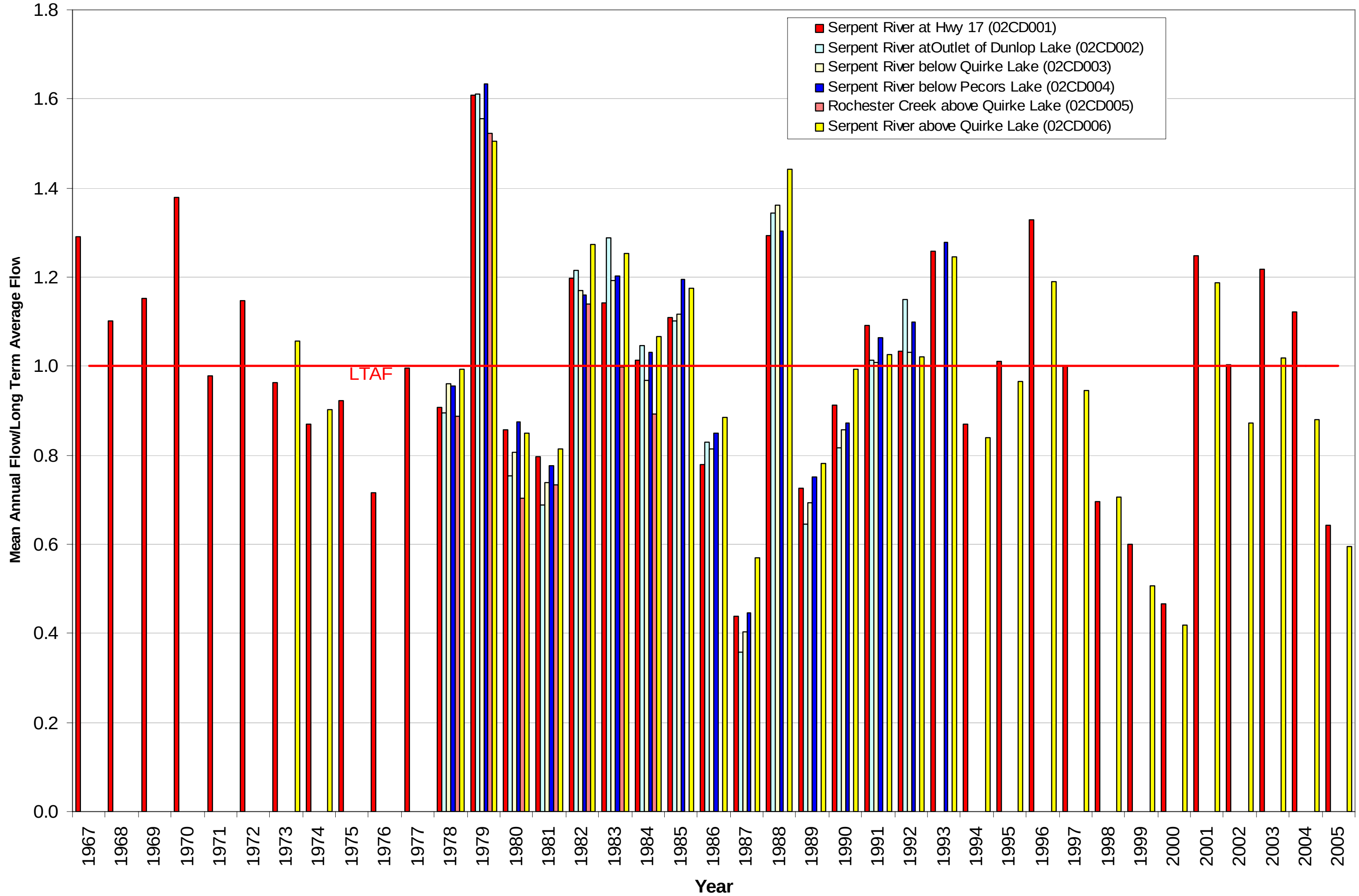


Figure 4
Xeneca Power
Serpent River Hydro Development
Annual Flow Variability

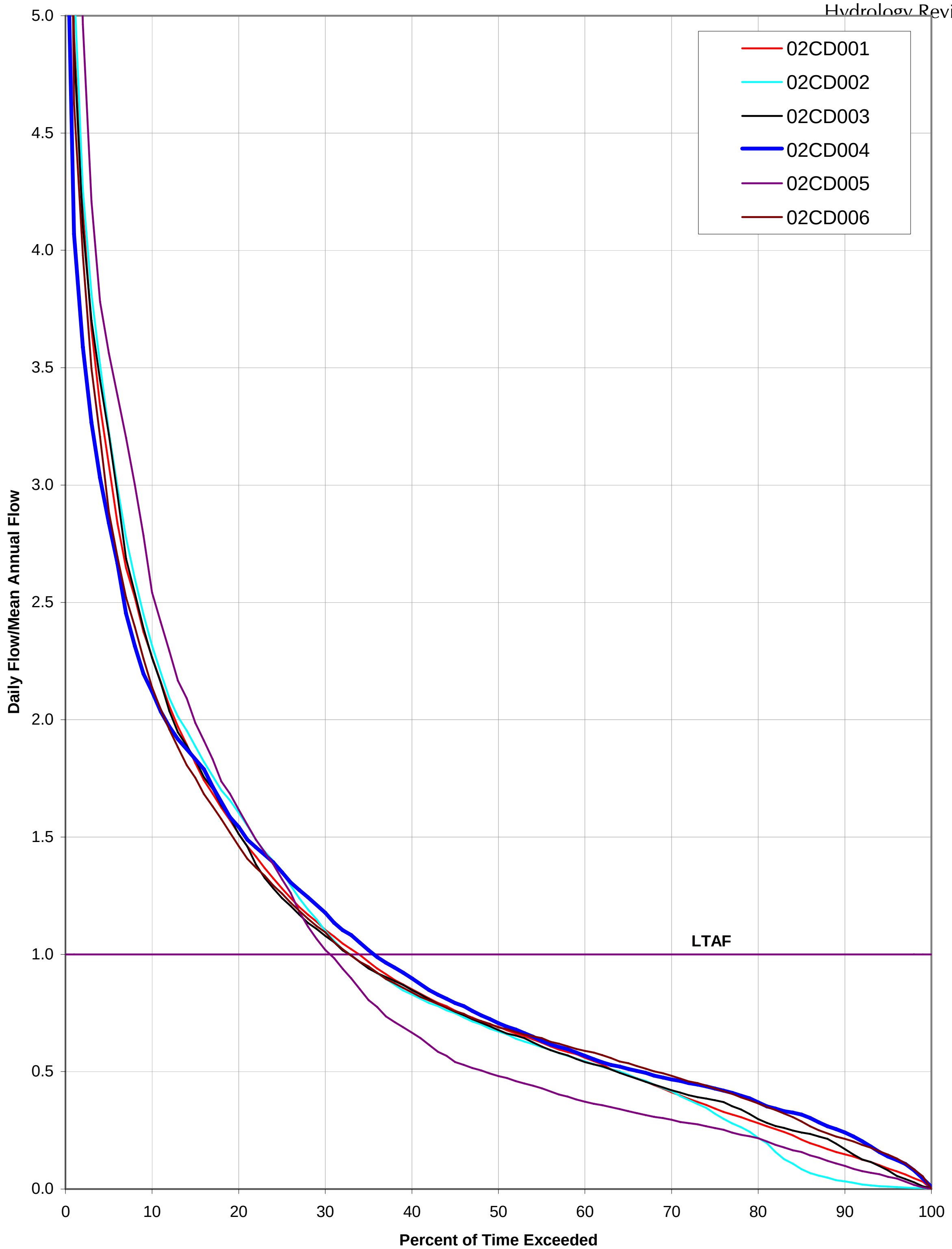


Figure 5
Xeneca Power
Serpent River Hydro Development
Flow Duration Curves

