THE WEST COAST
REGIONAL COUNCIL

State of the Environment Report

West Coast Climate and Surface Water Quantity 2000 to 2004

November 2005

West Coast Climate and Surface Water Quantity

State of the Environment Technical Report 05003

November 2005

A technical report presenting climate and hydrological data collected within the West Coast Region for the five year period from 1 January 2000 to 31 December 2004

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Acknowledgements

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Executive Summary

A 5 year "State of the Environment" hydrometric report has been produced for the years from 2000 to 2004, inclusive. This follows a comprehensive summary of long-term climate, rainfall and flow normals produced by Bowis and Faulkner in 2000. These long-term normals are scheduled to be recalculated in 2010.

Climate, rainfall and flow statistics are presented to fulfil the Regional Council's responsibility to monitor and report on the environment, and to assist Council staff and resources users in climate, rainfall and river flow and analysis. Parameters and sites included in the report were based on those presented in 2000, with the aim of disclosing trends and patterns that characterised the 2000 to 2004 period.

In general the period was characterised by slightly higher than average temperatures and sunshine hours, and accordingly less frost days than usual.

Annual rainfall for each of the five years considered tended to be below average for gauges north of Greymouth, but about average for gauges south of this. Reefton especially showed lower than average annual rainfall totals for the reporting period. Seasonal rainfall anomalies are discussed. Notably, all sites recorded below average autumn rainfall for each of the years from 2001 to 2004.

Rivers flows for 2000 to 2004 also had a definite regional pattern. North of the Hokitika township mean flows across the entire reporting period were about normal – and they encompassed a number of significant flood and low flow events. Extreme low flows were especially prevalent; and in several cases the lowest ever recorded flows occurred within the reporting period. South of Hokitika township mean flows for the entire reporting period were consistently below the long-term mean for each site. However, significant floods and low flows were not prevalent, as they were for the northern half of the region. Within this general pattern there were a number of interesting anomalies, which are detailed in the text. When river flows for the reporting period are considered alongside climatic conditions, it is evident that the observed flow patterns were in response to rainfall patterns. From this analysis, human induced change to catchment flow regimes is not indicated.

The results presented provide useful information about meteorological and hydrological conditions over the last 5 years. The statistics are put in context with long-term expected averages, which provides relevance to many industries and developments in the region. They also provide a context for analysing other types of data, both within and external to the Regional Council.

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1. Introduction

Regional Councils in New Zealand are obligated to monitor the environment, as determined by Section 35 (1 and 2a) of the Resource Management Act 1991. Accordingly, the West Coast Regional Council monitor, or contribute towards the monitoring of, many environmental parameters within the West Coast region. Continual monitoring is important for disclosing environmental change (both natural and human induced), and provides an objective measure by which the Council's polices and plans to protect the environment can be assessed.

On the West Coast rainfall and river flows are monitored primarily for the purpose of flood warning. Other applications of the data include works operations, engineering, consent processing and compliance, input to water plan and allocation regimes, national statistics, flood mapping, and legal evidence. It also provides context for analysing other types of data (contaminate concentrations in water bodies, seasonal milk yields from dairy properties etc). The data is also an important public good used for farming, recreational and educational purposes.

In 2000 a comprehensive report was produced by the West Coast Regional Council that summarised extensive lengths of record for a number of climate, rainfall and flow stations in the region (Bowis and Faulkner, 2000). The report provided a timely analysis of long term physical conditions in the West Coast region. It doesn't concentrate on environmental change so much as provide a reference point against which future environmental indicators and trends can be compared.

This current report is the first hydrometric "state of the environment" report produced subsequent to the 2000 data summary. It analyses data for the 5 years from 2000 to 2004 (inclusive), and presents the results in context with the long-term expected averages calculated by Bowis and Faulkner in 2000. It was recommended in the 2000 Hydrometric Summary that the long-term normals be updated every 5 years. However, on further consideration it was decided that for 2005 a five year state of the environment report would be of more value, and that the long-term average statistics be updated in 2010.

2. Methodology

The sites and parameters chosen to report on were based on those presented in the 2000 Hydrometric Summary. For consistency the results are also presented in the same order; climate, rainfall and river flows. Statistics drawn for the data are similar, although less comprehensive, to those in 2000, and the 2000-2004 results are generally presented as a comparison to long-term averages. Most results are presented graphically, although absolute numbers are available from the West Coast Regional Council on request. The focus of this document is on trends and environmental change.

2.1 Climate Data

Data was obtained from the 7 climate sites for which data was presented in 2000 (see Table 2.1 and Figure 2.1). Monitoring site details can be found in the 2000 report (Bowis and Faulkner , 2000) and are not repeated in this report.

Parameters reported on, where available, are:

- air temperature
- sunshine hours
- ground frost occurrence (number of days)

Table 2.1: Climate Stations included in analysis

Catchment	Climate Station	Site Number	Map Reference	Altitude (metres)	Start of Record	Recording Authority
Karamea	Arapito	F12213	L27:393-927	10	1978	NIWA
Buller	Westport AWS*	F11754	K29:917-399	10	1944	NIWA
Inangahua	Reefton EWS**	F21182	L30:156-984	160	1960	NIWA
Grey	Grey Aero	F21422	J32:612-592	2	1947	NIWA
Hokitika	Hokitika Aero	F20793	J32:452-306	20	1963	NIWA
Waiho	Franz Josef	F30311/2	H35:817-534	155	1953	NIWA
Haast	Haast AWS	F39803	F37:891-976	5	1941	NIWA

*AWS = Automatic Weather Station ** EWS = Electronic Weather Station

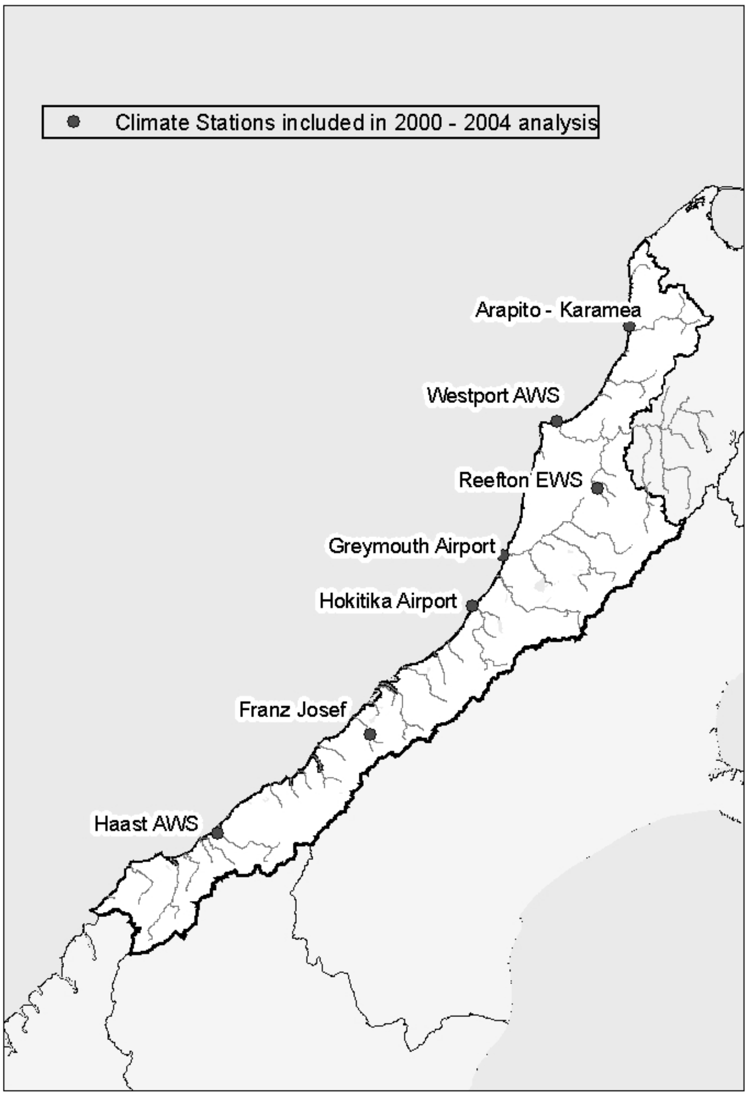

Figure 2.1: Location of climate stations included in the analysis

2.2 Rainfall Data

Of the 27 gauges that were analysed in 2000, 15 were chosen to illustrate rainfall patterns for 2000 to 2004. See Table 2.2 and Figure 2.3. These 15 gauges were chosen primarily for their long length of record (30 years or more), which is required if rainfall is to be compared to long term averages. The rain gauges also provide good regional representation, which is important with the large variations in rainfall within the West Coast Region. This can be seen in Figure 2.2 where long-term mean annual rainfall at each of the 15 sites is plotted.

The rainfall results include annual, seasonal and maximum daily rainfall for 2000 to 2004, compared with long-term averages. The number of days without rainfall for each year is also given.

