ANNEX 1-E

SERPENT RIVER AT FOUR SLIDE FALLS HYDROLOGIC ANALYSES

CANADIAN PROJECTS LIMITED
#240, 523 Woodpark Blvd SW
Calgary, Alberta T2W 4J3
Phone: (403) 508-1560 Fax: (403) 238-5460

File: 1052-001-3.1.1

April 26, 2011

Mr. Nava Pokharel, M.Sc., P.Eng.
Senior Project Manager
Xeneca Power Development Inc.
5160 Yonge Street, Suite 520
Toronto, ON, M2N 6L9

Dear Nava:

Re: Ontario South Hydro
Serpent River at Four Slide Falls Hydrologic Analyses

Xeneca Power Development Inc. is proposing to develop the Four Slide hydropower project on the Serpent River in Ontario. Xeneca commissioned Canadian Projects Ltd. (CPL) to prepare hydrologic analyses for the project in accordance with Ontario Ministry of the Environment (MOE) requirements as listed in Table 1. The table provides a concordance between the MOE requirements and the various sections, tables and figures in this letter report.

The analyses relied on hydrologic information, including the site catchment area and a set of synthetic daily flow estimates for the project, provided by Hatch[1]. The synthetic data was extended to include the years 2006 through 2009 which were not included in the Hatch dataset, using the methods and factors presented in the Hatch report.

1. Season Definitions

Xeneca defined four seasons for the hydrologic analyses, as described in the project Operating Plan[2]. The season definitions are illustrated on Figure 1.

2. Flow-Duration Curves of Total Streamflow

MOE requirements c) and e) include analyses of daily mean discharges to obtain flow-duration curves for the full year, and on a monthly and seasonal basis. Flow-duration estimates were obtained by analysis of the synthetic dataset as follows:

[1] Hydrology Review for Serpent River Hydropower Site. Hatch Ltd. January 8, 2010.
[2] Proposed Operating Flows and Levels: Four Slide Hydro Project. Xeneca Power Development Inc., March 2011.

- Standard (or Period of Record) flow-duration curves for the full year and for each season of the year are shown on Figure 2 and Table 2.
- Standard (or Period of Record) flow-duration curves for each month of the year are shown on Figure 3 and Table 3.

3. Flow-Duration Curves of Baseflow

MOE requirement d) specifies a flow-duration analysis of baseflow data. The series of synthetic daily discharges was analyzed to obtain estimates of daily baseflow using the Streamflow Analysis and Assessment Software (SAAS) developed at Trent University and recommended by MOE. SAAS implements a recursive digital filtering method to estimate baseflow. Following the SAAS methodology, the first and last months of the dataset were removed to eliminate the end effects of the filtering procedure. In addition, two days of zero flow (in September 1999) in the original input file were revised to values of 0.001 m^3/s so that SAAS could process the file.

- Standard (or Period of Record) baseflow flow-duration curves for the full year and for each season of the year are shown on Figure 4 and Table 4.
- Standard (or Period of Record) baseflow flow-duration curves for each month of the year are shown on Figure 5 and Table 5.

4. Median of Percentiles Analysis

MOE requirement e) specifies a "median of percentiles" analysis in which the period of record is subdivided into years, seasons or months; flow exceedance statistics are computed individually for each period; and then the values for each percentile are analyzed to obtain the median value for that percentile across the years of record.

- Median of Percentiles analysis results for the full year and for each season of the year are shown on Figure 6 and Table 6.
- Median of Percentiles analysis results for each month of the year are shown on Figure 7 and Table 7.

5. Low Flow Analysis

MOE requirements b) and g) specify a low-flow frequency analysis of 7-day average low flow for return periods of 2, 10 and 20 years. The Hatch report provided preliminary drought frequency estimates, but recommended that detailed low flow analyses be undertaken for environmental assessment and design phases of the projects. Therefore CPL conducted low flow analyses. The analyses were based on the series of minimum 7-day average discharges on a water year basis (May 1 – April 30). Four probability distributions were tested using the Hyfran[3] software: Gumbel (used by Hatch), Weibull or Gumbel III (recommended by Environment Canada[4]), Pearson III, and lognormal.

The lognormal distribution provided the best fit to the data. Results are presented in Table 8.

[3] Developed by the Institut National de la Recherche Scientifique - Eau Terre et Environnement (INRS-ETE) at the University of Quebec with sponsorship from Hydro-Quebec and the Natural Sciences and Engineering Research Council of Canada.
[4] Modelling of Low Flow Frequency Distributions and Parameter Estimation. R. Condie and G.A. Nix. International Water Resources Symposium, Water for Arid Lands, Teheran, Iran, December 8-9, 1975.

6. Flood Frequency Analysis

MOE requirement f) specifies a flood frequency analysis of maximum instantaneous discharges. The Hatch report provided preliminary flood frequency estimates, but recommended that detailed flood analyses should be undertaken for environmental assessment and design phases of the projects. Therefore CPL conducted a new flood frequency analysis which encompassed the 1:2 year to the 1:10,000 year instantaneous flood flows as documented in a separate report[5].

Maximum instantaneous flood estimates for various return periods are provided in Table 9.

7. Summary Statistics

MOE requirement a) specifies descriptive statistics of daily discharges including the maximum, mean, median, minimum and 20% and 80% exceedance values. Summary statistics are presented in Table 10.

The maximum daily discharge presented in Table 10 is inconsistent with the results of the flood frequency analysis presented in Table 9. It appears that the synthetic dataset of daily data produced by Hatch contains a few anomalously high values. The anomalous values are not considered to represent reality; the actual maximum daily discharge at the site is believed to be much lower than the table indicates.

8. Conclusion

This hydrological analysis letter report was prepared and provides the information compiled in accordance with MOE requirements. We trust that the information contained in this letter meets with your requirements.

Sincerely,

CANADIAN PROJECTS LIMITED

Wes Dick, M.Sc.
Senior Hydrologist

WD/wd

Reviewed By

Paul Kemp, P.Eng.
Project Director

[5] Ontario South Hydro: Hydrology Review and Flood Frequency Analyses – DRAFT. Letter report to Xeneca, Canadian Projects Limited, February 17, 2011.