HATCH™

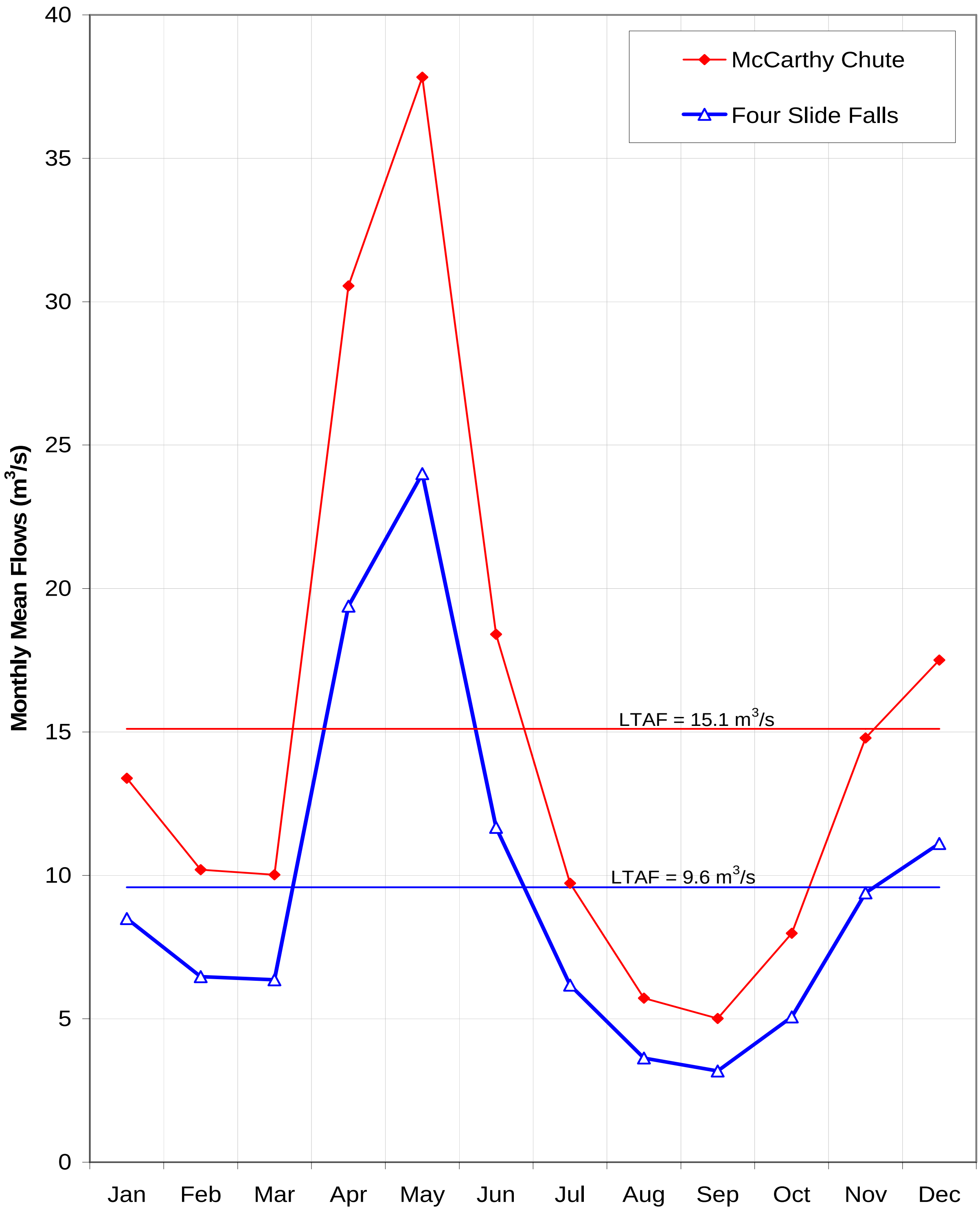


Figure 6
Xeneca Power
Serpent River Hydro Development
Serpent River at Project Sites - Seasonal Flow Patterns

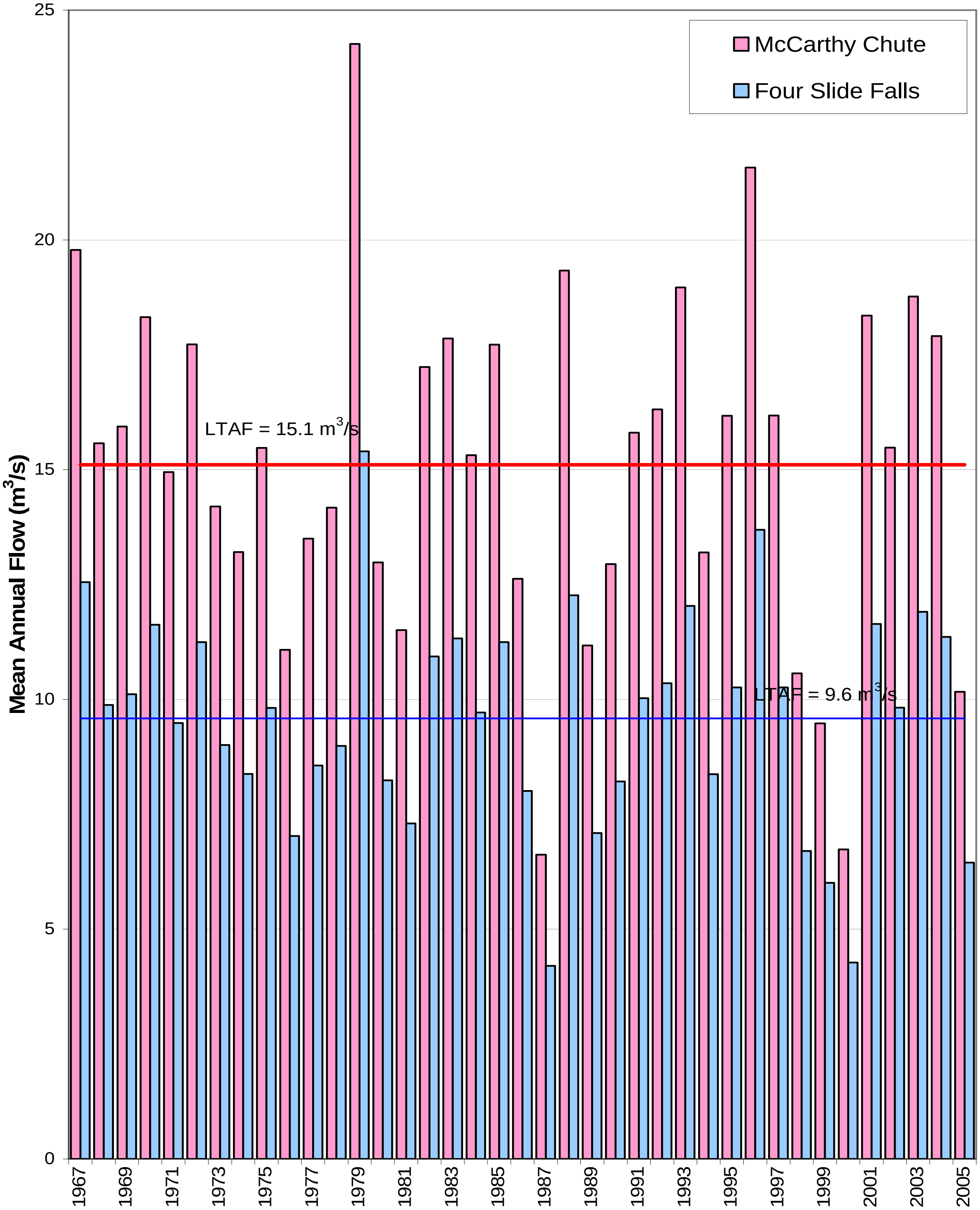
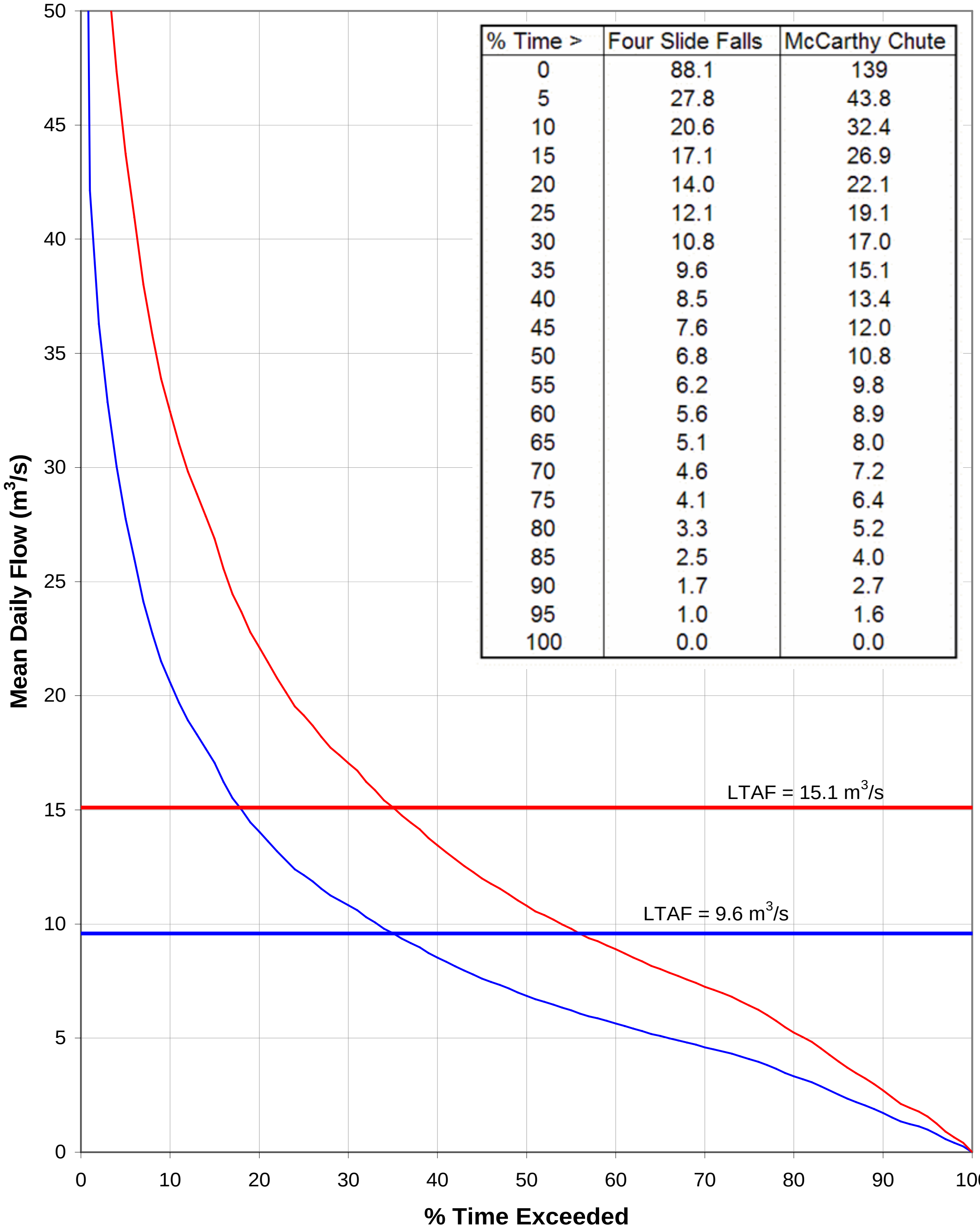