Table 2.2: Rainfall Stations included in analysis

Catchment	Raingauge	Site Number	Map Reference	Altitude (metres)	Start of Record	Recording Authority
Karamea	Arapito	F12213	L27:393-927	10	1978	NIWA
Buller	Westport AWS	F11754	K29:917-399	10	1944	NIWA
Inangahua	Reefton EWS	F21182	L30:156-984	160	1960	NIWA
Punakaiki	Punakaiki Rocks	F21132	K30:722-983	4	1960	NIWA
Grey	Greymouth Aero	F21422	J32:612-592	2	1947	NIWA
Arnold	Rotomanu 2	F21653	K32:938-385	107	1960	NIWA
Taramakau	Inchbonnie	F21641	K32:831-338	110	1939	NIWA
Hokitika	Hokitika Aero	F20794	J32:448-306	20	1963	NIWA
Cropp	Cropp Hut	301913	J34:459-900	860	1979	NIWA
Ross	Ross	209810	J33:311-105	20	1909	MET
Okarito	Okarito	F30312	H34:790-720	6	1981	NIWA
Waiho	Franz Josef	F30311/2	H35:817-534	155	1926	NIWA
Mahitahi	Mahitahi (Bruce Bay)	F39662	G36:356-233	30	1958	NIWA
Paringa	Paringa	F39741	G36:250-161	43	1956	NIWA
Haast	Haast AWS	F39803	F37:891-976	5	1941	NIWA

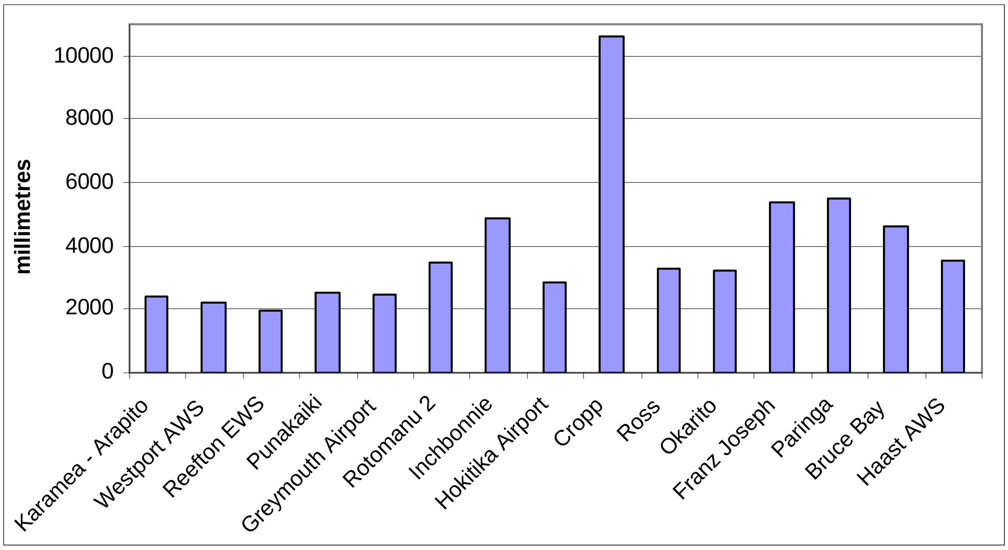

Figure 2.2: Mean annual rainfall of rainfall sites analysed.

Figure 2.3: Location of rainfall stations included in the analysis

2.3 Flow Data

All sites with good long-term flow record have been included in this report. See Table 2.3 and Figure 2.4. Note, that all the sites included are owned and operated by NIWA, due to Council river stations recording only stage (water level), or having only short data record. The data has been audited by NIWA staff up to the end of 2004, which includes the entire reporting period. However, hydrology is an inexact science, and archived data is always subject to future change, if subsequent information indicates editing is necessary. The data presented in this report is the most accurate to our knowledge at this given point time.

The rivers analysed are variable in terms of their catchment area, flow, and the location of their catchment headwaters. For context Figure 2.5 shows the mean flow of each of the rivers included in this report. The sites have variable length of record; the minimum being 18 years of data for Makawhio River at Rocks, with most sites having more than 25 years of data (see Table 2.3).

In the results mean flows for the years 2000 to 2004 are presented alongside annual mean flows for the entire record. A three-year moving mean has been put through the data to smooth the results and highlight long term flow trends.

Annual maximum instantaneous flows for 2000 to 2004 are given for each of the sites, along with estimated return periods. Annual "7 day low flows" and the estimated return periods of these low flows are also given. A "7 day low flow" is the lowest mean flow over 7 consecutive days (24 hour periods). A mean flow over 7 days, as opposed to an instantaneous minimum flow value, is used to smooth out any noise in the recorded data. Noise could be generated by such things as the monitoring equipment itself, or some human induced effect in the river. Generally there in little variation in flow over the 7 days.

The return period estimates are based on flow frequency analysis carried out by Bowis and Faullkner in 2000 and assume an EV1 (Gumbel) distribution . The accuracy of the estimates is very dependant on the length of record and the "goodness of fit" of the EV1 distribution for the river in question. It is likely that there is some inaccuracy in the return period estimates and they should be considered as indicative only. They should not be used for design purposes. It is recommended that the flow frequency analysis be updated in 2010, or before this time as required.

Site comments are not given, as they are outside the scope of this report. Selected site comments were provided by Bowis and Faulkner (2000)

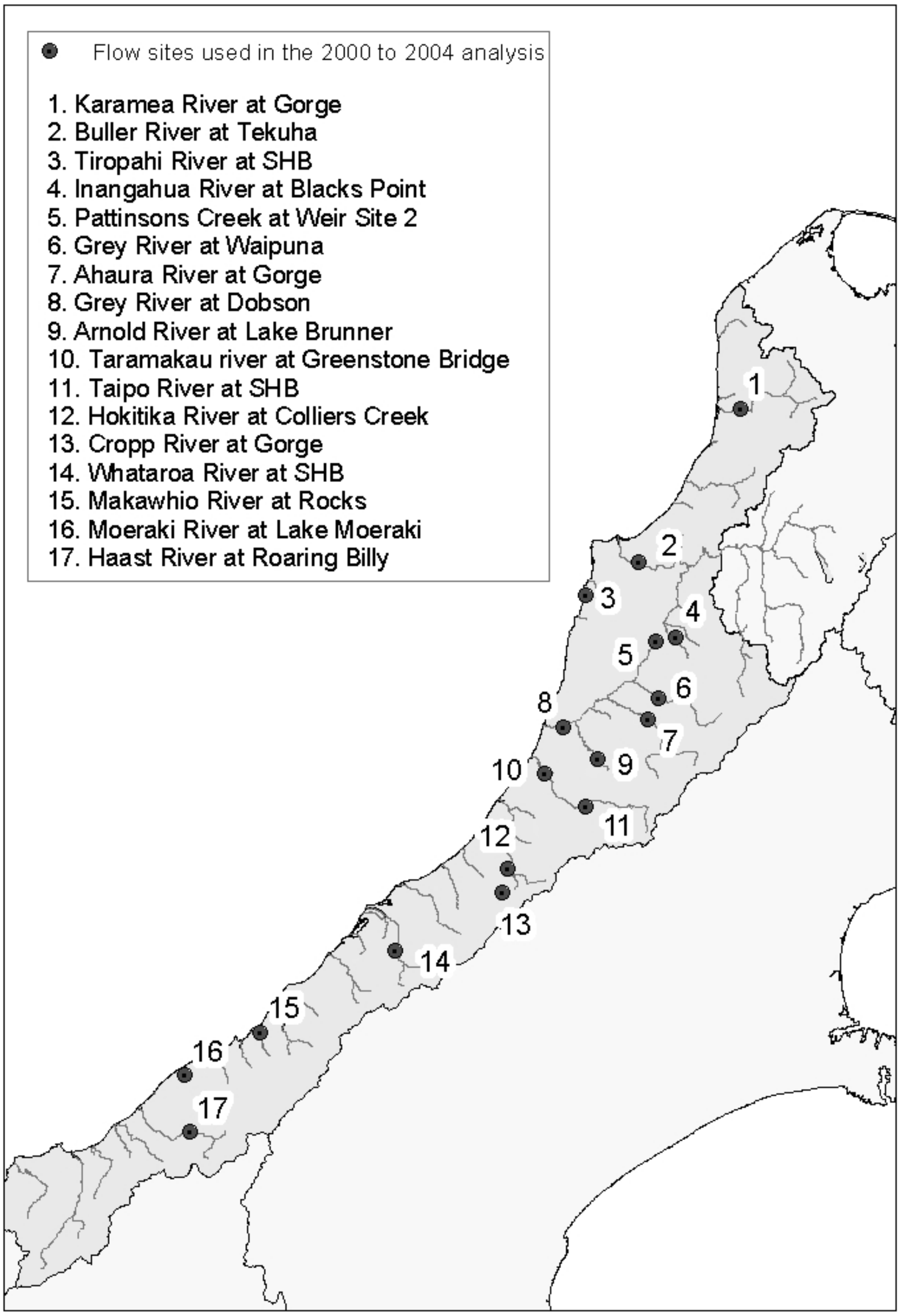

Figure 2.4: Location of flow stations included in the analysis

Table 2.3: Flow stations included in the analysis

River	Site	Site Number	Catchment Area (km^2)	Map Reference	Start of Record	Recording Authority
Karamea	Gorge	95102	1160	L27:446-944	06/77	NIWA/WCRC
Buller	Te Kuha	93203	6350	K29:020-295	07/63	NIWA/WCRC
Tiropahi	SH Bridge	92602	36.5	K30:793-156	12/84	NIWA
Inangahua	Blacks Point	93207	234	L30:172-976	10/63	NIWA
Pattinson Ck	Weir Site No.2	91412	0.66	K30:092-960	12/78	NIWA
Grey	Waipuna	91404	642	L31:100-720	03/69	NIWA/WCRC
Ahaura	Gorge	91407	790	K31:055-632	05/68	NIWA/WCRC
Grey	Dobson	91401	3830	J31:700-601	07/68	NIWA/WCRC
Arnold	Lake Brunner	91405	37	K32:844-467	02/68	Trustpower
Taramakau	Greenstone Br	91104	863	J32:622-403	01/79	NIWA
Taipo	SH Bridge	91103	181	K33:794-266	05/78	NIWA
Hokitika	Colliers Ck/Gorge*	90604/12	37	J33:465-004	05/71	NIWA/WCRC
Cropp	Gorge	90607	12.2	J34:443-902	12/79	NIWA
Whataroa	SH Bridge	89301	445	I35:994-656	11/79	NIWA/WCRC
Makawhio	Rocks	87801	135	G36:425-314	12/86	NIWA
Moeraki	Lake Moeraki	87301	98.4	G36:106-135	11/96	NIWA
Haast	Roaring Billy	86802	1020	G37:129-895	06/69	NIWA/WCRC

*Flow data has been collected on the Hokitika River at "Colliers Creek" from 1971 to 1996, and since then at "Gorge". The sites are synonymous in terms flows up to and including mean flow.