Table 1
Concordance between MOE Requirements and Report

MOE Requirement	Results Presented In		
	Section No.	Figure No.	Table No.
a) Descriptive flow statistics using all available daily flows for all years: mean, median, minimum, maximum, flow exceeded 20% time, flow exceeded 80% time.	7	--	10
b) Extreme low flow statistics: $7Q_2$ (2 year return period 7-day-average-low flow), $7Q_{10}$ (10 year return period 7-day-average-low flow) and $7Q_{20}$ (20 year return period 7-day-average-low flow).	5	--	8
c) Flow duration curves and tables using total daily average flow data for the entire period, for all four seasons and for all twelve months.	2	2 – 3	2 – 3
d) Flow duration curves and tables using daily baseflow data for the entire period, for all four seasons and for all twelve months.	3	4 – 5	4 – 5
e) Flow duration curves derived using both the percentile method and the median of percentiles method. Both methods are incorporated into the flow analysis tool, developed by Schmidt and Metcalfe (2009), which can be downloaded for free from http://trentu.ca/iws/software.php.	2, 4	2 – 3, 6 – 7	2 – 3, 6 – 7
f) Flood frequency analysis using instantaneous maximum flow of each year for the entire period of records.	6	--	9
g) Low flow frequency analysis using 7-day-average-low flow for the entire period of records.	5	--	8
h) Altered flow of the bypass reach and the reach below tailrace, if applicable.*	--	--	--
i) Compensation flow for the bypass reach and the reach below tailrace, if applicable.*	--	--	--

* These items are addressed in the Operation Plan.