Figure 7
Xeneca Power
Serpent River Hydro Development
Serpent River at Project Sites - Annual Flow Variability



% Time >	Four Slide Falls	McCarthy Chute
0	88.1	139
5	27.8	43.8
10	20.6	32.4
15	17.1	26.9
20	14.0	22.1
25	12.1	19.1
30	10.8	17.0
35	9.6	15.1
40	8.5	13.4
45	7.6	12.0
50	6.8	10.8
55	6.2	9.8
60	5.6	8.9
65	5.1	8.0
70	4.6	7.2
75	4.1	6.4
80	3.3	5.2
85	2.5	4.0
90	1.7	2.7
95	1.0	1.6
100	0.0	0.0

Figure 8
Xeneca Power
Serpent River Hydro Development
Serpent River at Project Sites - Daily Flow Duration Curves

APPENDIX A
Flow Metrics

FOUR SLIDE FALLS - SERPENT
FLOW METRICS DATA SHEET

STATION INFORMATION

SITE ID	2CD14
RIVER NAME	SERPENT
SITE NAME	FOUR SLIDE FALLS
REGION	NORTHEAST
DISTRICT	SAULT STE. MARIE
DRAINAGE AREA	593 km^2
OWNER	XENECA

Flow metrics are provided for the potential waterpower site based on flows from WSC station 02CD004 (infilled and extended). Metrics are based on WSC flows from 1967 to 2005 (39 years).

The flow record for the site has been synthesized by infilling gauge flows to 1967-2005 from 02CD001 and prorating LTAF between 02CD004 (A = 569 km^2) and 02CD001 (A = 1350 km^2) for the site (A = 593 km^2). Other descriptive metrics have been included in the data sheet to provide a more complete description of the ranges of streamflow on the river system and to facilitate comparisons between river

Annual (1967 - 2005):

I. Streamflow Time Series

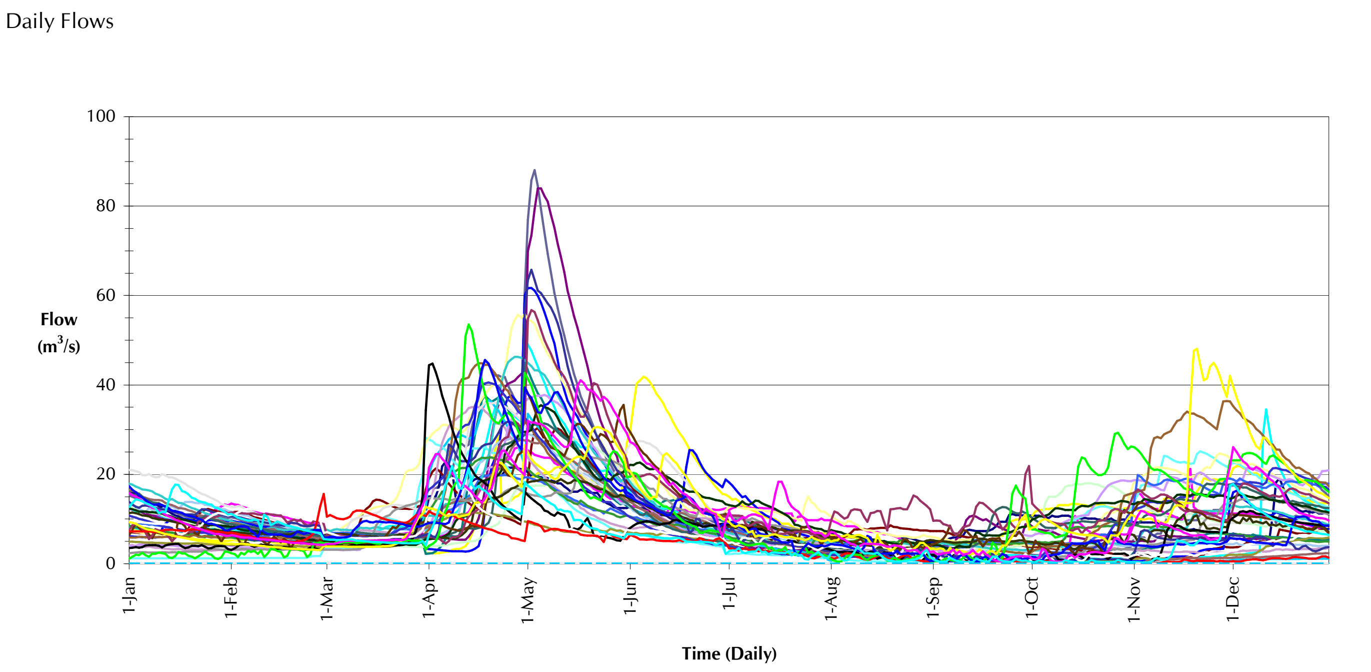


Figure 1 : Annual Daily flow hydrographs from 1967 to 2005.

Table 1 : Annual flow metrics based on 39 years of data.

Descriptive Metric		
Mean Annual Flow	9.59	m^3/s
20% Time Exceeded Flow	14.04	m^3/s
Median Flow	6.85	m^3/s
80% Time Exceeded Flow	3.33	m^3/s
Mean Rising Rate of Change of Flow	0.66	$m^3/s/day$
Mean Falling Rate of Change of Flow	-0.34	$m^3/s/day$
Extreme Low Flow Conditions:		
7-day-avg. low flow in 2-yr return period, $7Q_2$	1.34	m^3/s
7-day-avg. low flow in 10-yr return period, $7Q_{10}$	0.25	m^3/s
7-day-avg. low flow in 20-yr return period, $7Q_{20}$	0.13	m^3/s
Target Metric		
Riparian Flows (Q_2 - Q_{20})	36 -71	m^3/s
Bankfull Flows ($Q_{1.5}$ - $Q_{1.7}$)	30 -33	m^3/s

II. Flow Duration

Time Exceeded %	Flow (m^3/s)
0%	88.1
1%	42.1
5%	27.8
10%	20.6
20%	14.0
30%	10.8
40%	8.5
50%	6.8
60%	5.6
70%	4.6
80%	3.3
90%	1.7
95%	1.0
99%	0.3
100%	0.1

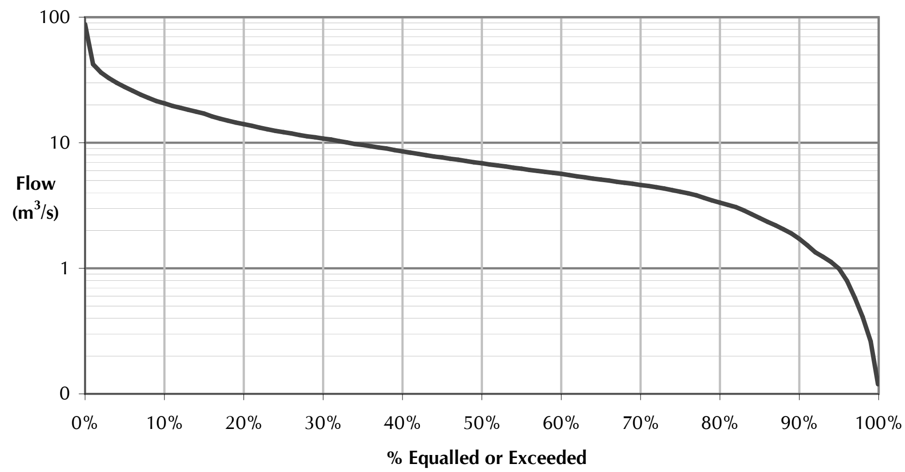


Table 2 & Figure 2 : Flow duration table and curve displaying flow vs. percent time exceeded over 27 years.

