

Appendix B – Precipitation

Kruskal-Wallis Test (from Walpole & Myers, 1993, and Maidment, 1993)

The Kruskal-Wallis test is a non-parametric test (introduced in 1952 by W.H. Kruskal and W.A. Wallis) which tests the equality of means of independent samples, to identify whether they are from the identical populations.

The samples sets are combined, and ranked in ascending order. These ranks then replace the actual data in each sample. An “H” statistic is found through the following equation:

$$H = \frac{12}{n(n+1)} \sum_{i=1}^k \frac{R_i^2}{n_i} - 3(n+1)$$

Where R_i is the sum of ranks for each sample, n_i is the number of data in each sample, and n is the total number of data in all the samples combined.

This is then compared to the 95% Chi squared distribution, with degrees of freedom, and defines whether the null hypothesis (sample sets are from the same population) is met or not. If H falls within the critical region greater than the Chi squared variable ($H > X_{\alpha}^2$), then the null hypothesis is rejected at that significance, otherwise, the null hypothesis is accepted.

Mann-Kendall Test (from Haan, 2002, and Helsel & Hirsch, 2002)

The Mann-Kendall Test is a non-parametric test that identifies trend, typically with time, in a series of data. Each value ($X(t)$) is compared to every other later value in the series ($X(t')$), and the comparisons are ranked as either positive or negative, and placed in a matrix ($z(k)$). This is evident in the matrices presented in Tables B-1.2.

$$\begin{aligned} z(k) &= 1 \quad \text{if } X(t) > X(t') \\ z(k) &= 0 \quad \text{if } X(t) = X(t') \\ z(k) &= -1 \quad \text{if } X(t) < X(t') \end{aligned}$$

The sum of the matrix values (S), the variance of the matrix ($V(S)$), and the probability of trend (U_c), are then calculated, using the following equations.

$$V(S) = \frac{1}{18} [n(n-1)(2n+5)] \qquad u_c = \frac{S+m}{\sqrt{V(S)}}$$

The value of m is +1 if S is negative, and -1 if S is positive, and n is the number of data values.

The U_c value is then compared to the z -table. If U_c is less than the corresponding z value, there is no significant trend in the data.