Figure 1

Hydrologic Season Definitions for Serpent River at Four Slide Falls

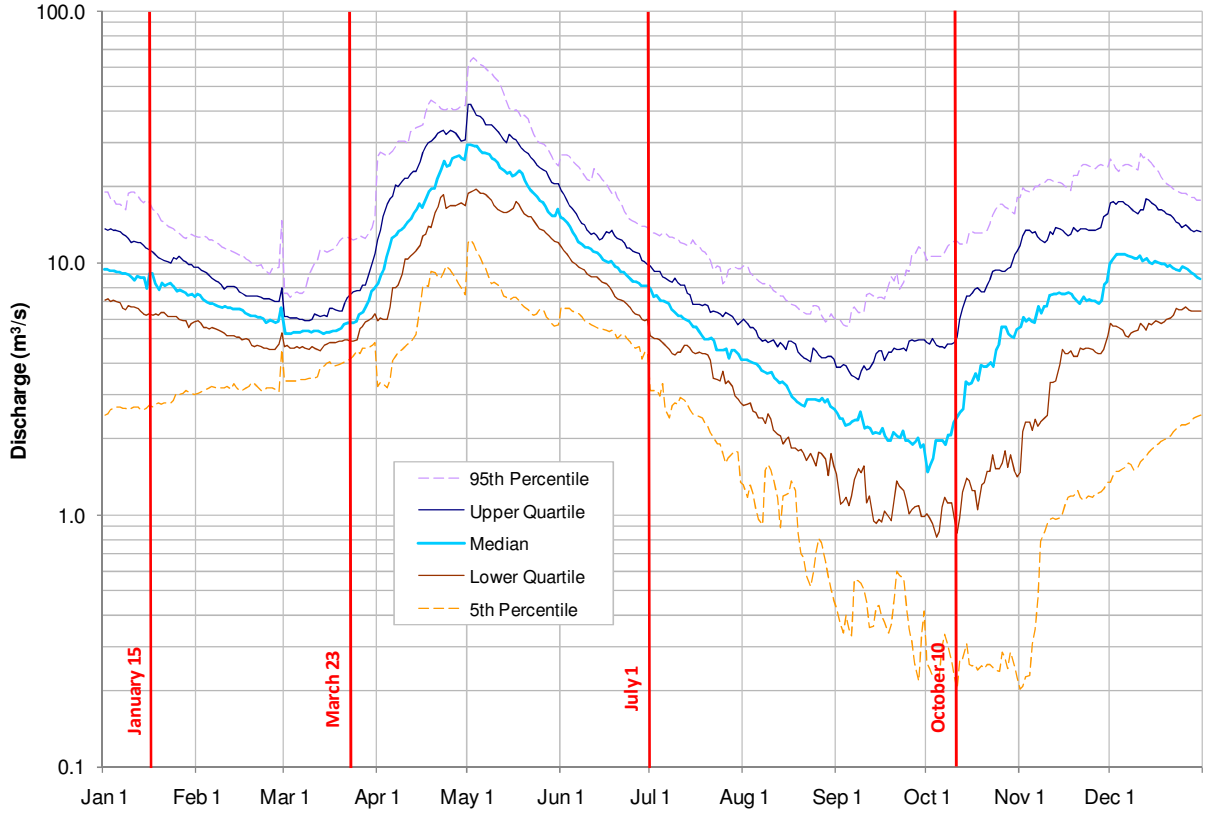

Figure 2

Annual and Seasonal Flow-Duration Curves
Serpent River at Four Slide Falls

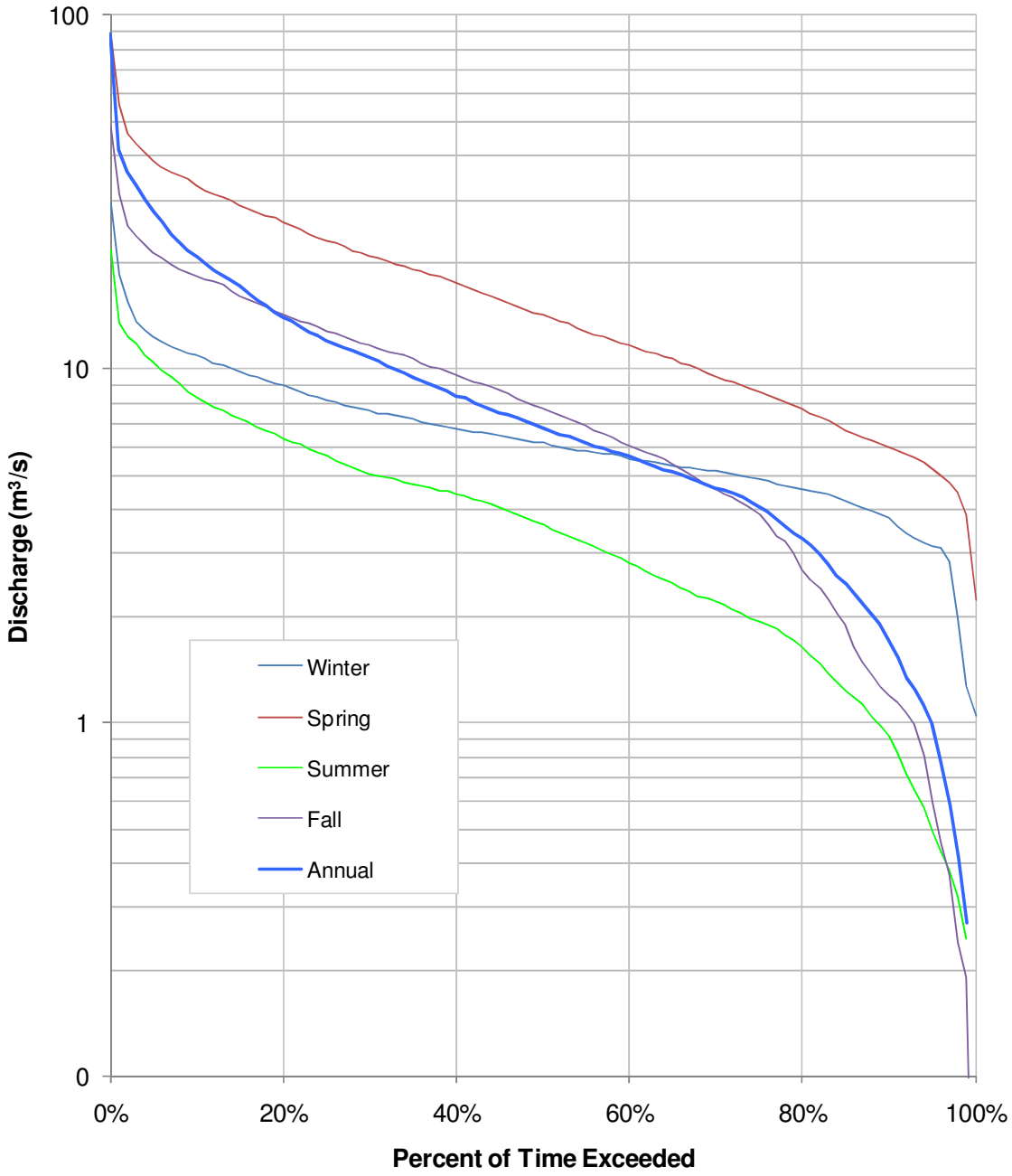

Table 2
Annual and Seasonal Flow-Duration Estimates
Serpent River at Four Slide Falls

% of Time Exceeded	Discharge (m^3/s)				
	Winter	Spring	Summer	Fall	Annual
	Jan 15 Mar 22	Mar 23 Jun 30	Jul 1 Oct 9	Oct 10 Jan 14	
1	18.4	55.8	13.5	31.4	41.8
5	12.4	38.7	10.5	21.3	27.8
10	10.9	33.0	8.34	18.3	20.7
15	9.77	28.9	7.22	16.1	17.2
20	8.98	26.0	6.34	14.2	14.0
25	8.15	23.1	5.66	12.8	12.1
30	7.59	20.9	5.05	11.6	10.7
35	7.21	19.1	4.73	10.7	9.48
40	6.80	17.5	4.42	9.58	8.41
45	6.49	15.6	4.07	8.66	7.53
50	6.17	14.1	3.62	7.72	6.80
55	5.86	12.7	3.22	6.90	6.19
60	5.59	11.6	2.82	6.06	5.64
65	5.34	10.7	2.47	5.40	5.10
70	5.13	9.52	2.19	4.56	4.60
75	4.88	8.63	1.93	3.86	4.07
80	4.56	7.70	1.63	2.71	3.30
85	4.21	6.72	1.23	1.89	2.46
90	3.80	5.97	0.916	1.20	1.72
95	3.16	5.21	0.495	0.593	0.994
99	1.28	3.89	0.246	0.190	0.272