III. Flood Frequency Analysis

Return Period (years)	Flow (m^3/s)
1.05	16.2
1.25	24.7
1.5	29.8
1.7	32.7
2	36.0
5	51.1
10	61.2
20	70.8
50	83.2
100	92.6

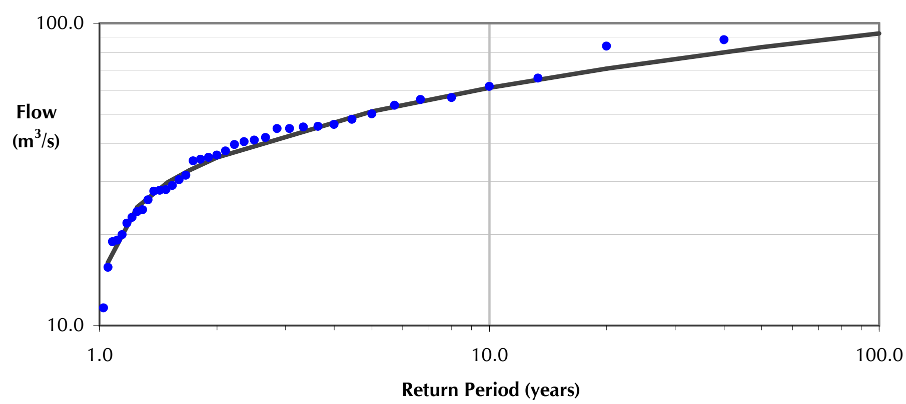


Table 3 & Figure 3 : Flood frequency analysis and curve fitted by the Gumbel probability distribution.

IV. Low Flow Frequency Analysis (Performed using 7-day-average low flow)

Return Period (years)	Flow (m^3/s)
1.005	8.11
1.01	7.17
1.11	3.89
1.25	2.83
2	1.34
5	0.49
10	0.25
20	0.13
50	0.06
100	0.03

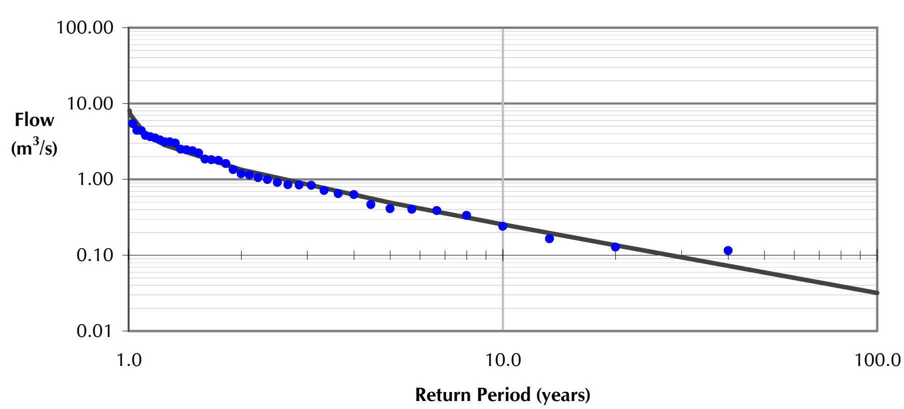


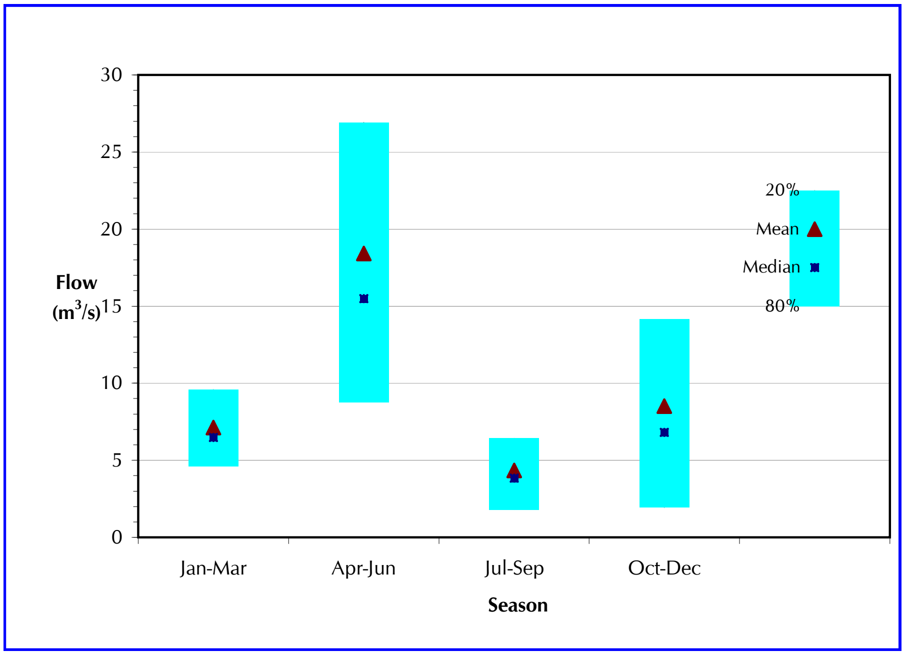
Table 4 & Figure 4 : 7-day-average low flow frequency analysis and curve fitted by the Gumbel probability distribution.

Seasonal :

I. Flow Duration

Table 5 & Figure 5 : Seasonal median flow duration for determining minimum flow targets.

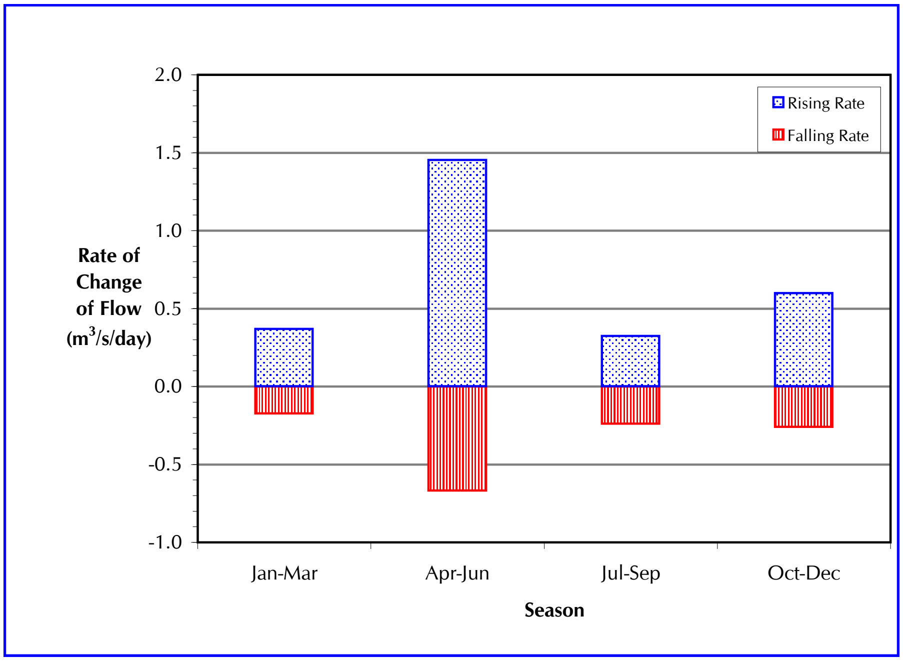
Season	20% Time Exceeded (m^3/s)	Median (m^3/s)	80% Time Exceeded (m^3/s)
Jan-Mar	9.6	6.5	4.6
Apr-Jun	26.9	15.5	8.8
Jul-Sep	6.4	3.8	1.8
Oct-Dec	14.1	6.8	1.9



II. Rate of Change of Flow

Table 6 & Figure 6 : Seasonal rising and falling rates of change of flow for determining ramping rate targets.