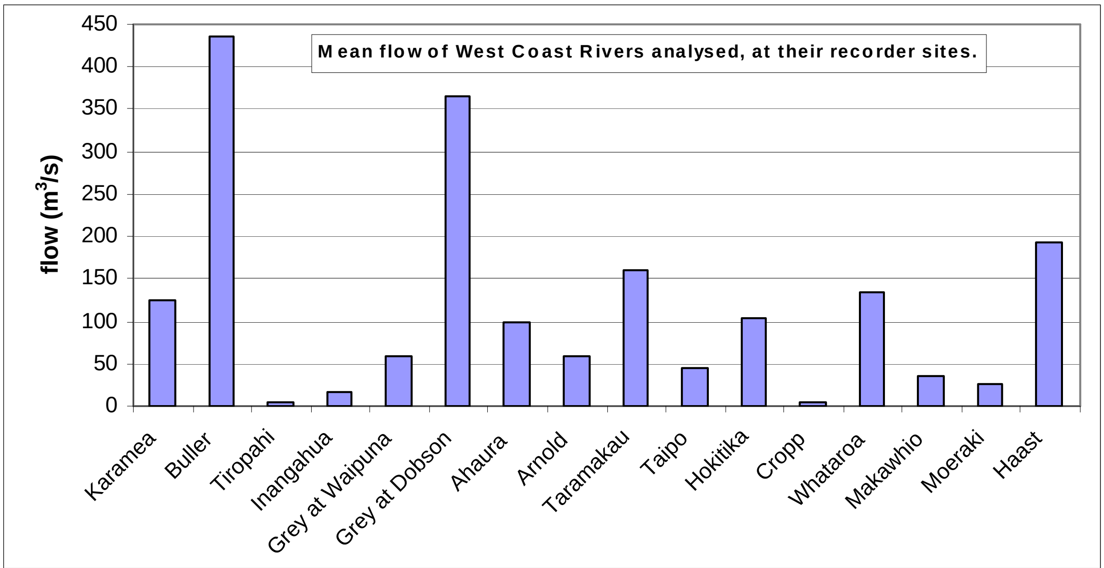

Figure 2.5: Mean flow of flow sites analysed.

3. Climate Results

The following section presents climate data for the 7 nominated stations from 2000 to 2004; in relation to long-terms means presented by Bowis and Faulkner in 2000. In some cases certain parameters were not available – this is indicated in the text. A general summary of the 2000 to 2004 conditions, on the basis of the data presented, is given in Section 6.

3.1 Karamea at Arapito

Air Temperature:

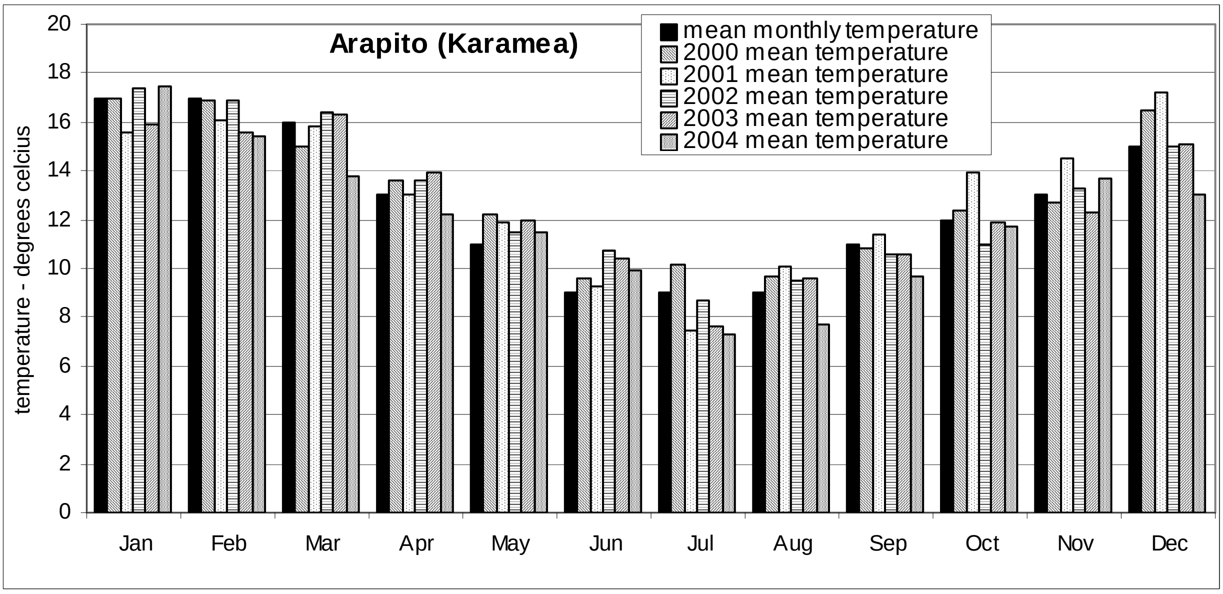

Figure 3.1: 2000 to 2004 air temperatures for Karamea at Arapito

April, May and June temperatures were above average at Arapito for all 5 years reviewed. Temperatures were above average for the period October to December 2001, and below average for the period July to September 2004.

Sunshine hours:

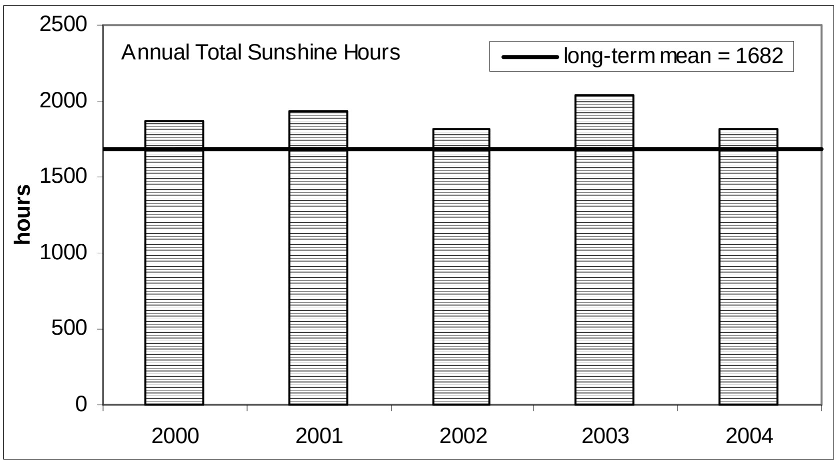

Figure 3.2: 2000 to 2004 sunshine hours for Karamea at Arapito

Annual total sunshine hours for Arapito were slightly above average for all years reviewed

Ground Frost Occurrence:

Table 3.1: 2000 to 2004 Ground Frosts (number of days) for Arapito at Karamea

	mean	2000	2001	2002	2003	2004
Jan	**0**	0	0	0	0	0
Feb	**0**	0	0	0	0	0
Mar	**0**	0	0	0	0	0
Apr	**0**	0	0	0	0	0
May	**2**	0	4	0	0	0
Jun	**6**	2	6	0	1	5
Jul	**9**	6	14	10	14	19
Aug	**5**	3	3	4	2	17
Sep	**1**	2	0	2	1	1
Oct	**0**	0	0	0	0	0
Nov	**0**	0	0	0	0	0
Dec	**0**	0	0	0	0	0
Total	**23**	**13**	**27**	**16**	**18**	**42**

Arapito had less frost days than usual in 2000 and 2002, and significantly more frost days than usual in 2004.

3.2 Westport AWS

Air Temperature:

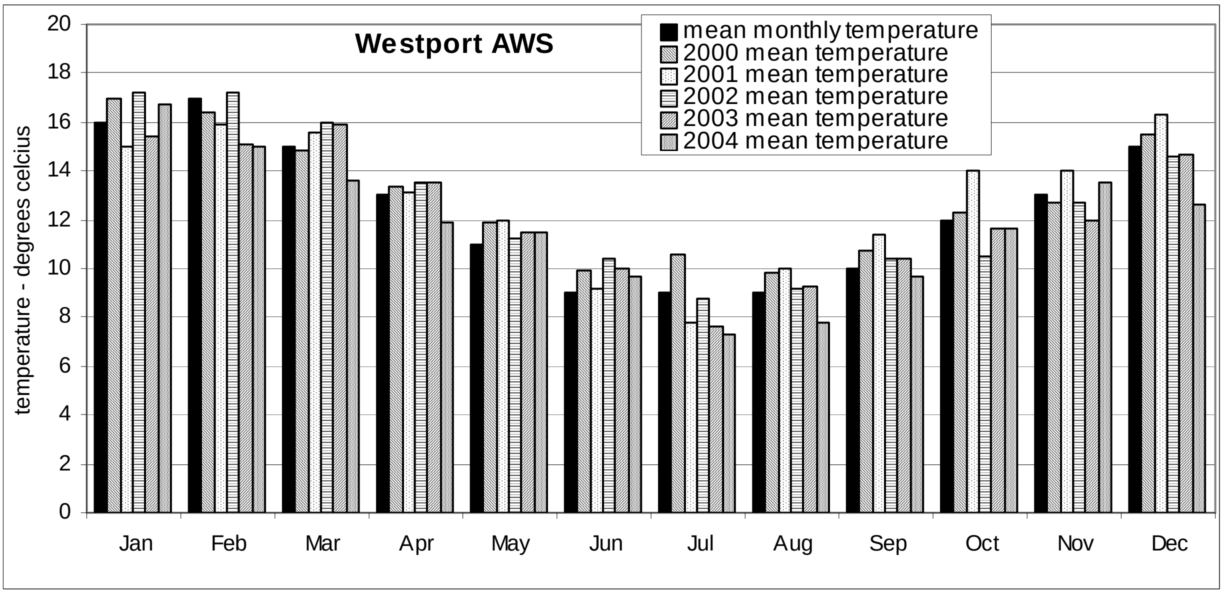

Figure 3.3: 2000 to 2004 air temperatures for Westport AWS

May and June temperatures were above average at Wesport AWS for all 5 years reviewed. Temperatures were above average for the period September to December 2001, and below average for most months in 2004.