Figure 3

Monthly Flow-Duration Curves
Serpent River at Four Slide Falls

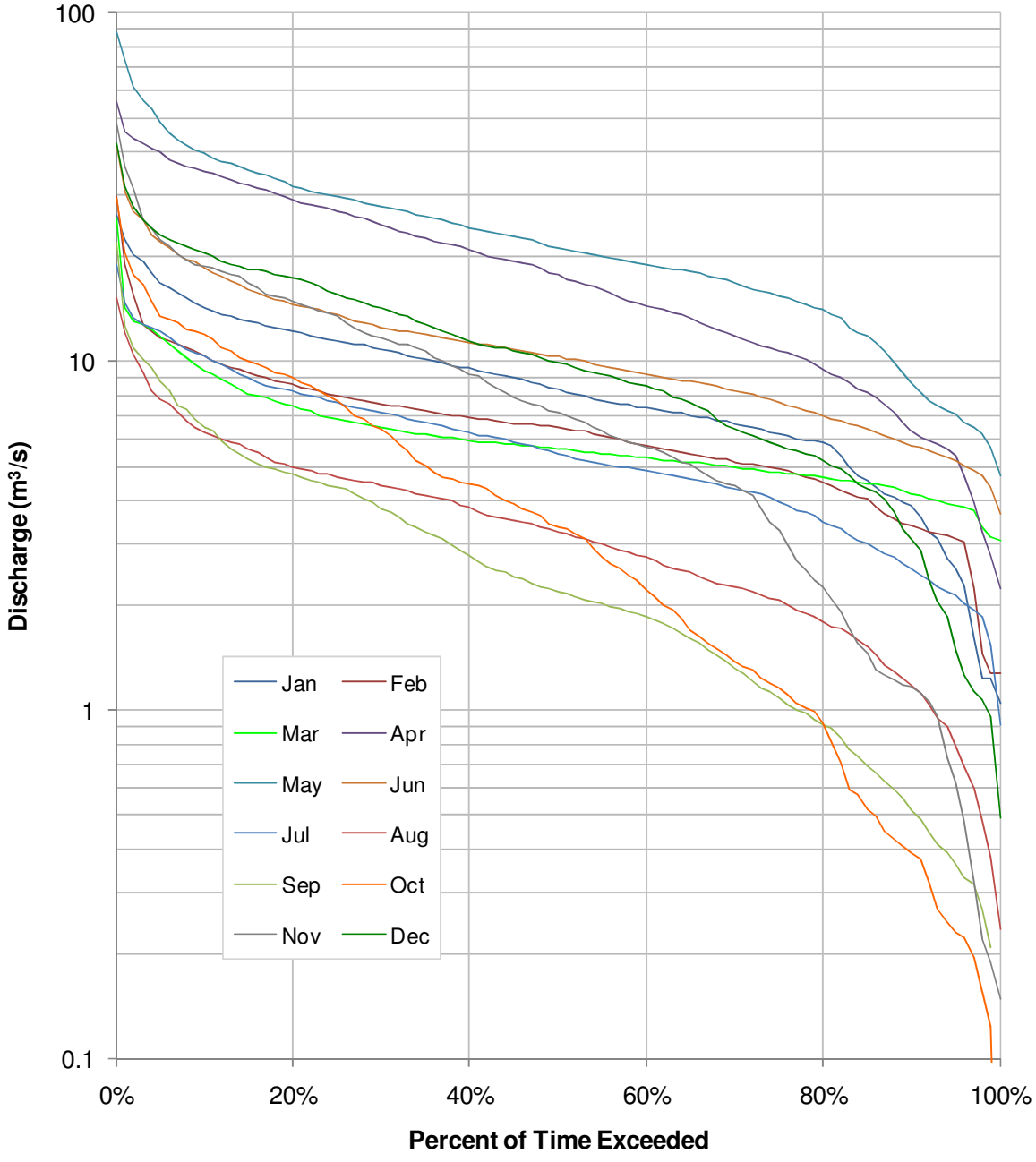

Table 3
Monthly Flow-Duration Estimates
Serpent River at Four Slide Falls

% of Time Exceeded	Discharge (m^3/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	22.4	19.0	14.3	45.6	72.9	30.8	14.8	12.1	12.6	20.4	36.3	31.8
5	16.9	11.7	11.8	39.8	48.5	22.1	12.2	7.76	8.82	13.6	22.5	23.1
10	14.3	10.4	9.43	35.2	39.5	18.5	10.4	6.27	6.48	12.0	18.7	20.5
15	13.1	9.27	8.10	32.1	35.6	16.1	8.99	5.60	5.25	10.1	16.9	18.4
20	12.2	8.57	7.45	29.1	31.9	14.6	8.25	4.98	4.77	9.02	15.0	17.4
25	11.5	8.00	6.86	26.9	29.9	13.6	7.60	4.68	4.37	7.68	13.5	15.6
30	10.8	7.58	6.46	24.7	27.8	12.5	7.11	4.42	3.80	6.39	11.8	14.2
35	10.2	7.23	6.17	22.6	26.1	12.0	6.65	4.14	3.26	5.02	10.7	12.8
40	9.60	6.92	5.93	20.9	24.3	11.4	6.25	3.82	2.78	4.45	9.23	11.4
45	8.98	6.63	5.77	19.3	22.9	10.9	5.86	3.51	2.41	3.92	7.87	10.7
50	8.30	6.48	5.62	17.7	21.2	10.3	5.41	3.25	2.19	3.36	7.12	9.93
55	7.73	6.16	5.45	16.1	20.1	9.72	5.09	2.99	2.03	2.75	6.33	9.21
60	7.37	5.76	5.29	14.5	18.9	9.20	4.89	2.74	1.86	2.22	5.69	8.53
65	7.02	5.41	5.15	13.4	18.1	8.77	4.60	2.50	1.61	1.71	5.06	7.61
70	6.64	5.15	4.98	11.8	16.7	8.27	4.32	2.25	1.32	1.37	4.39	6.43
75	6.22	4.93	4.81	10.7	15.4	7.61	3.97	2.06	1.08	1.16	3.28	5.71
80	5.86	4.51	4.67	9.52	14.0	6.98	3.48	1.80	0.913	0.922	2.25	5.17
85	4.54	4.02	4.47	8.11	11.8	6.40	2.99	1.52	0.693	0.519	1.45	4.33
90	3.85	3.38	4.19	6.32	8.67	5.76	2.55	1.18	0.520	0.392	1.17	3.09
95	2.54	3.12	3.85	5.35	7.10	5.19	2.13	0.785	0.360	0.230	0.621	1.49
99	1.23	1.28	3.15	2.77	5.67	4.38	1.55	0.378	0.209	0.123	0.189	0.963

Figure 4

Annual and Seasonal Flow-Duration Curves
Serpent River Baseflow at Four Slide Falls