Season	Rising Rate ($m^3/s/day$)	Falling Rate ($m^3/s/day$)
Jan-Mar	0.37	-0.17
Apr-Jun	1.45	-0.67
Jul-Sep	0.32	-0.24
Oct-Dec	0.60	-0.26

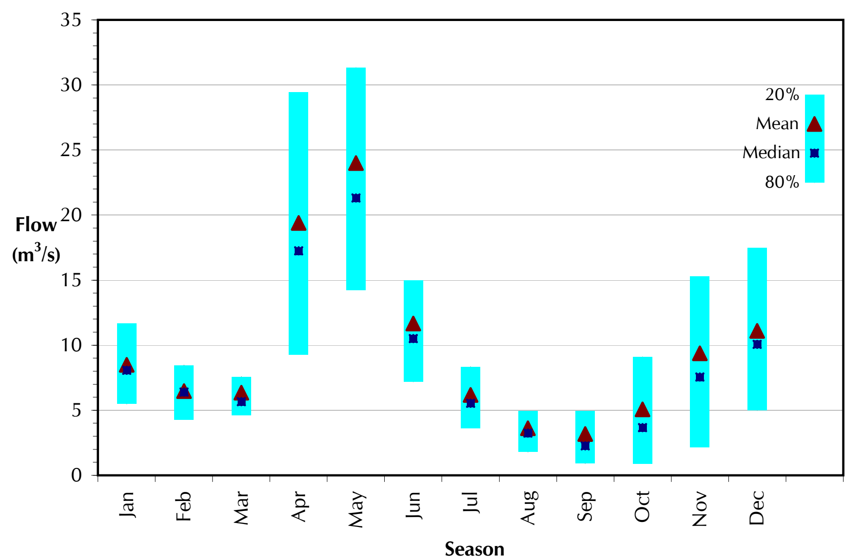


Monthly :

I. Flow Duration

Table 7 & Figure 7 : Monthly median flow duration for determining minimum flow targets.

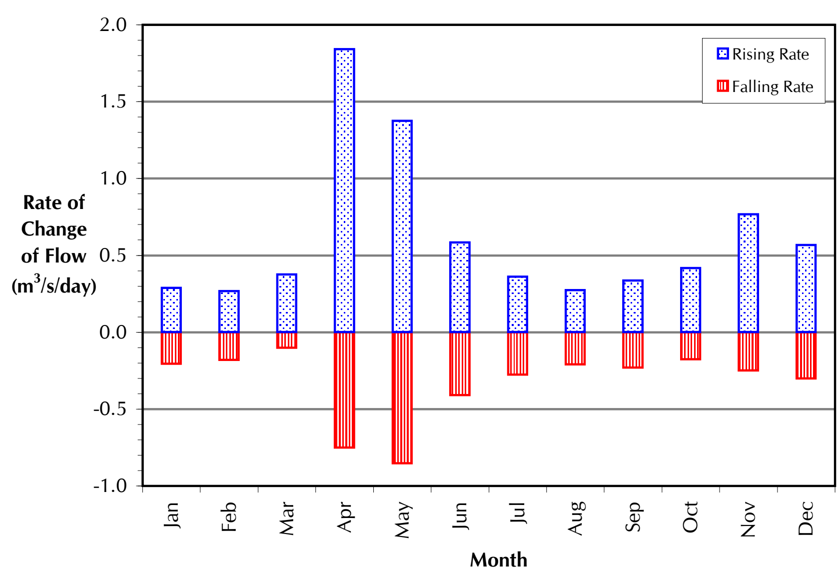
Month	20% Time Exceeded (m^3/s)	Median (m^3/s)	80% Time Exceeded (m^3/s)
Jan	11.7	8.1	5.5
Feb	8.5	6.4	4.3
Mar	7.6	5.7	4.6
Apr	29.4	17.3	9.3
May	31.3	21.3	14.2
Jun	15.0	10.5	7.2
Jul	8.4	5.6	3.6
Aug	4.9	3.2	1.8
Sep	4.9	2.3	0.9
Oct	9.1	3.7	0.9
Nov	15.3	7.6	2.2
Dec	17.5	10.1	5.0



II. Rate of Change of Flow

Table 8 & Figure 8 : Monthly rising and falling rates of change of flow for determining ramping rate targets.

Month	Rising Rate ($m^3/s/day$)	Falling Rate ($m^3/s/day$)
Jan	0.29	-0.20
Feb	0.27	-0.18
Mar	0.38	-0.10
Apr	1.84	-0.75
May	1.37	-0.85
Jun	0.58	-0.41
Jul	0.36	-0.28
Aug	0.27	-0.21
Sep	0.34	-0.23
Oct	0.42	-0.18
Nov	0.77	-0.25
Dec	0.57	-0.30



McCARTHY CHUTE - SERPENT
FLOW METRICS DATA SHEET

STATION INFORMATION

SITE ID	2CD15
RIVER NAME	SERPENT
SITE NAME	McCARTHY CHUTE
REGION	NORTHEAST
DISTRICT	SAULT STE. MARIE
DRAINAGE AREA	966 km^2
OWNER	XENECA

Flow metrics are provided for the potential waterpower site based on flows from WSC station 02CD004 (infilled and extended). Metrics are based on WSC flows from 1967 to 2005 (39 years).

The flow record for the site has been synthesized by infilling gauge flows to 1967-2005 from 02CD001 and prorating LTAF between 02CD004 (A = 569 km^2) and 02CD001 (A = 1350 km^2) for the site (A = 966 km^2). Other descriptive metrics have been included in the data sheet to provide a more complete description of the ranges of streamflow on the river system and to facilitate comparisons between river

Annual (1967 - 2005):

I. Streamflow Time Series

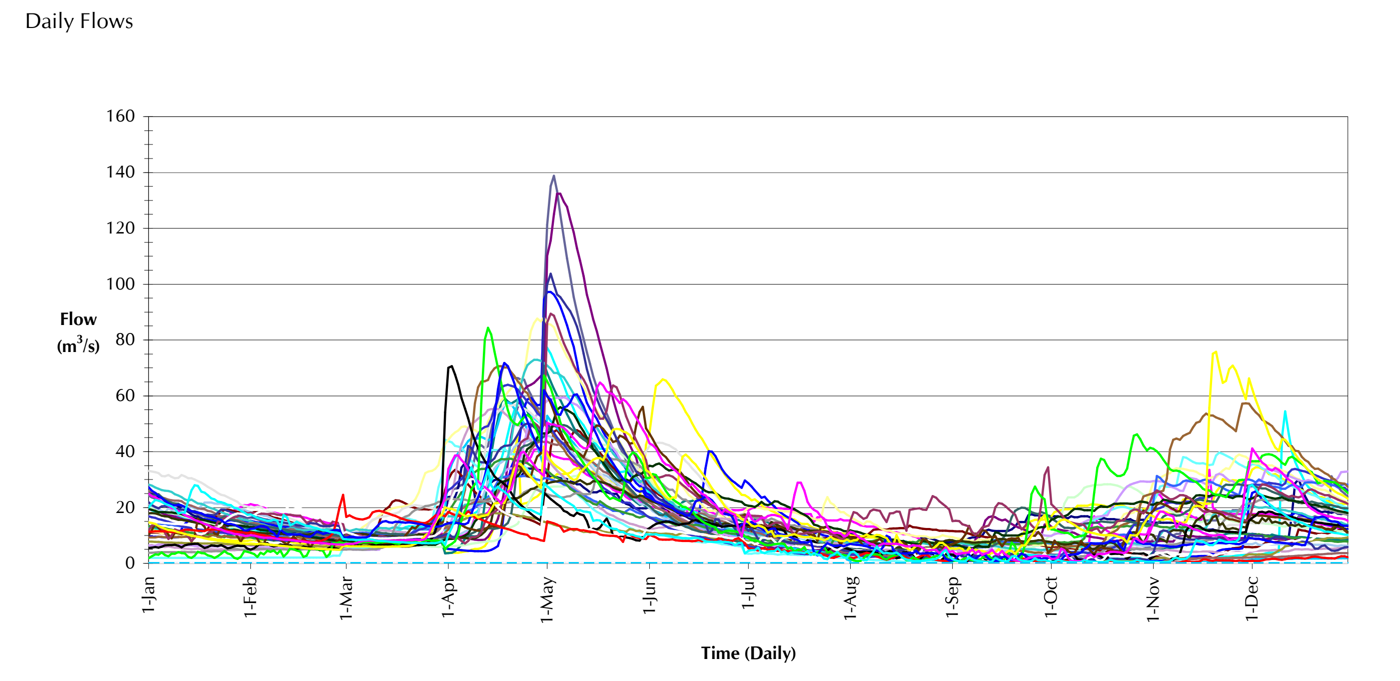


Figure 1 : Annual Daily flow hydrographs from 1967 to 2005.

Table 1 : Annual flow metrics based on 39 years of data.