Sunshine hours: sunshine data for 2000 to 2004 not available from Westport AWS

Ground Frost Occurrence:

Table 3.2: 2000 to 2004 Ground Frosts (number of days) for Westport AWS

	mean	2000	2001	2002	2003	2004
Jan	**0**		0	0	0	0
Feb	**0**		0	0	0	
Mar	**0**		0	0		
Apr	**1**				0	1
May	**3**		4	0		0
Jun	**7**		5	0	0	
Jul	**10**		14	4	4	10
Aug	**9**	0	2	2		
Sep	**4**	1	0			
Oct	**2**	0	0		0	0
Nov	**0**	0	0	0	0	0
Dec	**0**	0		0	0	
Total	**36**	**?**	**25**	**?**	**?**	**?**

Blank spaces indicate missing record

Westport AWS had less frost days than usual in 2001. Insufficient record is available to comment on other years reviewed, although most months for which there is record had less frost than usual.

3.3 Reefton EWS

Air Temperature:

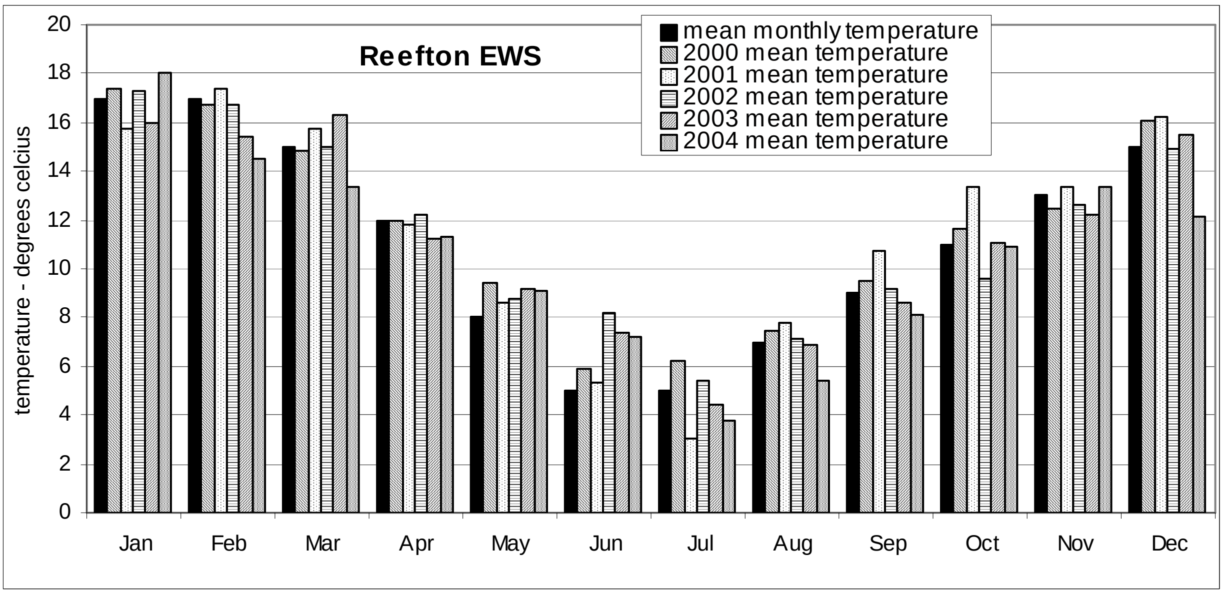

Figure 3.4: 2000 to 2004 air temperatures for Reefton EWS

May, June and July temperatures were above average at Reefton EWS for all 5 years reviewed. Temperatures were above average for September and October 2001, and below average for Feb/Mar/April and July/Aug/Sept of 2004.

Sunshine hours: sunshine data for 2000 to 2004 not available from Reefton EWS

Ground Frost Occurrence

Table 3.3: 2000 to 2004 Ground Frosts (number of days) for Reefton EWS

	mean	2000	2001	2002	2003	2004
Jan	**0**	0	0	0	0	0
Feb	**0**	0	0	0	0	0
Mar	**1**	2	1	0	0	1
Apr	**2**	1	0	2	6	4
May	**8**	1	7	2	4	8
Jun	**13**			1	7	5
Jul	**17**	16	24	12	18	23
Aug	**13**	10	10	14	14	15
Sep	**6**	8	4	4	6	4
Oct	**2**	2	1	6	3	3
Nov	**1**	2	1	3	0	0
Dec	**0**	0	0	0	0	0
Total	**63**	**?**	**?**	**44**	**58**	**63**

Blank spaces indicate missing record

Reefton EWS had fewer frost days than average in 2002, but around average number of days in 2003 and 2004. Insufficient record is available to comment on the 2000 and 2001 winters, however seven more frost days than usual were recorded in July 2001.

3.4 Greymouth Airport

Air Temperature:

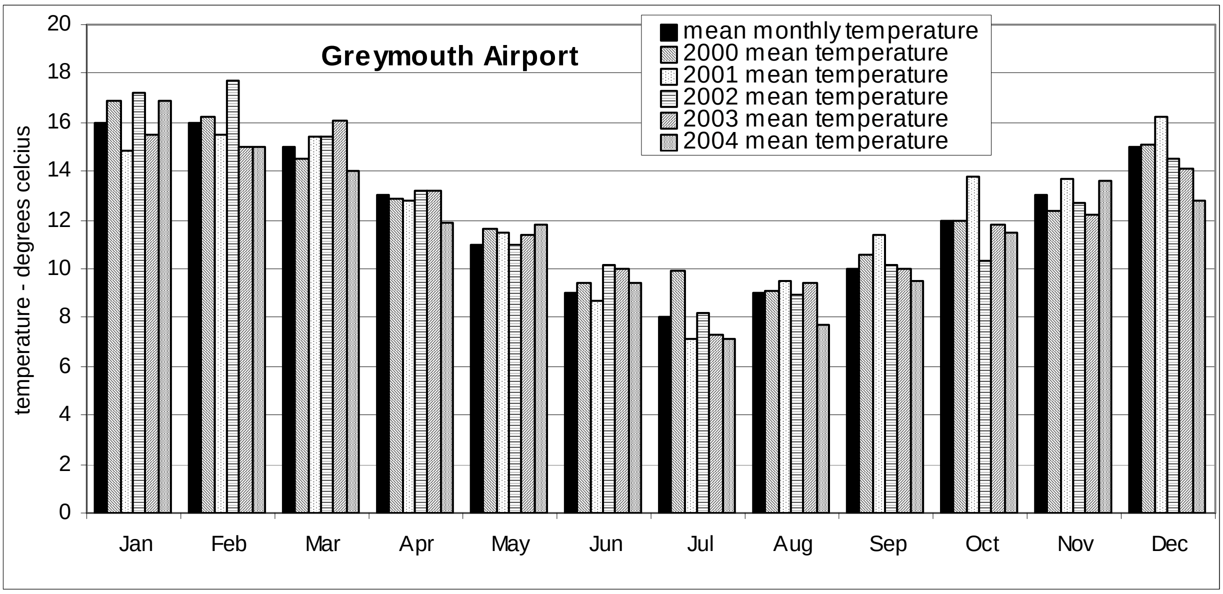

Figure 3.5: 2000 to 2004 air temperatures for Greymouth Airport

May and June temperatures were above average at Greymouth Airport for all 5 years reviewed. Temperatures were above average for September to December 2001, and below average for July and August of 2004.

Sunshine hours:

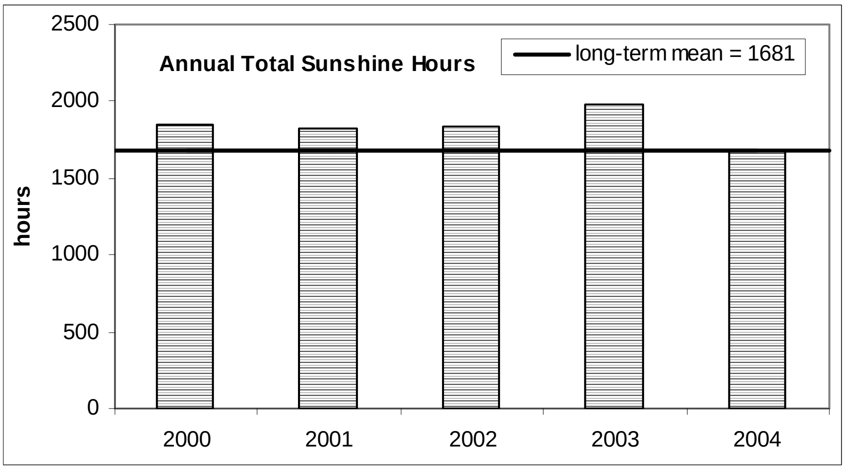

Figure 3.6: 2000 to 2004 sunshine hours for Greymouth Airport

Annual total sunshine hours for Greymouth were slightly above average for 2000 to 2003, and average for 2004.

Ground Frost Occurrence

Table 3.4: 2000 to 2004 Ground Frosts (number of days) for Greymouth Airport

	mean	2000	2001	2002	2003	2004
Jan	**0**	0	0	0	0	0
Feb	**0**	0	0	0	0	0
Mar	**0**	0	0	0	0	0
Apr	**0**	0	0	0	0	0
May	**2**	0	1	0	0	0
Jun	**5**	2	1	0	1	0
Jul	**8**	0	11	2	3	2
Aug	**5**	1	0	2	0	6
Sep	**2**	1	0	0	0	0
Oct	**0**	0	0	0	0	0
Nov	**0**	0	0	0	0	0
Dec	**0**	0	0	0	0	0
Total	**22**	**4**	**13**	**4**	**4**	**8**

Greymouth Airport had fewer frost days than usual for all 5 years reviewed. Exceptions were July 2001 and August 2004.