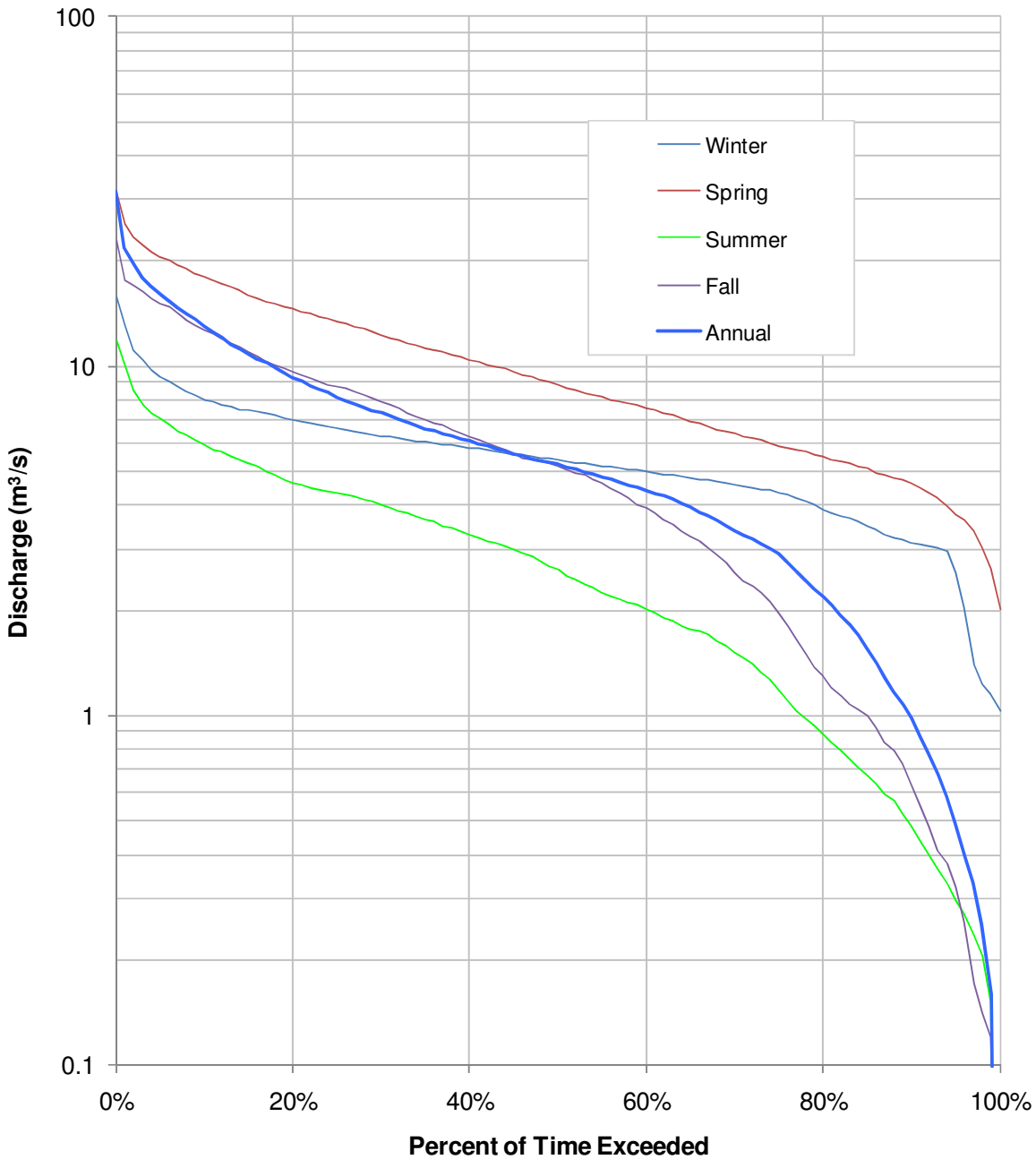

Table 4
Annual and Seasonal Baseflow Flow-Duration Estimates
Serpent River at Four Slide Falls

% of Time Exceeded	Discharge (m^3/s)				
	Winter	Spring	Summer	Fall	Annual
	Jan 15 Mar 22	Mar 23 Jun 30	Jul 1 Oct 9	Oct 10 Jan 14	
1	13.2	25.6	10.1	17.6	21.7
5	9.31	20.6	7.08	15.1	16.0
10	8.02	18.0	5.95	12.7	13.0
15	7.45	16.0	5.26	11.0	10.8
20	7.03	14.6	4.64	9.68	9.30
25	6.61	13.4	4.31	8.73	8.15
30	6.31	12.3	4.01	7.88	7.34
35	6.06	11.3	3.65	7.01	6.62
40	5.83	10.5	3.30	6.31	6.09
45	5.59	9.61	3.00	5.60	5.62
50	5.37	8.81	2.61	5.16	5.23
55	5.18	8.16	2.25	4.62	4.83
60	4.98	7.60	2.02	3.93	4.41
65	4.77	6.96	1.77	3.25	3.93
70	4.56	6.40	1.52	2.57	3.40
75	4.34	5.91	1.18	1.95	2.91
80	3.90	5.49	0.881	1.30	2.19
85	3.50	5.08	0.669	0.999	1.55
90	3.12	4.60	0.486	0.640	0.977
95	2.56	3.77	0.298	0.323	0.493
99	1.15	2.63	0.152	0.120	0.160