Descriptive Metric		
Mean Annual Flow	15.11	m^3/s
20% Time Exceeded Flow	22.12	m^3/s
Median Flow	10.79	m^3/s
80% Time Exceeded Flow	5.24	m^3/s
Mean Rising Rate of Change of Flow	1.04	$m^3/s/day$
Mean Falling Rate of Change of Flow	-0.54	$m^3/s/day$
Extreme Low Flow Conditions:		
7-day-avg. low flow in 2-yr return period, $7Q_2$	2.12	m^3/s
7-day-avg. low flow in 10-yr return period, $7Q_{10}$	0.40	m^3/s
7-day-avg. low flow in 20-yr return period, $7Q_{20}$	0.21	m^3/s
Target Metric		
Riparian Flows (Q_2 - Q_{20})	57 -112	m^3/s
Bankfull Flows ($Q_{1.5}$ - $Q_{1.7}$)	47 -51	m^3/s

II. Flow Duration

Time Exceeded %	Flow (m^3/s)
0%	138.8
1%	66.4
5%	43.8
10%	32.4
20%	22.1
30%	17.0
40%	13.4
50%	10.8
60%	8.9
70%	7.2
80%	5.2
90%	2.7
95%	1.6
99%	0.4
100%	0.2

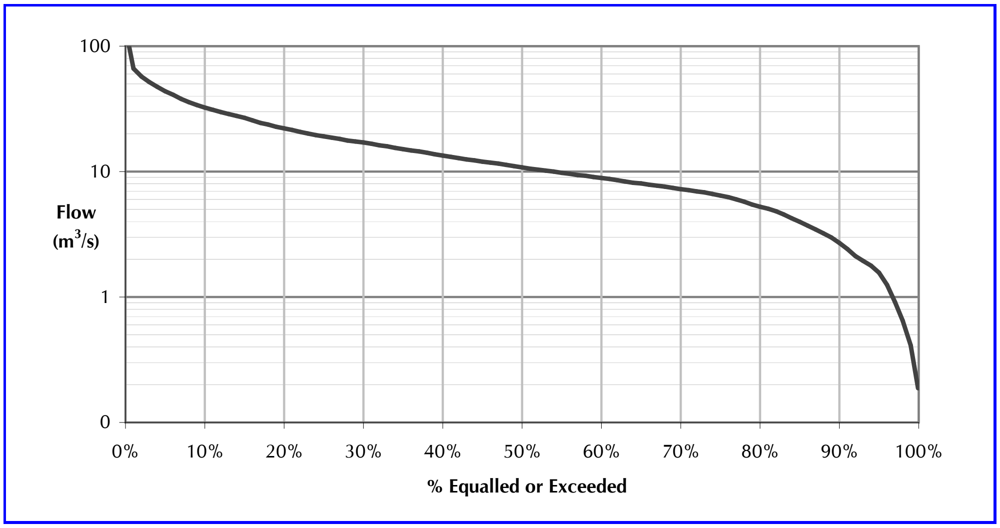


Table 2 & Figure 2 : Flow duration table and curve displaying flow vs. percent time exceeded over 27 years.

III. Flood Frequency Analysis

Return Period (years)	Flow (m^3/s)
1.05	25.5
1.25	38.9
1.5	47.0
1.7	51.5
2	56.7
5	80.6
10	96.4
20	111.6
50	131.2
100	145.9

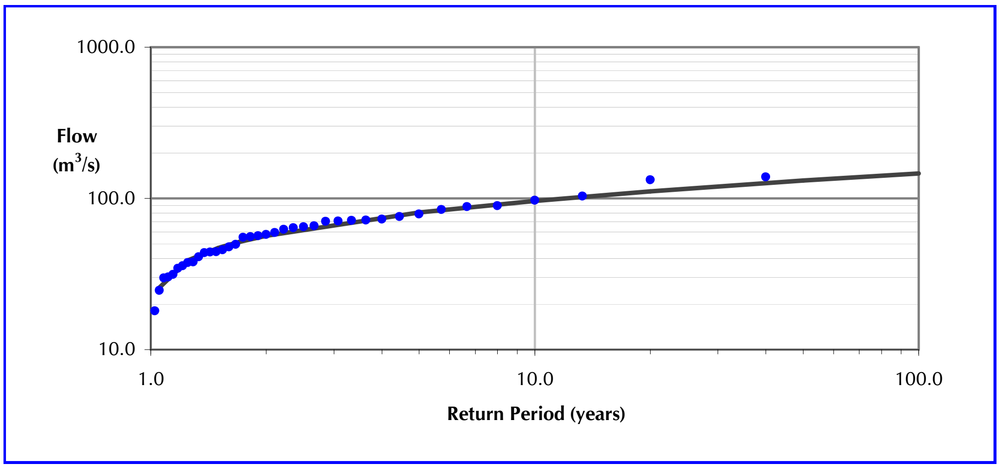


Table 3 & Figure 3 : Flood frequency analysis and curve fitted by the Gumbel probability distribution.

IV. Low Flow Frequency Analysis (Performed using 7-day-average low flow)

Return Period (years)	Flow (m^3/s)
1.005	12.78
1.01	11.30
1.11	6.13
1.25	4.45
2	2.12
5	0.78
10	0.40
20	0.21
50	0.09
100	0.05

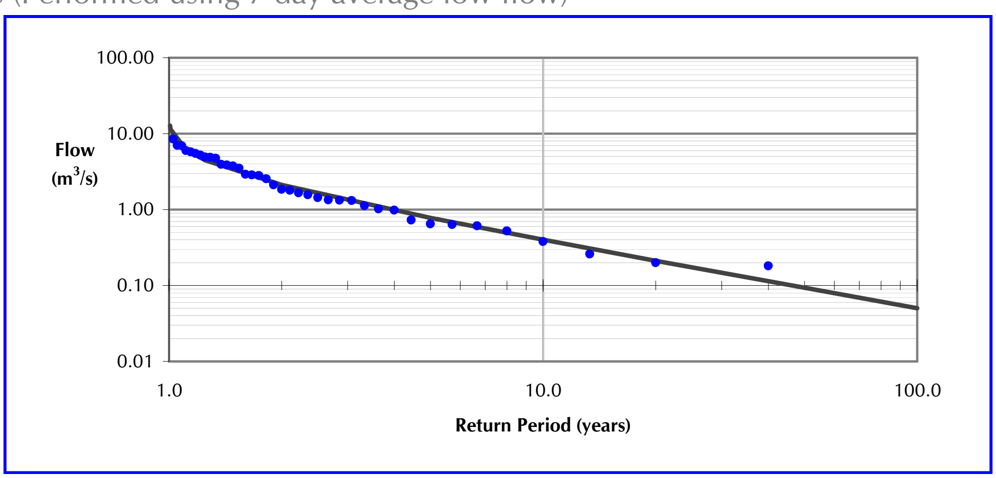


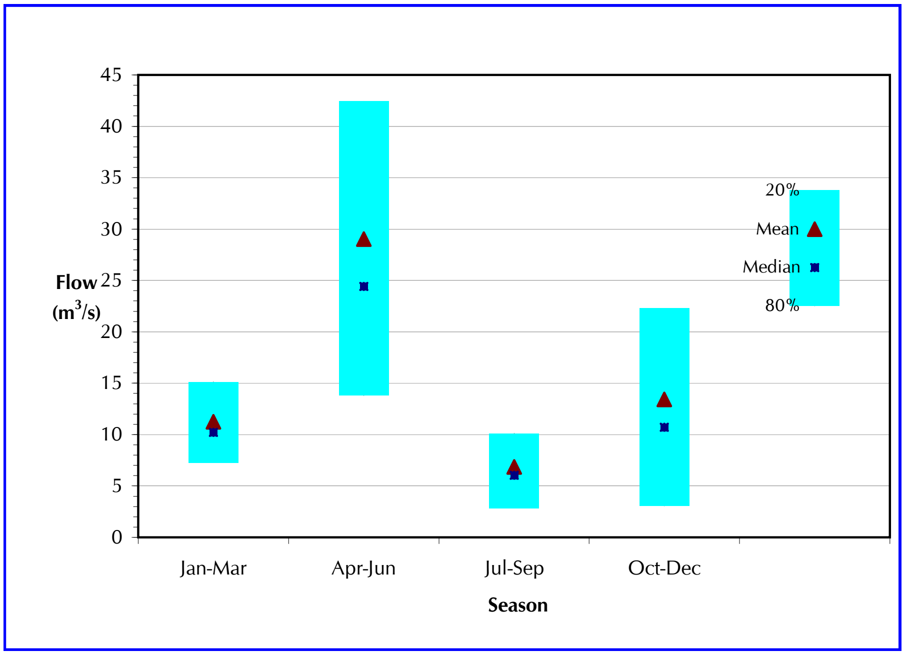
Table 4 & Figure 4 : 7-day-average low flow frequency analysis and curve fitted by the Gumbel probability distribution.

Seasonal :

I. Flow Duration

Table 5 & Figure 5 : Seasonal median flow duration for determining minimum flow targets.