B-1 – Combined Precipitation

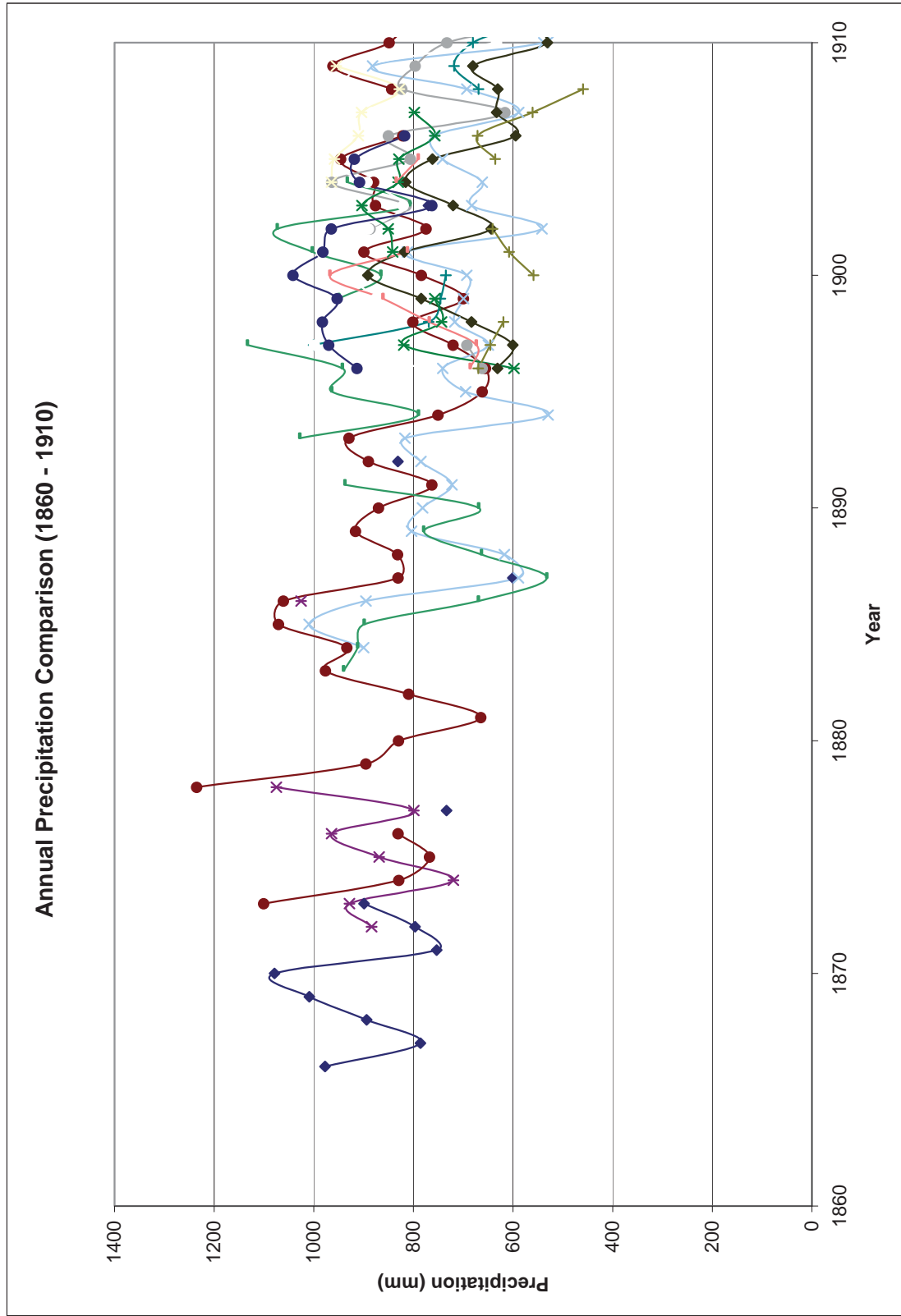


Figure B-1.1a – 1860-1910 Annual Precipitation at Climate Stations

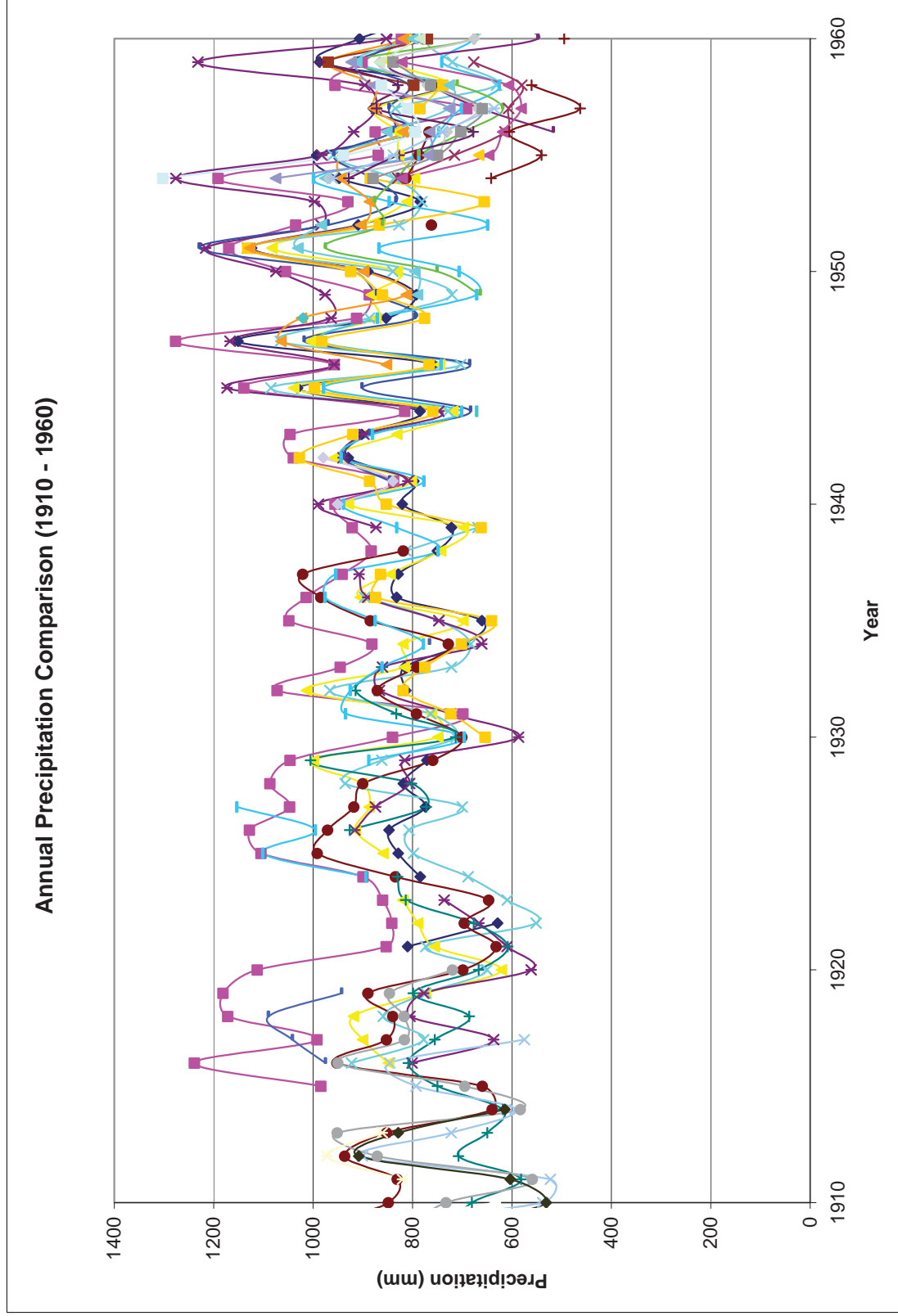


Figure B-1.1b – 1910-1960 Annual Precipitation at Climate Stations

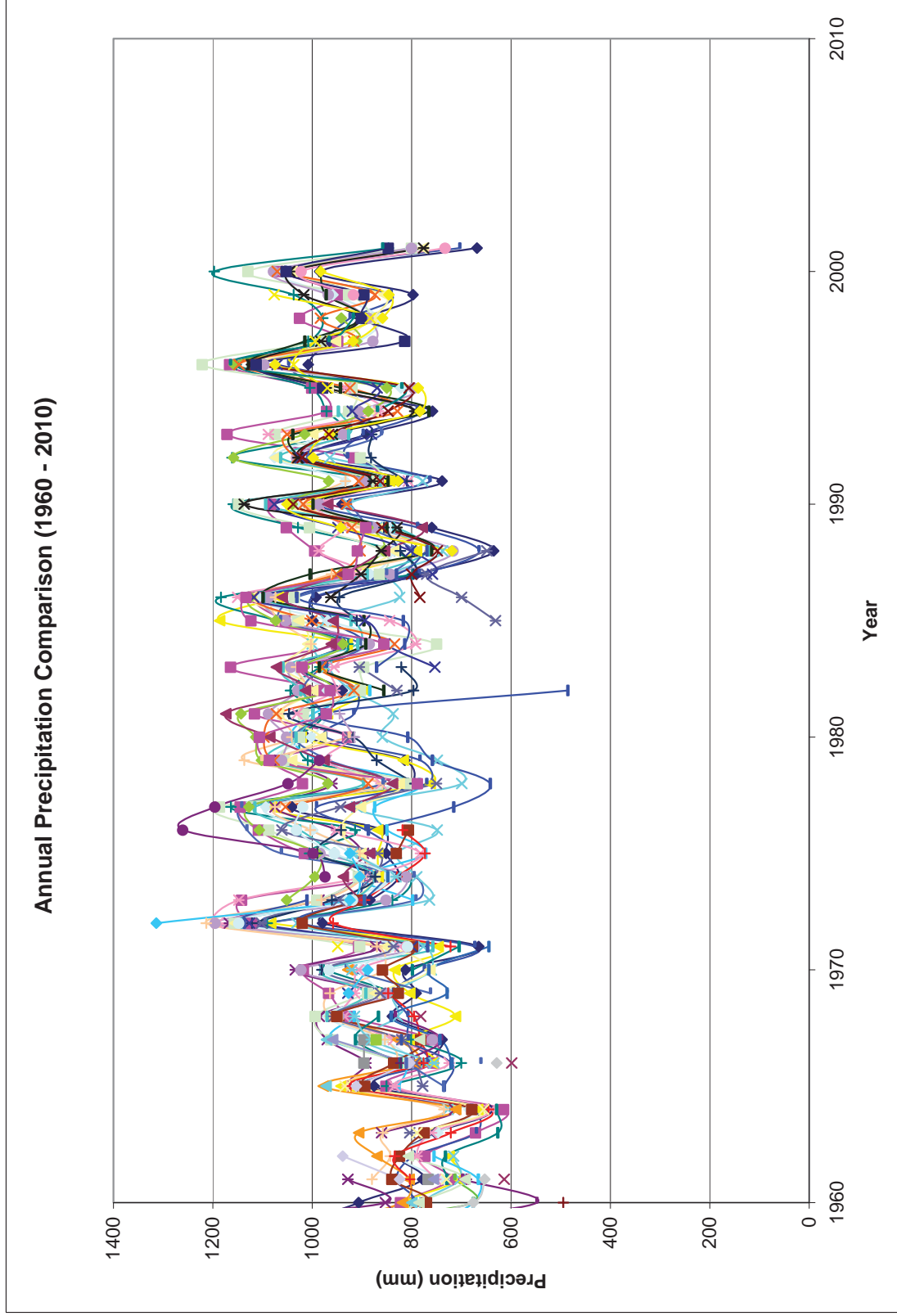


Figure B-1.1c – 1960-2010 Annual Precipitation at Climate Stations

Table B-1.1: Precipitation Kruskal-Wallis Test

Delta1961									Godfrey1961	Hartington1961				Kingston Airport1961		
Delta1962									Godfrey1962	Hartington1962				Kingston Airport1962		
Delta1963									Godfrey1963	Hartington1963				Kingston Airport1963		
Delta1964									Godfrey1964	Hartington1964				Kingston Airport1964		
Delta1965									Godfrey1965	Hartington1965				Kingston Airport1965		
Delta1966									Godfrey1966	Hartington1966				Kingston Airport1966		
Delta1967									Godfrey1967	Hartington1967				Kingston Airport1967		