Figure 5

Monthly Flow-Duration Curves
Serpent River Baseflow at Four Slide Falls

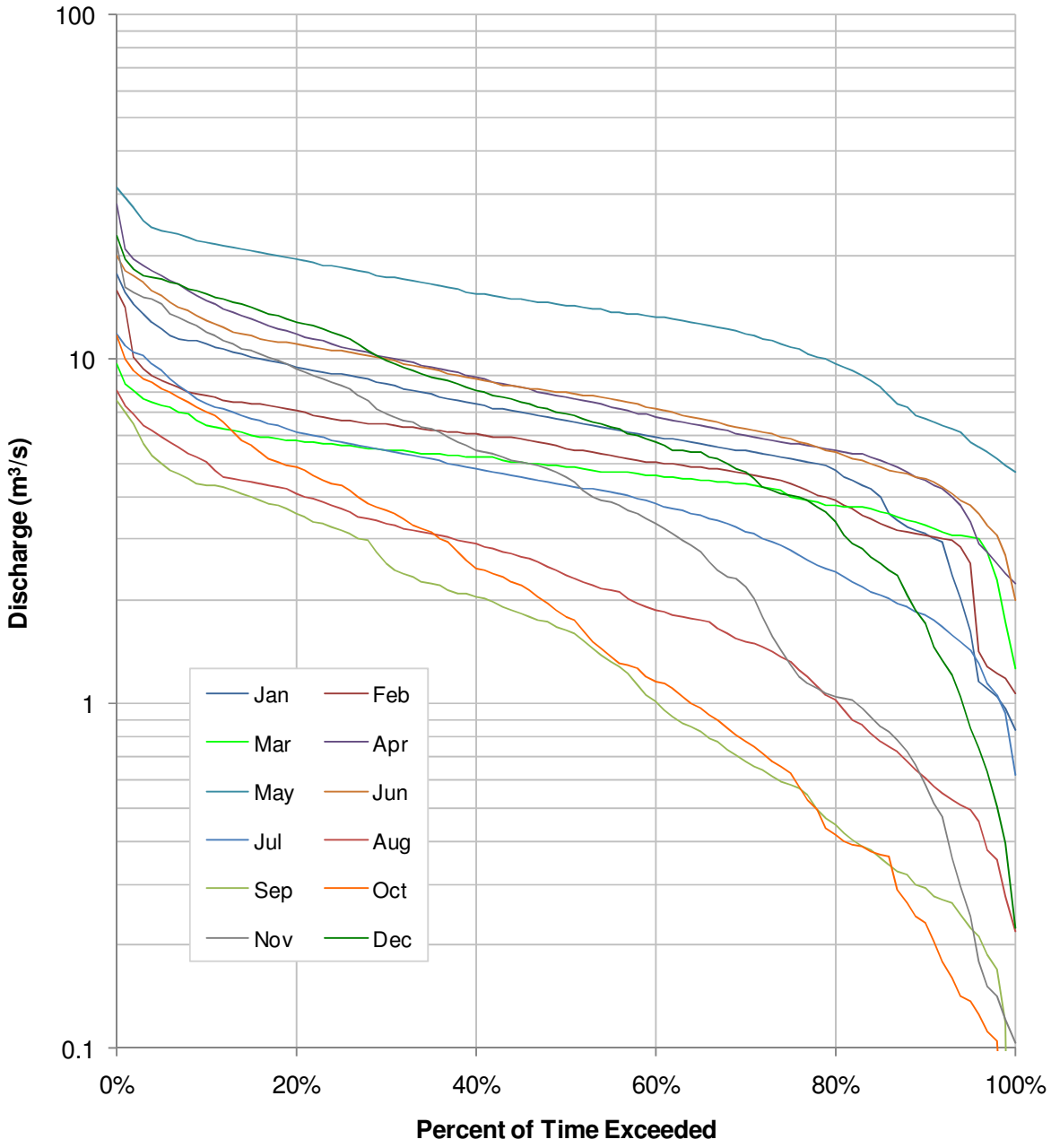

Table 5
Monthly Baseflow Flow-Duration Estimates
Serpent River at Four Slide Falls

% of Time Exceeded	Discharge (m^3/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	15.6	14.2	8.51	21.0	29.5	18.1	11.0	7.35	7.04	10.0	16.1	19.6
5	12.3	8.69	7.37	17.5	23.6	15.2	9.23	5.94	4.98	8.25	14.4	17.1
10	11.0	7.82	6.39	14.8	21.8	12.9	7.45	5.01	4.30	7.04	12.0	15.5
15	10.2	7.43	6.01	13.1	20.6	11.7	6.74	4.41	3.97	5.60	10.6	14.2
20	9.48	7.08	5.81	11.8	19.5	11.1	6.17	4.09	3.57	4.84	9.34	12.8
25	9.02	6.66	5.65	10.9	18.4	10.6	5.76	3.68	3.19	4.29	8.41	11.7
30	8.48	6.47	5.44	10.2	17.3	9.99	5.44	3.34	2.54	3.63	6.93	9.87
35	7.89	6.23	5.31	9.53	16.4	9.36	5.13	3.13	2.22	3.17	6.27	8.87
40	7.42	6.05	5.20	8.83	15.5	8.75	4.82	2.91	2.05	2.48	5.45	8.11
45	6.98	5.85	5.02	8.26	14.9	8.30	4.55	2.68	1.82	2.20	5.03	7.50
50	6.64	5.52	4.88	7.77	14.4	7.98	4.31	2.35	1.64	1.79	4.55	6.96
55	6.27	5.27	4.72	7.30	13.8	7.68	4.12	2.14	1.33	1.38	3.83	6.35
60	5.96	5.03	4.58	6.81	13.3	7.20	3.82	1.88	1.01	1.16	3.32	5.76
65	5.69	4.87	4.47	6.43	12.7	6.72	3.52	1.74	0.831	0.965	2.76	5.37
70	5.41	4.66	4.34	6.02	11.9	6.30	3.16	1.52	0.681	0.781	2.18	4.69
75	5.15	4.34	4.00	5.70	10.9	5.87	2.80	1.32	0.582	0.628	1.30	4.02
80	4.77	3.90	3.76	5.43	9.67	5.36	2.41	1.03	0.445	0.416	1.05	3.37
85	4.00	3.34	3.62	5.09	8.26	4.87	2.07	0.776	0.359	0.366	0.860	2.55
90	3.10	3.09	3.30	4.45	6.72	4.48	1.81	0.609	0.292	0.231	0.582	1.70
95	1.62	2.56	3.06	3.39	5.73	3.76	1.44	0.492	0.223	0.137	0.241	0.851
99	0.972	1.19	1.74	2.38	4.90	2.70	0.936	0.276	0.119	0.040	0.122	0.393