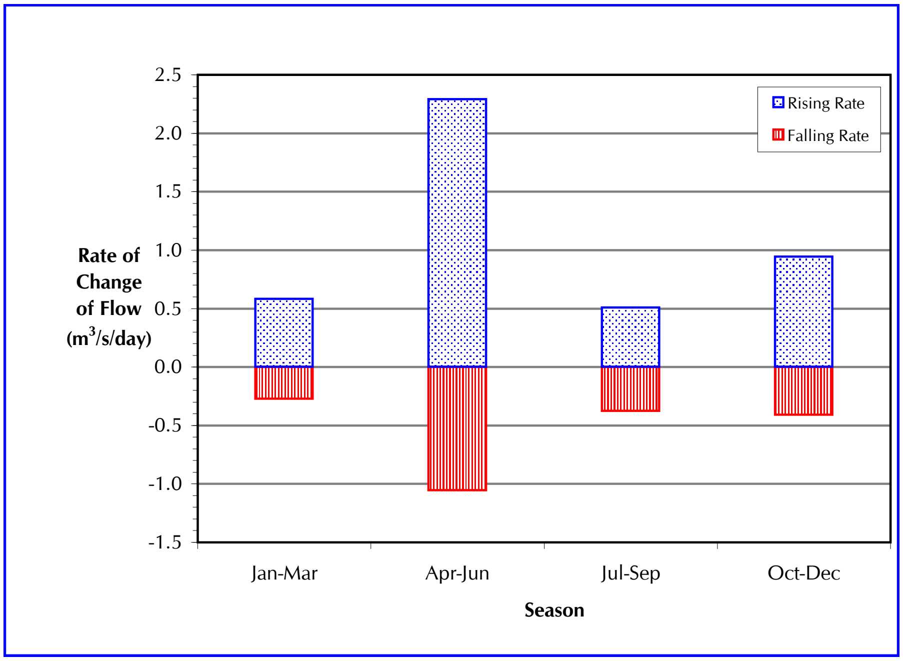
Season	20% Time Exceeded (m^3/s)	Median (m^3/s)	80% Time Exceeded (m^3/s)
Jan-Mar	15.1	10.2	7.3
Apr-Jun	42.4	24.4	13.8
Jul-Sep	10.1	6.0	2.8
Oct-Dec	22.3	10.7	3.0



II. Rate of Change of Flow

Table 6 & Figure 6 : Seasonal rising and falling rates of change of flow for determining ramping rate targets.

Season	Rising Rate ($m^3/s/day$)	Falling Rate ($m^3/s/day$)
Jan-Mar	0.58	-0.27
Apr-Jun	2.29	-1.05
Jul-Sep	0.51	-0.37
Oct-Dec	0.95	-0.41

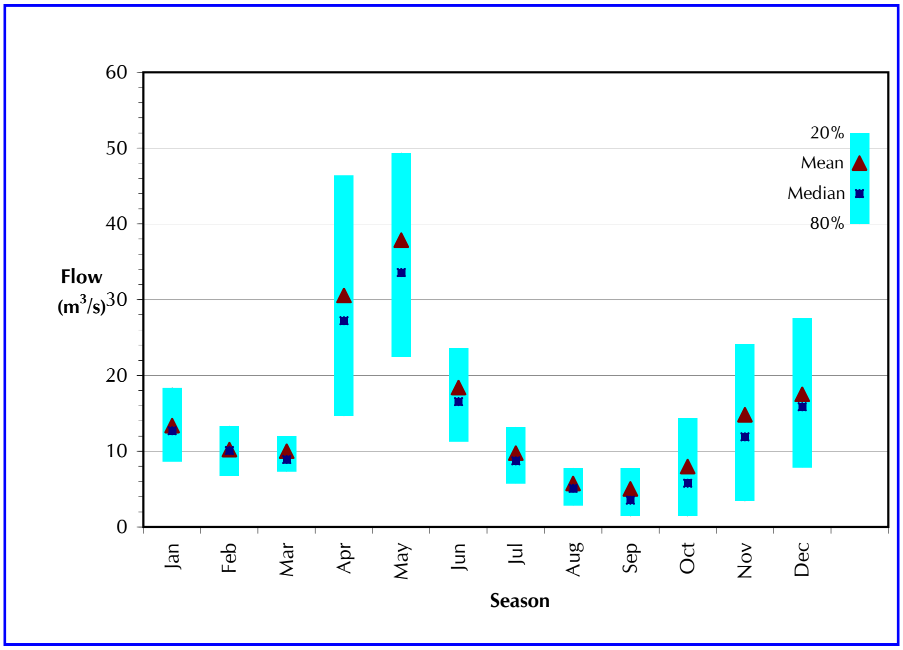


Monthly :

I. Flow Duration

Table 7 & Figure 7 : Monthly median flow duration for determining minimum flow targets.

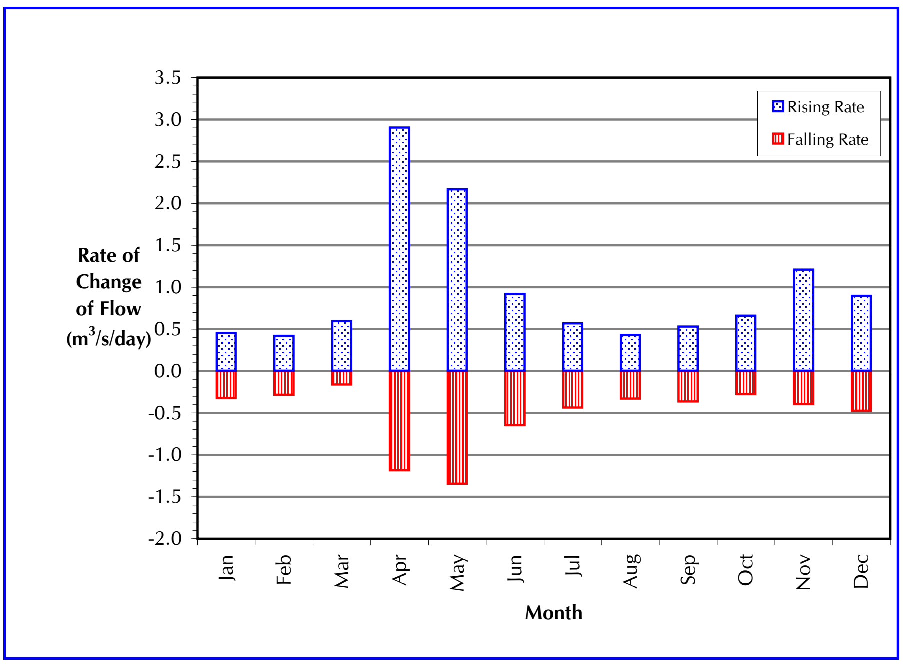
Month	20% Time Exceeded (m^3/s)	Median (m^3/s)	80% Time Exceeded (m^3/s)
Jan	18.4	12.7	8.6
Feb	13.3	10.1	6.8
Mar	11.9	8.9	7.3
Apr	46.4	27.2	14.6
May	49.4	33.6	22.5
Jun	23.6	16.6	11.3
Jul	13.2	8.7	5.8
Aug	7.8	5.1	2.8
Sep	7.7	3.6	1.4
Oct	14.4	5.8	1.4
Nov	24.1	11.9	3.4
Dec	27.5	15.9	7.9



II. Rate of Change of Flow

Table 8 & Figure 8 : Monthly rising and falling rates of change of flow for determining ramping rate targets.

Month	Rising Rate (m^3/s/day)	Falling Rate (m^3/s/day)
Jan	0.45	-0.32
Feb	0.42	-0.28
Mar	0.59	-0.16
Apr	2.90	-1.18
May	2.17	-1.34
Jun	0.92	-0.64
Jul	0.57	-0.44
Aug	0.43	-0.33
Sep	0.53	-0.36
Oct	0.66	-0.28
Nov	1.21	-0.39
Dec	0.90	-0.47



APPENDIX B

Lake Evaporation vs. Latitude in Ontario

Lake Evaporation vs. Latitude in Ontario

Lake evaporation in Ontario generally occurs between April and November each year when lakes are free of ice. Lake evaporation varies with extra terrestrial radiation, temperature, vapour pressure, humidity and wind speed. Although lake evaporation varies from year it is more stable than evapotranspiration or general evaporation loss in a river basin because it does not depend on the surficial geology or land use in the basin, which can affect the precipitation reaching the ground and the soil moisture available for transpiration.

Lake Evaporation datasets in Ontario are limited and not always complete, but Environment Canada publishes average lake evaporation data for some climate stations in the online Canadian Climate Normals or Averages 1971-2000 series.

The table below shows Annual Average Lake Evaporation data for six climate stations in Ontario and one each from Manitoba and Quebec.

Station	Province	Latitude ° N	Altitude m	Annual E_{Lake} mm
Amos	QUE	48.57	310	538
Atikokan	ONT	48.80	442	538
Delhi	ONT	42.87	232	709
Harrow	ONT	42.02	191	789
Moosonee	ONT	51.27	8	433
Ottawa	ONT	45.37	79	672
Rawson Lake	ONT	49.65	358	556
Norway House Forestry	MAN	54.00	217	320

The *Evaporation Atlas for the Contiguous 48 United States, NOAA Technical Report NWS 33, Washington D.C. June, 1982* shows that annual free water surface evaporation from shallow lakes (1956-70) varies approximately linearly with latitude in the states contiguous with the Province of Ontario.