Delta1968									Godfrey1968	Hartington1968				Kingston Airport1968		138
Delta1969									Godfrey1969	Hartington1969				Kingston Airport1969		183.5
Delta1970									Godfrey1970	Hartington1970			886.7	Kingston Airport1970		128
Delta1971									Godfrey1971	Hartington1971			921.3	Kingston Airport1971		107
Delta1972									Godfrey1972	Hartington1972			1011.8	Kingston Airport1972		187
Delta1973									Godfrey1973	Hartington1973			994.5	Kingston Airport1973		203.5
Delta1974									Godfrey1974	Hartington1974			912.9	Kingston Airport1974		152
Delta1975									Godfrey1975	Hartington1975			905.9	Kingston Airport1975		231
Delta1976									Godfrey1976	Hartington1976			997.4	Kingston Airport1976		294
Delta1977									Godfrey1977	Hartington1977			811	Kingston Airport1977		86.5
Delta1978									Godfrey1978	Hartington1978			856.6	Kingston Airport1978		307
Delta1979									Godfrey1979	Hartington1979			986.1	Kingston Airport1979		278
Delta1980									Godfrey1980	Hartington1980			1022.6	Kingston Airport1980		284
Delta1981									Godfrey1981	Hartington1981			1130.8	Kingston Airport1981		308
Delta1982									Godfrey1982	Hartington1982			947.6	Kingston Airport1982		177
Delta1983									Godfrey1983	Hartington1983			928.2	Kingston Airport1983		162
Delta1984									Godfrey1984	Hartington1984			1212.1	Kingston Airport1984		338
Delta1985									Godfrey1985	Hartington1985				Kingston Airport1985		56
Delta1986									Godfrey1986	Hartington1986			1140.7	Kingston Airport1986		318
Delta1987									Godfrey1987	Hartington1987			870	Kingston Airport1987		73
Delta1988									Godfrey1988	Hartington1988			867.1	Kingston Airport1988		25
Delta1989									Godfrey1989	Hartington1989			805.3	Kingston Airport1989		47
Delta1990									Godfrey1990	Hartington1990			1030.1	Kingston Airport1990		220
Delta1991									Godfrey1991	Hartington1991			1032	Kingston Airport1991		266
Delta1992									Godfrey1992	Hartington1992			969.1	Kingston Airport1992		236
Delta1993									Godfrey1993	Hartington1993			1004	Kingston Airport1993		188
Delta1994									Godfrey1994	Hartington1994			957.2	Kingston Airport1994		207
Delta1995									Godfrey1995	Hartington1995			828.5	Kingston Airport1995		
Delta1996									Godfrey1996	Hartington1996			1193.7	Kingston Airport1996		
Delta1997									Godfrey1997	Hartington1997			1023.6	Kingston Airport1997		
Delta1998									Godfrey1998	Hartington1998			912.9	Kingston Airport1998		
Delta1999									Godfrey1999	Hartington1999			767.1	Kingston Airport1999		
Delta2000									Godfrey2000	Hartington2000			1066.9	Kingston Airport2000		
Delta2001									Godfrey2001	Hartington2001			716.4	Kingston Airport2001		
Delta2002									Godfrey2002	Hartington2002			1071.7	Kingston Airport2002		
Count									24	18			Count			27
Sum									5758.5	3104			Sum			5200.5
									1381680	535268						1001674