3.5 Hokitika Airport

Air Temperature:

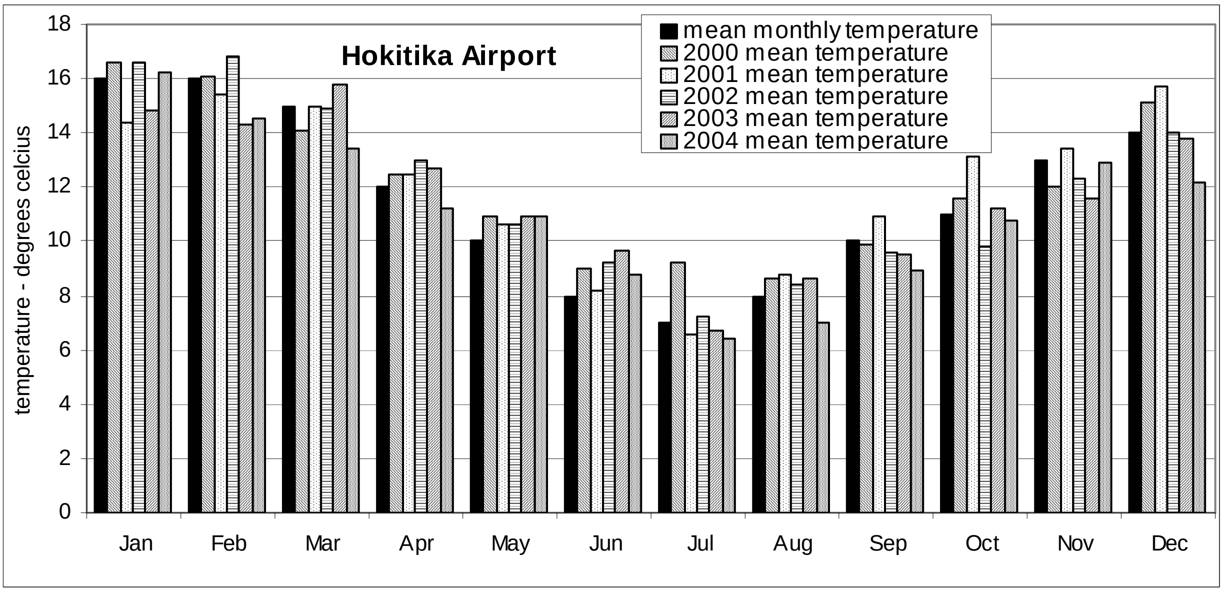

Figure 3.7: 2000 to 2004 air temperatures for Hokitika Airport

May and June temperatures were above average at Hokitika Airport for all 5 years reviewed. Temperatures were above average for September to December 2001, and below average for Feb/Mar/April and Aug/Sept and December of 2004.

Sunshine hours:

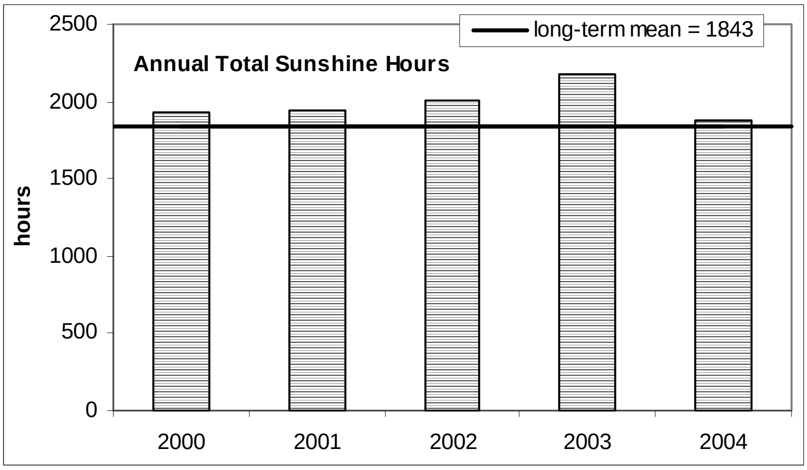

Figure 3.8: 2000 to 2004 sunshine hours for Hokitika Airport

Annual total sunshine hours for Hokitika Airport were slightly above average for 2000 to 2003, and average for 2004.

Ground Frost Occurrence

Table 3.5: 2000 to 2004 Ground Frosts (number of days) for Hokitika Airport

	mean	2000	2001	2002	2003	2004
Jan	**0**	0	0	0	0	0
Feb	**0**	0	0	0	0	0
Mar	**0**	0	0	0	0	0
Apr	**2**	1	0	0	0	2
May	**6**	0	10	1	0	2
Jun	**12**	11	17	1	4	7
Jul	**15**	11	26	9	21	19
Aug	**12**	14	7	6	9	14
Sep	**5**	6	1	1	5	6
Oct	**2**	2	0	1	1	0
Nov	**1**	0	0	0	0	0
Dec	**0**	0	0	0	0	0
Total	**55**	**45**	**61**	**19**	**40**	**50**

Hokitika Airport had less frost days than usual for 2000, 2002 and 2003. There were more frost days than usual in 2001.

3.6 Franz Joseph

Air Temperature:

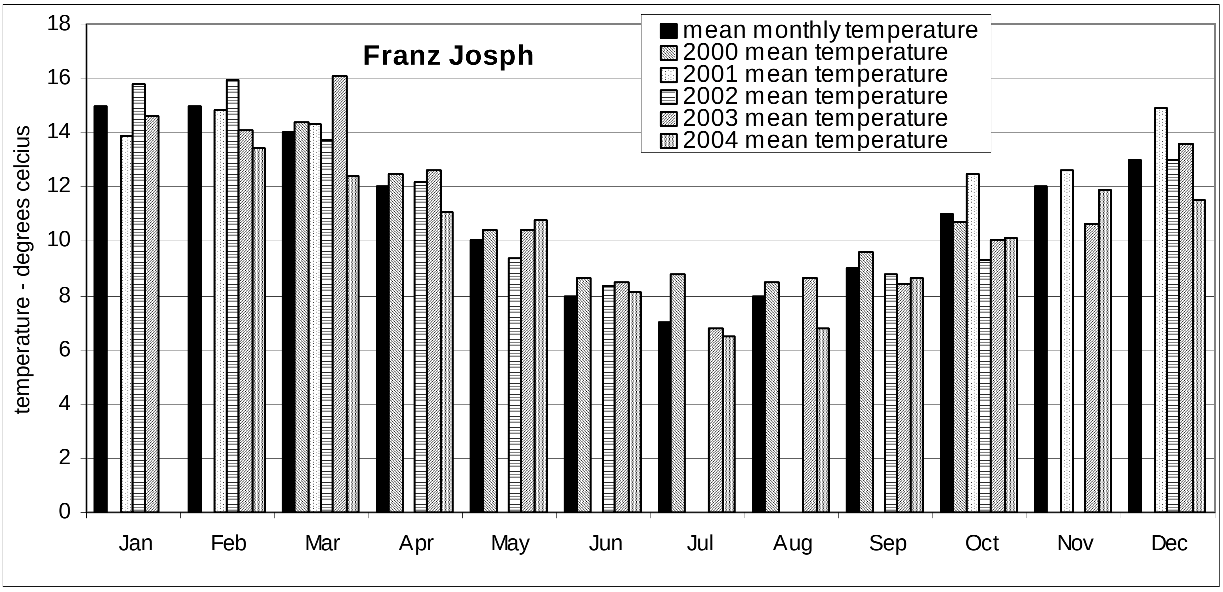

Figure 3.9: 2000 to 2004 air temperatures for Franz Joseph

There are several months with missing temperature readings for the Franz Joseph climate site. The However, the data that is presented shows that temperatures in Franz Joseph were above average for the period October 2001 to February 2002, and below average for July and August 2004.

Sunshine hours: sunshine data for 2000 to 2004 not available from Franz Joseph

Ground Frost Occurrence

Table 3.6: 2000 to 2004 Ground Frosts for (number of days) Franz Joseph

	mean	2000	2001	2002	2003	2004
Jan	0					
Feb	0					
Mar	0					
Apr	0					
May	5					
Jun	11		*Not applicable - too much missing record*			
Jul	14					
Aug	11					
Sep	7					
Oct	2					
Nov	1					
Dec	0					
Total	51					

3.7 Haast AWS

Air Temperature:

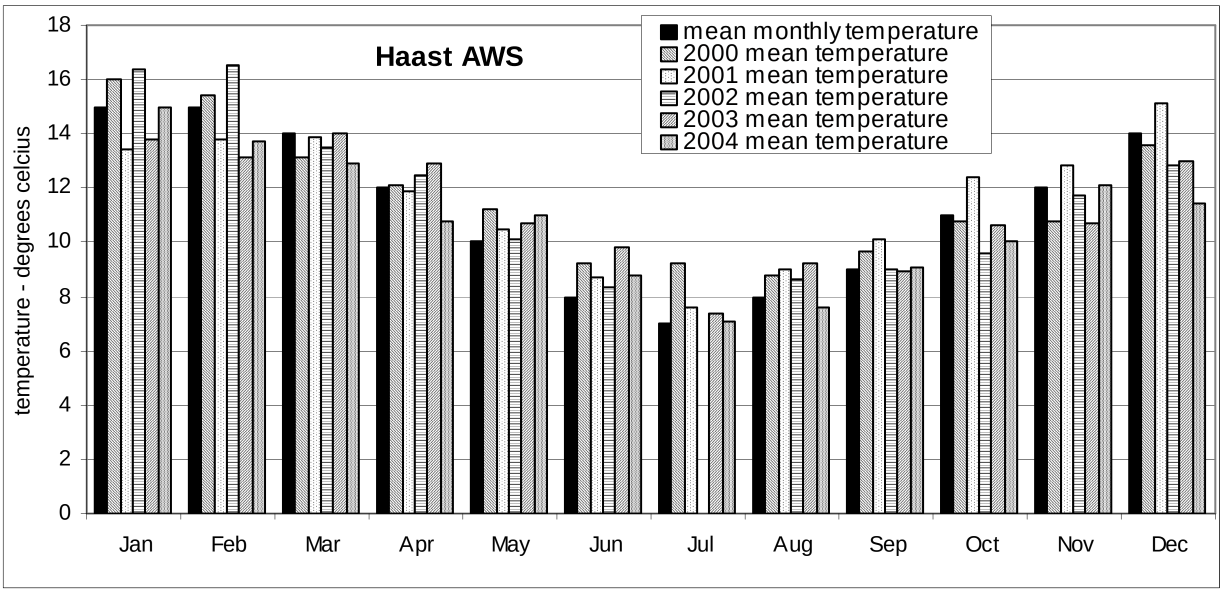

Figure 3.10: 2000 to 2004 air temperatures for Haast AWS

May and June temperatures were above average at Haast AWS for all 5 years reviewed. Temperatures were also above average for the period September 2001 to Febraury 2002. They were below average for Feb/Mar/April and December of 2004.