Figure 6

Annual and Seasonal Medians of Percentiles
Serpent River at Four Slide Falls

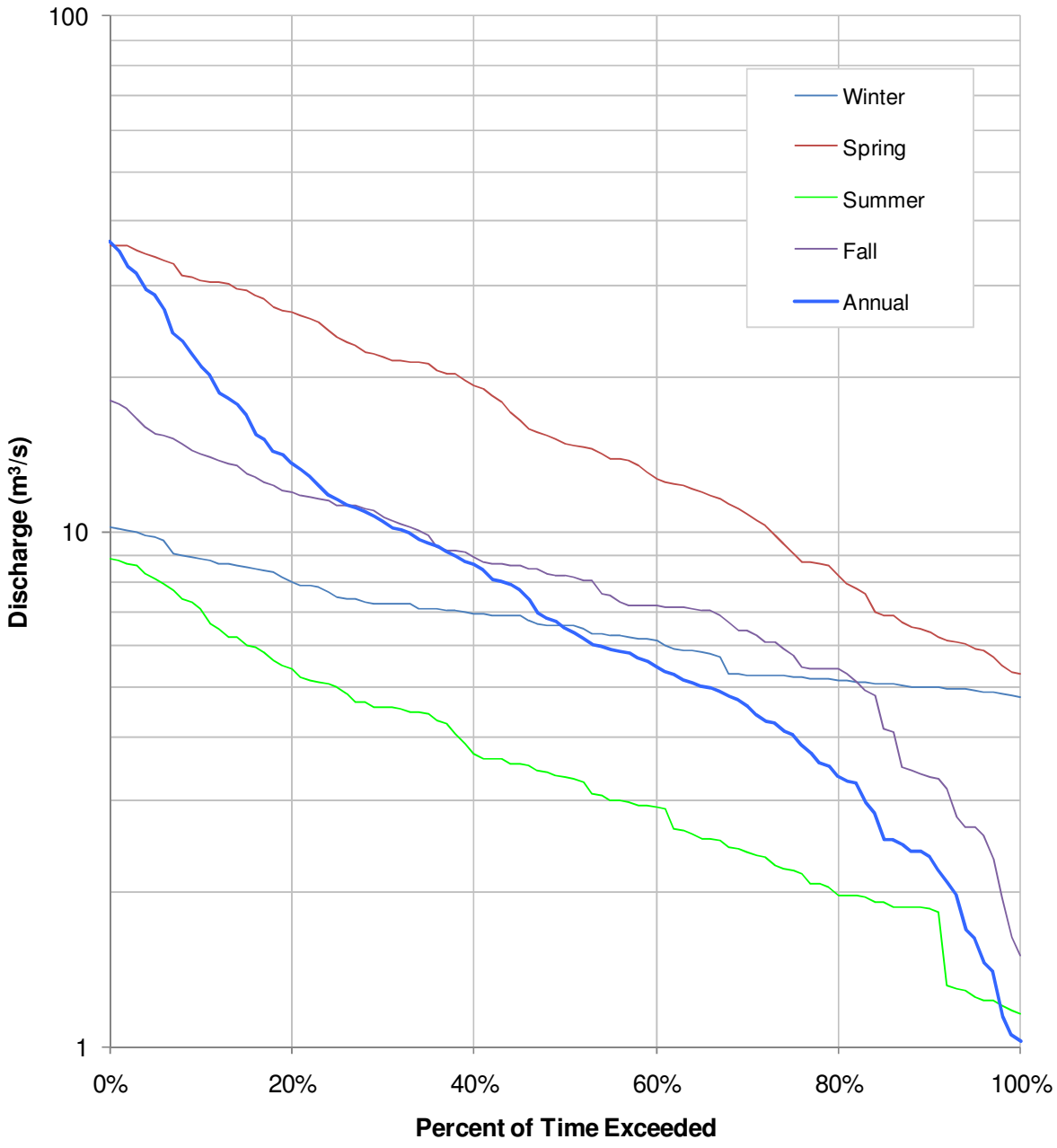

Table 6
Annual and Seasonal Medians of Percentiles
Serpent River at Four Slide Falls

Percent of Time	Discharge (m^3/s)				
	Winter	Spring	Summer	Fall	Annual
	Jan 15 Mar 22	Mar 23 Jun 30	Jul 1 Oct 9	Oct 10 Jan 14	
1	10.1	36.0	8.78	17.7	34.9
5	9.74	34.1	8.08	15.5	28.7
10	8.86	30.7	7.07	14.2	20.9
15	8.51	29.3	6.03	13.0	16.9
20	7.99	26.7	5.41	11.9	13.6
25	7.49	23.9	4.99	11.2	11.6
30	7.26	21.7	4.58	10.6	10.4
35	7.07	21.1	4.42	9.84	9.47
40	6.92	19.2	3.71	8.90	8.64
45	6.86	16.5	3.53	8.62	7.69
50	6.59	14.8	3.34	8.20	6.49
55	6.31	13.9	3.02	7.54	5.91
60	6.14	12.7	2.91	7.16	5.47
65	5.82	11.9	2.54	7.05	5.00
70	5.27	10.8	2.39	6.41	4.60
75	5.23	9.05	2.20	5.74	4.03
80	5.16	8.23	1.97	5.42	3.36
85	5.05	6.87	1.90	4.13	2.53
90	4.99	6.37	1.85	3.35	2.34
95	4.91	5.92	1.24	2.66	1.63
99	4.82	5.34	1.18	1.63	1.06