Table B-1.1: Precipitation Kruskal-Wallis Test

Napanee1961		Picton1961		Sandhurst1961		Wolfe Island1961	
Napanee1962		Picton1962		Sandhurst1962		Wolfe Island1962	
Napanee1963		Picton1963		Sandhurst1963		Wolfe Island1963	
Napanee1964		Picton1964		Sandhurst1964		Wolfe Island1964	
Napanee1965		Picton1965		Sandhurst1965		Wolfe Island1965	
Napanee1966		Picton1966		Sandhurst1966		Wolfe Island1966	
Napanee1967		Picton1967		Sandhurst1967		Wolfe Island1967	
Napanee1968		Picton1968		Sandhurst1968		Wolfe Island1968	
Napanee1969		Picton1969	44	Sandhurst1969		Wolfe Island1969	
Napanee1970		Picton1970	70	Sandhurst1970		Wolfe Island1970	
Napanee1971		Picton1971	113.5	Sandhurst1971		Wolfe Island1971	
Napanee1972		Picton1972		Sandhurst1972		Wolfe Island1972	
Napanee1973		Picton1973	93	Sandhurst1973		Wolfe Island1973	
Napanee1974		Picton1974		Sandhurst1974		Wolfe Island1974	
Napanee1975		Picton1975		Sandhurst1975		Wolfe Island1975	
Napanee1976		Picton1976	349	Sandhurst1976		Wolfe Island1976	
Napanee1977		Picton1977	252	Sandhurst1977		Wolfe Island1977	
Napanee1978		Picton1978		Sandhurst1978		Wolfe Island1978	
Napanee1979		Picton1979		Sandhurst1979		Wolfe Island1979	
Napanee1980		Picton1980		Sandhurst1980		Wolfe Island1980	
Napanee1981		Picton1981	310	Sandhurst1981		Wolfe Island1981	
Napanee1982		Picton1982	166	Sandhurst1982		Wolfe Island1982	
Napanee1983		Picton1983	63	Sandhurst1983		Wolfe Island1983	
Napanee1984		Picton1984	337	Sandhurst1984		Wolfe Island1984	
Napanee1985		Picton1985	36	Sandhurst1985		Wolfe Island1985	
Napanee1986		Picton1986		Sandhurst1986		Wolfe Island1986	
Napanee1987		Picton1987	882.1	Sandhurst1987		Wolfe Island1987	776.1
Napanee1988		Picton1988	796.9	Sandhurst1988		Wolfe Island1988	
Napanee1989	871.9	Picton1989	839.3	Sandhurst1989		Wolfe Island1989	863.9
Napanee1990	982.1	Picton1990	1020.1	Sandhurst1990		Wolfe Island1990	975.8
Napanee1991	1016.8	Picton1991		Sandhurst1991		Wolfe Island1991	986.9
Napanee1992	898.1	Picton1992		Sandhurst1992		Wolfe Island1992	
Napanee1993	978.7	Picton1993		Sandhurst1993		Wolfe Island1993	948.4
Napanee1994	847.7	Picton1994	1033.9	Sandhurst1994	916.6	Wolfe Island1994	931
Napanee1995	693.6	Picton1995		Sandhurst1995	687	Wolfe Island1995	661.8
Napanee1996	1074.4	Picton1996		Sandhurst1996	1226.4	Wolfe Island1996	1147.2
Napanee1997		Picton1997		Sandhurst1997	1065	Wolfe Island1997	
Napanee1998	892.5	Picton1998		Sandhurst1998	985.2	Wolfe Island1998	
Napanee1999	760.1	Picton1999		Sandhurst1999		Wolfe Island1999	
Napanee2000		Picton2000		Sandhurst2000		Wolfe Island2000	
Napanee2001		Picton2001		Sandhurst2001	801.1	Wolfe Island2001	
Napanee2002		Picton2002		Sandhurst2002		Wolfe Island2002	
Count	10	Count	16	Count	6	Count	8
Sum	1374.5	Sum	2537.5	Sum	1047	Sum	1213
	188925		402432		182702		183921

Table B-1.2a: Mann Kendall Test - Picton

	831.5	818.1	855.7	895.5	880.6	1166.8	1018.8	1082.9	933.1	845.1	1132.9	808.3	882.1	796.9	839.3	1020.1	1033.9
831.5																	
818.1	-1																
855.7	1	1															
895.5	1	1	1														
880.6	1	1	1	-1													
1166.8	1	1	1	1	1												
1018.8	1	1	1	1	1	-1											
1082.9	1	1	1	1	1	-1	1										
933.1	1	1	1	1	1	-1	-1	-1									
845.1	1	1	-1	-1	-1	-1	-1	-1	-1								
1132.9	1	1	1	1	1	-1	1	1	1	1							
808.3	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1						
882.1	1	1	1	-1	1	-1	-1	-1	-1	1	-1	1					
796.9	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1				
839.3	1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1			
1020.1	1	1	1	1	1	-1	1	-1	1	1	-1	1	1	1	1		
1033.9	1	1	1	1	1	-1	1	-1	1	1	-1	1	1	1	1	1	

S=	14
m=	-1
N=	17
n=	0
V(S)=	589
uc=	0.536

No Trend