Sunshine hours: sunshine data for 2000 to 2004 not available from Haast AWS

Ground Frost Occurrence

Table 3.7: 2000 to 2004 Ground Frosts for (number of days) Haast AWS

	mean	2000	2001	2002	2003	2004
Jan	0					
Feb	0					
Mar	0					
Apr	2					
May	6					
Jun	11			*Data not available*		
Jul	11					
Aug	11					
Sep	7					
Oct	5					
Nov	2					
Dec	1					
Total	56	0	0	0	0	0

4. Rainfall Results

The following section presents rainfall data for the 15 nominated stations from 2000 to 2004; in relation to long-term rainfall statistics presented by Bowis and Faulkner in 2000. Annual, seasonal and extreme rainfall statistics are presented. Periods of missing record do occur for some stations, which is made evident in the results.

4.1: Karamea at Arapito

Table 4.1: Rainfall extremes 2000 to 2004, Karamea at Arapito

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	56	28-Dec	18	2-Jul	
2001	48	22-Nov	10	1-Jul	
2002	57	14-Jun	11	10-Apr	
2003	37	12-Nov	20	7-Mar	
2004	73	15-Jun	6	18-Apr	

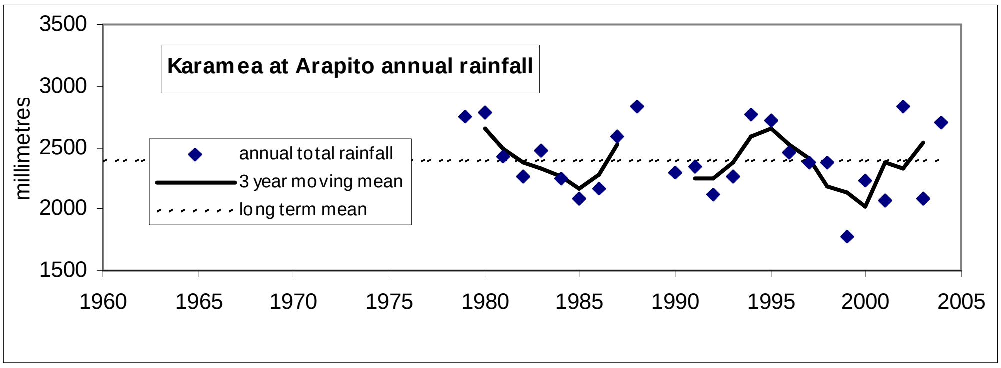

Figure 4.1: Annual rainfall totals to 2004 for Karamea at Arapito

Figure 4.1 shows annual rainfall at Arapito was below average for 2000, 2001 and 2003 and above average for 2002 and 2004.

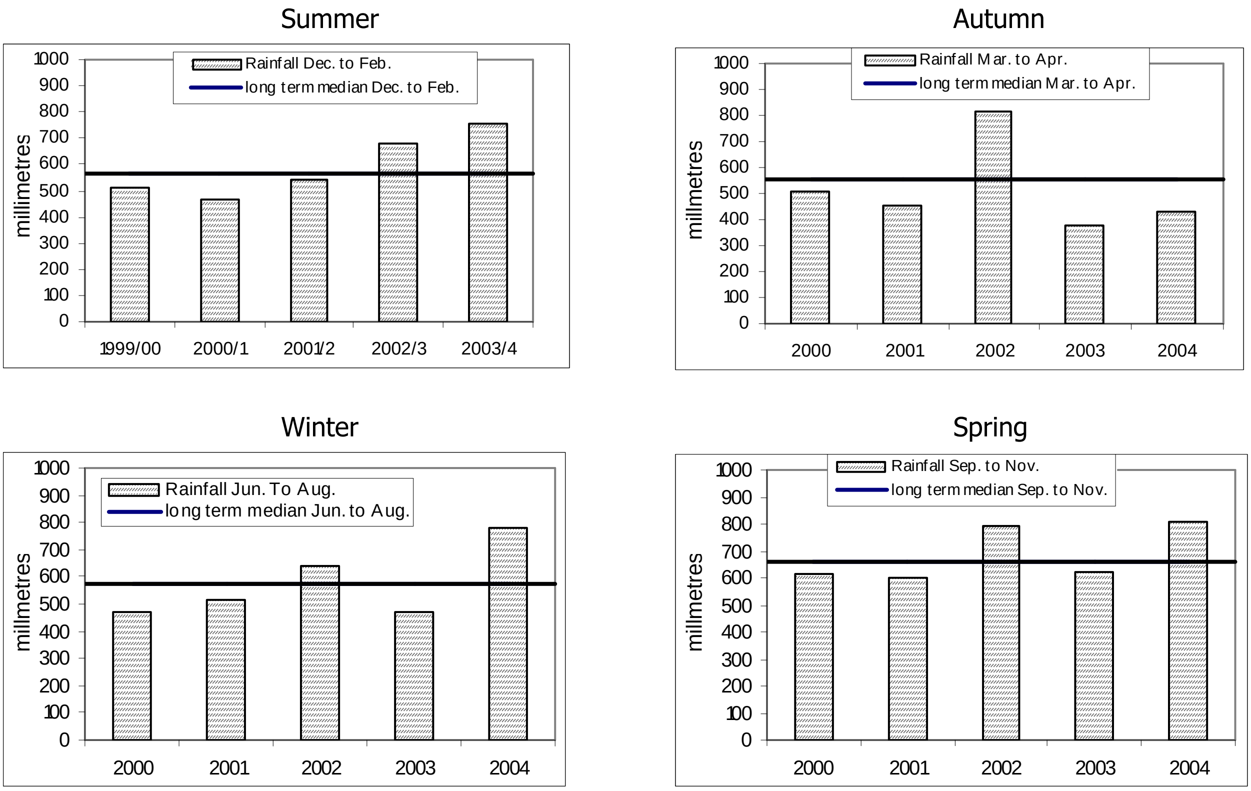

Figure 4.2: Seasonal rainfall plots for 2000 to 2004, Karamea at Arapito

Seasonal anomalies that stand out for Arapito were below average rainfall for all autumns except that of 2000, for the summers of 1999/00 and 2000/01, and for the dry winters of 2000, 2001 and 2003

4.2 Westport AWS

Table 4.2: Rainfall extremes 2000 to 2004, Westport AWS

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	69	6-Apr	9	1-Jul	
2001	85	21-Nov	12	9-May	1-Jul
2002	72	27-Jun	12	9-Apr	
2003	50	11-Oct	8	6-Mar	19-Jul
2004	65	8-Jan	6	20-Jan	9-Jul and 25-Aug

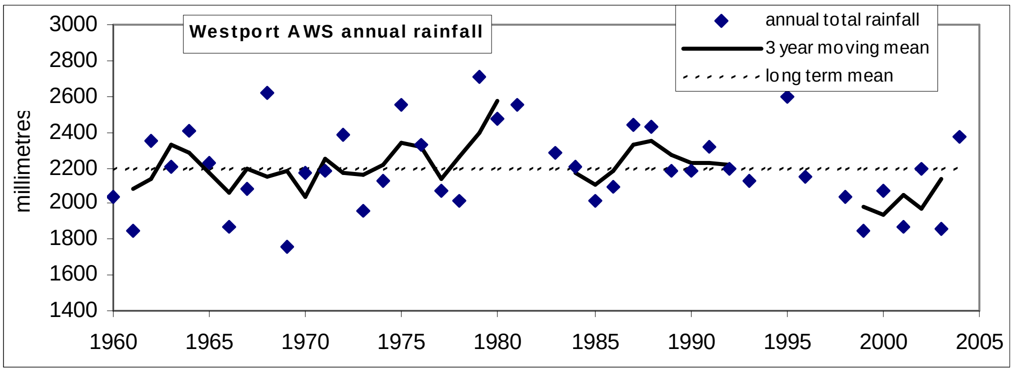

Figure 4.3: Annual rainfall totals to 2004 for Westport AWS

Figure 4.3 shows annual rainfall at Westport AWS was below average for 2000, 2001 and 2003, average for 2002 and above average for 2004.