Figure 7

Monthly Medians of Percentiles
Serpent River at Four Slide Falls

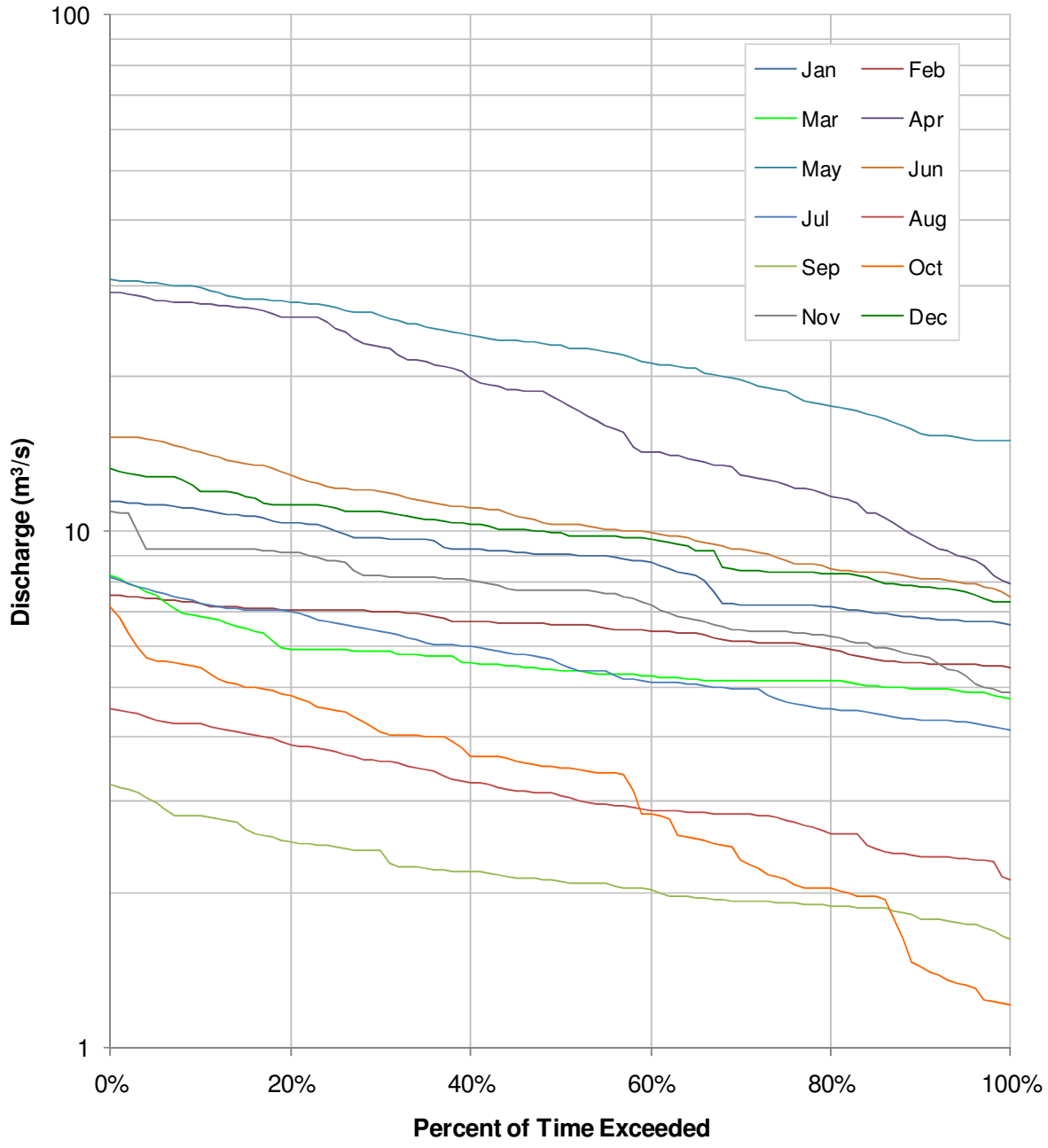

Table 7
Monthly Medians of Percentiles
Serpent River at Four Slide Falls

Percent of Time	Discharge (m^3/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	11.4	7.51	8.10	29.0	30.6	15.2	8.07	4.52	3.20	6.80	10.9	13.1
5	11.3	7.41	7.50	28.0	30.3	15.1	7.64	4.33	2.98	5.61	9.21	12.8
10	11.1	7.26	6.87	27.7	29.6	14.2	7.27	4.24	2.81	5.44	9.21	11.9
15	10.7	7.12	6.48	27.1	28.2	13.5	7.07	4.07	2.66	5.00	9.21	11.7
20	10.4	7.07	5.93	26.0	27.9	12.8	7.00	3.86	2.51	4.80	9.13	11.2
25	10.0	7.07	5.89	24.8	27.2	12.1	6.65	3.74	2.45	4.49	8.76	11.1
30	9.70	7.00	5.87	22.8	26.1	11.9	6.43	3.60	2.41	4.11	8.19	10.9
35	9.65	6.88	5.75	21.3	24.9	11.4	6.10	3.47	2.23	4.02	8.15	10.6
40	9.24	6.70	5.56	19.8	24.0	11.1	6.01	3.27	2.20	3.66	8.07	10.3
45	9.13	6.64	5.48	18.8	23.4	10.7	5.80	3.15	2.13	3.60	7.72	10.1
50	9.03	6.60	5.38	17.9	22.9	10.3	5.52	3.09	2.10	3.50	7.72	9.93
55	8.95	6.51	5.30	16.1	22.4	10.1	5.36	2.96	2.08	3.41	7.60	9.77
60	8.72	6.42	5.26	14.2	21.1	9.94	5.11	2.88	2.02	2.83	7.18	9.69
65	8.20	6.35	5.17	13.7	20.7	9.60	5.06	2.86	1.96	2.54	6.75	9.19
70	7.21	6.13	5.15	12.8	19.7	9.22	4.95	2.84	1.93	2.32	6.44	8.43
75	7.21	6.11	5.15	12.3	18.7	8.79	4.68	2.76	1.91	2.11	6.41	8.34
80	7.16	5.91	5.15	11.7	17.5	8.50	4.53	2.60	1.89	2.04	6.28	8.29
85	6.97	5.66	5.02	10.9	16.7	8.33	4.43	2.43	1.87	1.97	5.95	8.06
90	6.80	5.55	4.96	9.68	15.5	8.10	4.32	2.35	1.77	1.43	5.73	7.83
95	6.72	5.52	4.90	8.93	15.1	7.94	4.27	2.32	1.74	1.33	5.26	7.62
99	6.64	5.48	4.78	8.02	15.0	7.62	4.17	2.15	1.65	1.22	4.90	7.31

Table 8
Seven-Day Low Flow Frequency Estimates
Serpent River at Four Slide Falls

Return Period (years)	Discharge (m^3/s)
100	0.102
50	0.136
20	0.208
10	0.304
5	0.482
3.3	0.672
2	1.16

Table 9
Maximum Instantaneous Flood Estimates
Serpent River at Four Slide Falls

Return Period (years)	Maximum Instantaneous Discharge (m^3/s)
2	33.3
5	43.5
10	48.6
20	52.5
50	56.7
100	59.1
1000	64.9
10,000	68.5

Table 10
Descriptive Flow Statistics
Serpent River at Four Slide Falls[6]

Statistic	Daily Discharge (m^3/s)
Maximum	88.1
20% Exceedance	14.0
Mean	9.56
Median	6.80
80% Exceedance	3.30
Minimum	0.000

[6] Inconsistencies between the flood frequency estimates in Table 9 and the maximum daily discharge in Table 10 are believed to be due to a few anomalous values in the synthetic dataset.