To investigate whether this trend persists in Ontario the annual average lake evaporation data above were plotted against climate station latitude in Figure B-1. A linear regression equation fitted to this data set has a correlation coefficient $R^2 = 0.9655$ and gives the relationship for annual average lake evaporation:

$E_{Lake} = 2296.6 - 36.123 * \text{Latitude}$

Where: E_{Lake} is annual average lake evaporation in mm

Latitude is in decimal ° N.

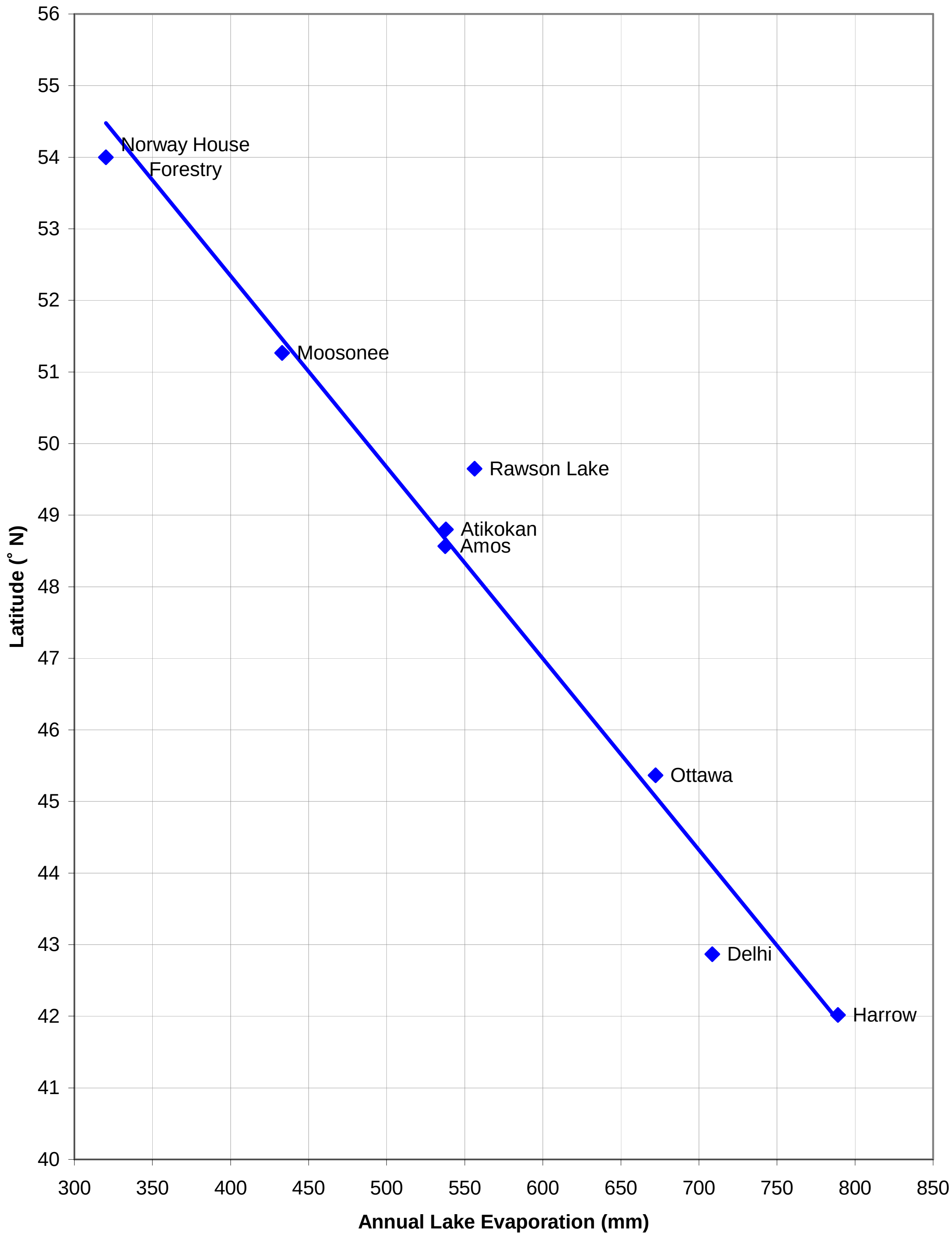


Figure B-1
Xeneca Power
Serpent River Hydro Development
Annual Average Lake Evaporation vs. Latitude

HATCH™

A typical monthly lake evaporation distribution for the Serpent River Project Site is shown in Figure B-2.

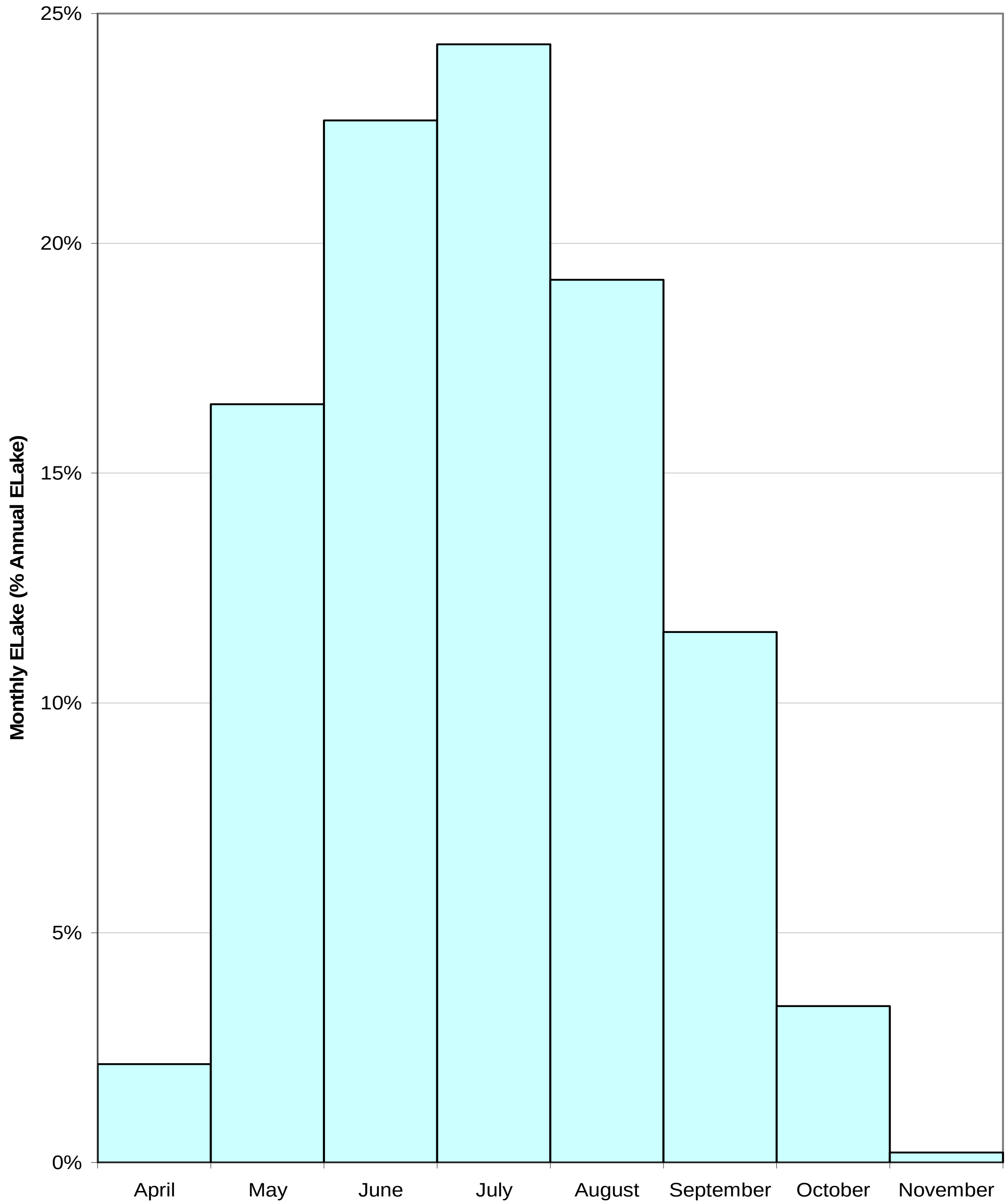


Figure B-2
Xeneca Power
Serpent River Hydro Development
Monthly Lake Evaporation Distribution in Ontario

APPENDIX C

CD-ROM containing Flow Series Datasets

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Oakville, Ontario, Canada L6M 2W2
Tel 905 469 3400 ◆ Fax 905 469 3404