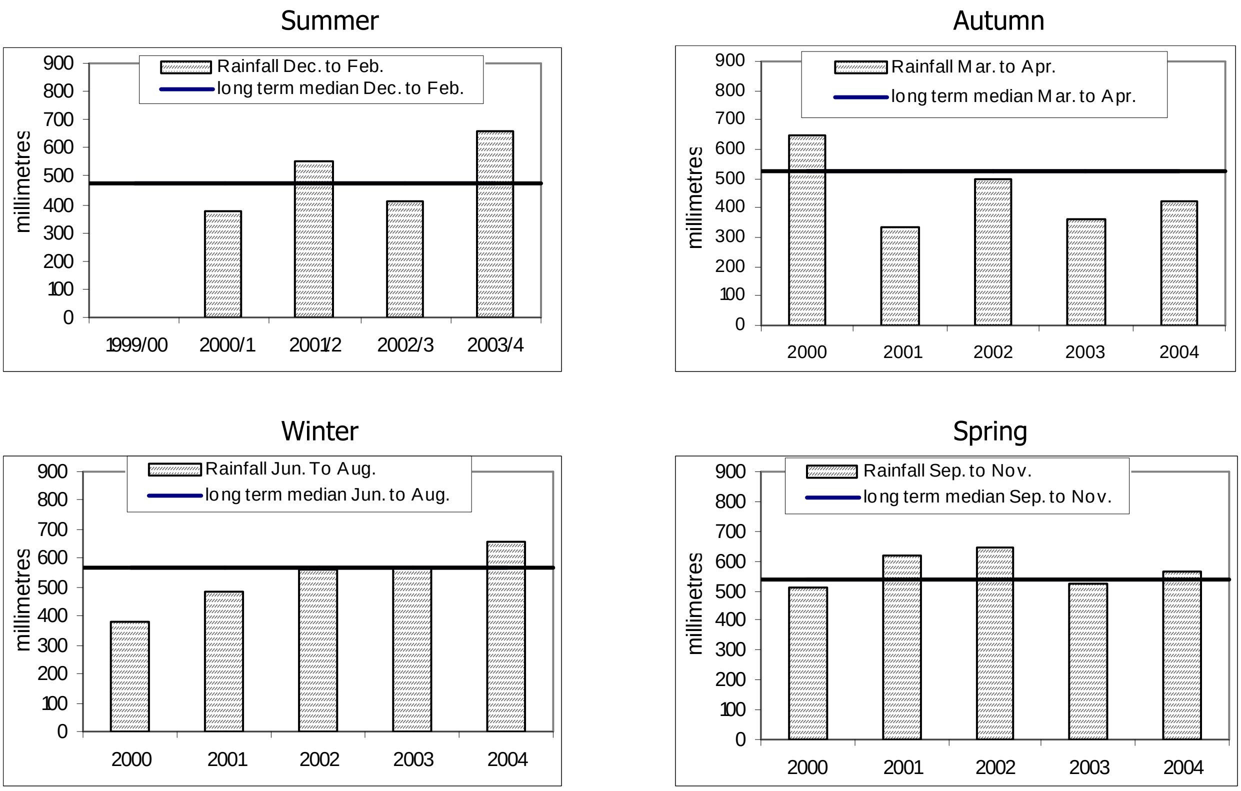

Figure 4.4: Seasonal rainfall plots for 2000 to 2004, Westport AWS

Seasonal anomalies that stand out for Westport AWS were below average rainfall for all autumns except that of 2000, for the summers of 2000/01 and 2002/03, and the winters of 2000 and 2001.

4.3 Reefton EWS

Table 4.3: Rainfall extremes 2000 to 2004, Reefton EWS

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	85	6-Apr	19	1-Jul	
2001	67	15-Jun	24	18-Feb	
2002	70	27-Jun	14	21-Jan	
2003	63	28-Jun	23	6-Mar	
2004	74	29-Dec	12	14-Apr	

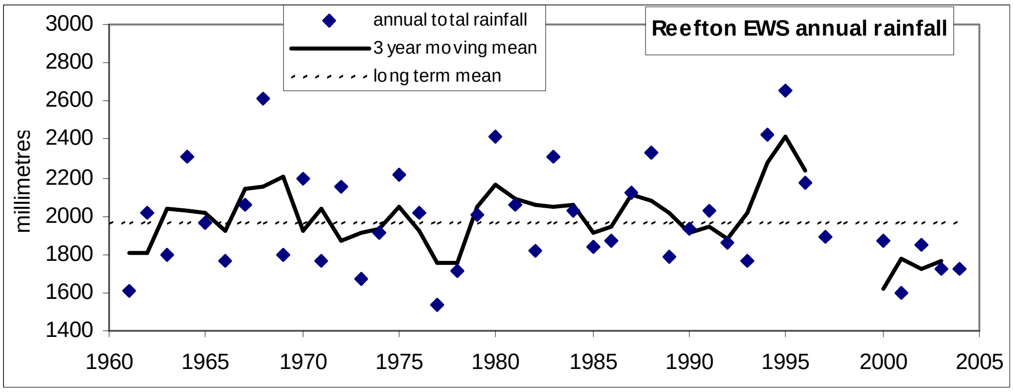

Figure 4.5: Annual rainfall totals to 2004 for Reefton EWS

Figure 4.5 shows annual rainfall at Reefton EWS was below average for all 5 years from 2000 to 2004

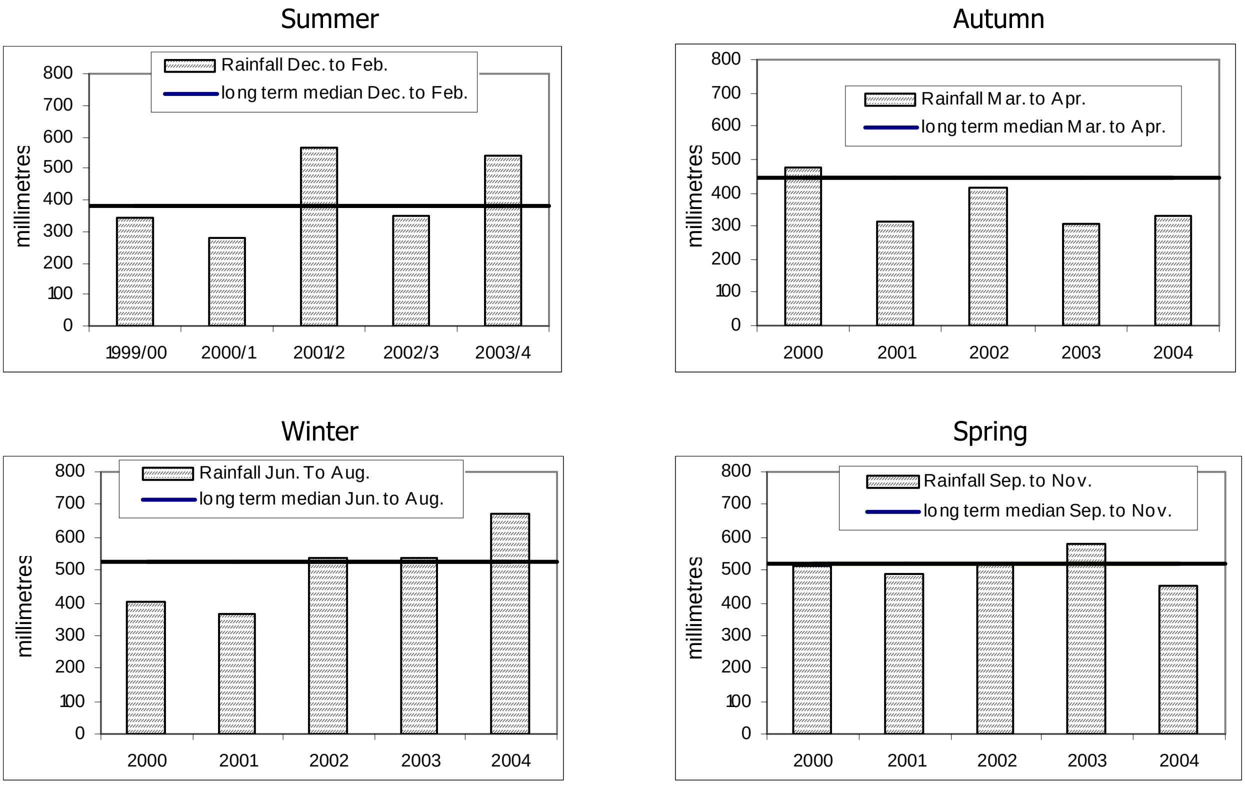

Figure 4.6: Seasonal rainfall plots for 2000 to 2004, Reefton EWS

Seasonal anomalies that stand out for Reefton EWS were below average rainfall for all autumns except that of 2000, for the summers of 1999/00, 2000/01 and 2002/03, and for the winters of 2000 and 2001. Summer 2001/02 and 2003/04 and winter 2004 had above average rainfall.

4.4 Punakaiki Rocks

Table 4.4: Rainfall extremes 2000 to 2004, Punakaiki Rocks

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	91	23-Jan	11	1-Jul	
2001	78	26-Mar	14	22-Apr	1-Jul
2002	78	27-Jun	10	22-Jan	
2003	76	29-Jun	14	10-Apr	
2004	47	8-Jan	6	4-Mar	

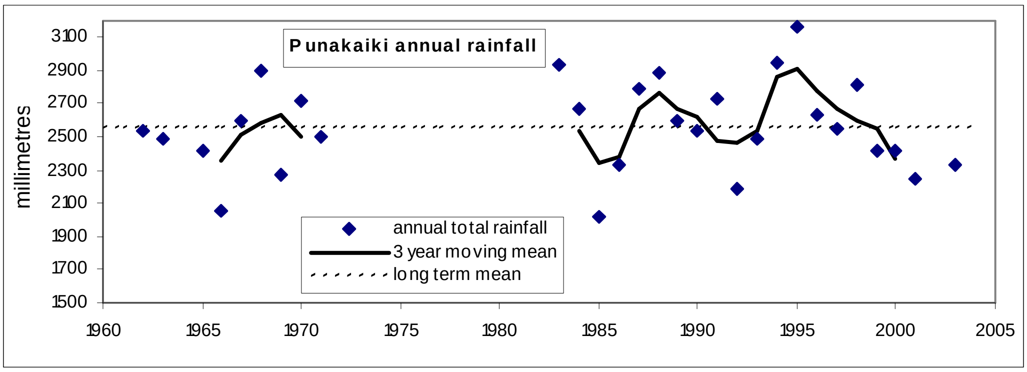

Figure 4.7: Annual rainfall totals to 2004 for Punakaiki Rocks
(missing record 2002 and 2004)

Figure 4.7 shows annual rainfall at Punakaiki Rocks EWS was below average 2000, 2001 and 2003. Annual total rainfall was not available for 2002 and 2004.

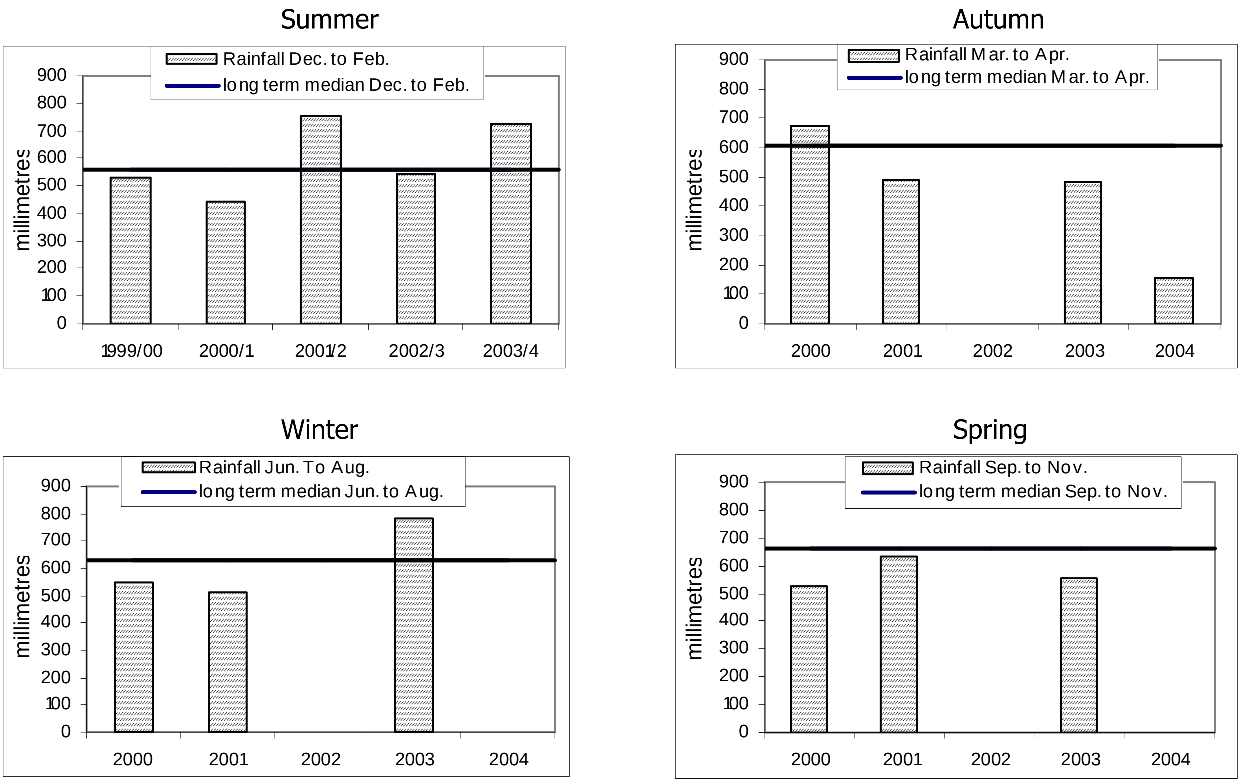

Figure 4.8: Seasonal rainfall plots for 2000 to 2004, Punakaiki Rocks
(no data indicates missing record)

For where there is data, seasonal anomalies that stand out for Punakaiki Rocks were below average rainfall for summer 2000/01, autumn 2001, 2003 and 2004, winter 2000 and 2001, and spring 2000 and 2003. Above average rainfall was recorded in summer of 2002/03 and 2003/04, and winter 2003.

4.5 Greymouth Airport

Table 4.5: Rainfall extremes 2000 to 2004, Greymouth Airport

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	163*	23-Jan	9	2-Jul	
2001	117	1-Jan	14	30-Jun	
2002	118	27-Jun	13	9-Apr	
2003	72	1-May	13	16-Mar	
2004	72	8-Jan	8	24-Aug	

*Highest 24 hour rainfall for Greymouth Airport on record.

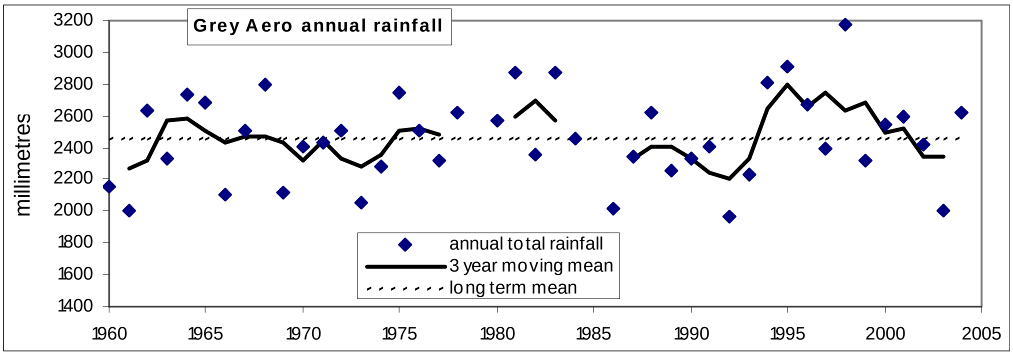

Figure 4.9: Annual rainfall totals to 2004 for Greymouth Airport

Figure 4.9 shows annual rainfall at Greymouth Airport was significantly below average for 2003 and above average for 2004.

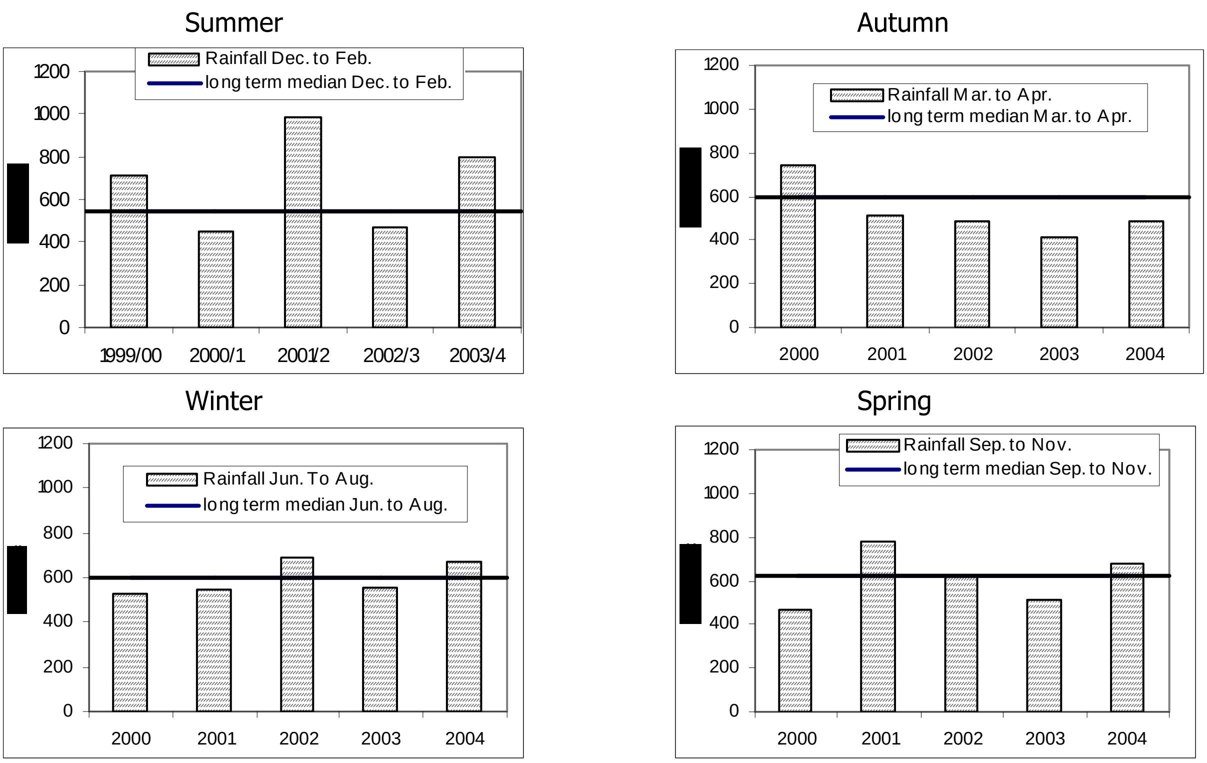

Figure 4.10: Seasonal rainfall plots for 2000 to 2004, Greymouth Airport

Seasonal anomalies that stand out for Greymouth Airport were below average rainfall for all autumns except that of 2000. The 2000/01 and 2002/03 summers had less rain than usual, and the 2001/02 and 2003/04 summers had more rain than usual. For other seasons rainfall was variable about the mean from year to year.

4.6 Rotomanu 2

Table 4.6: Rainfall extremes 2000 to 2004, Rotomanu 2

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	124	8-Oct	20	1-Jul	
2001	147	1-Jan	14	1-Jul	
2002	118	19-Mar	17	19-Jan	
2003	137	18-Feb	16	10-Apr	
2004	92	18-Jan	8	14-May	24-Aug

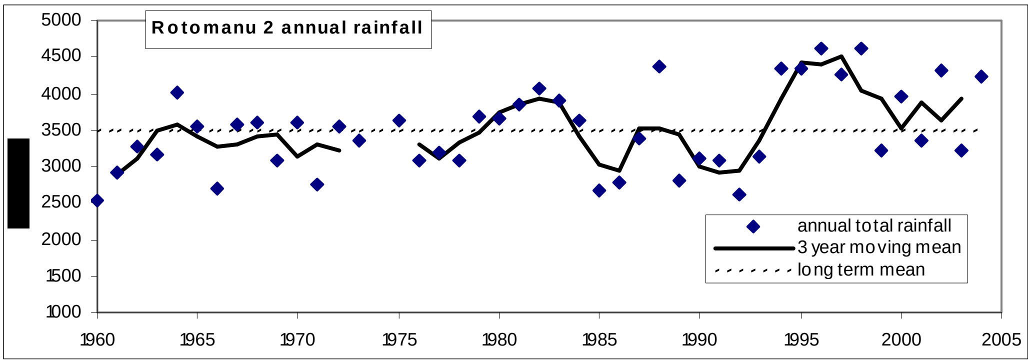

Figure 4.11: Annual rainfall totals to 2004 for Rotomanu 2

Figure 4.11 shows annual rainfall at Rotomanu 2 was variable about the mean for the 5 years reviewed, with 2002 and 2004 have having significantly more rainfall than usual.

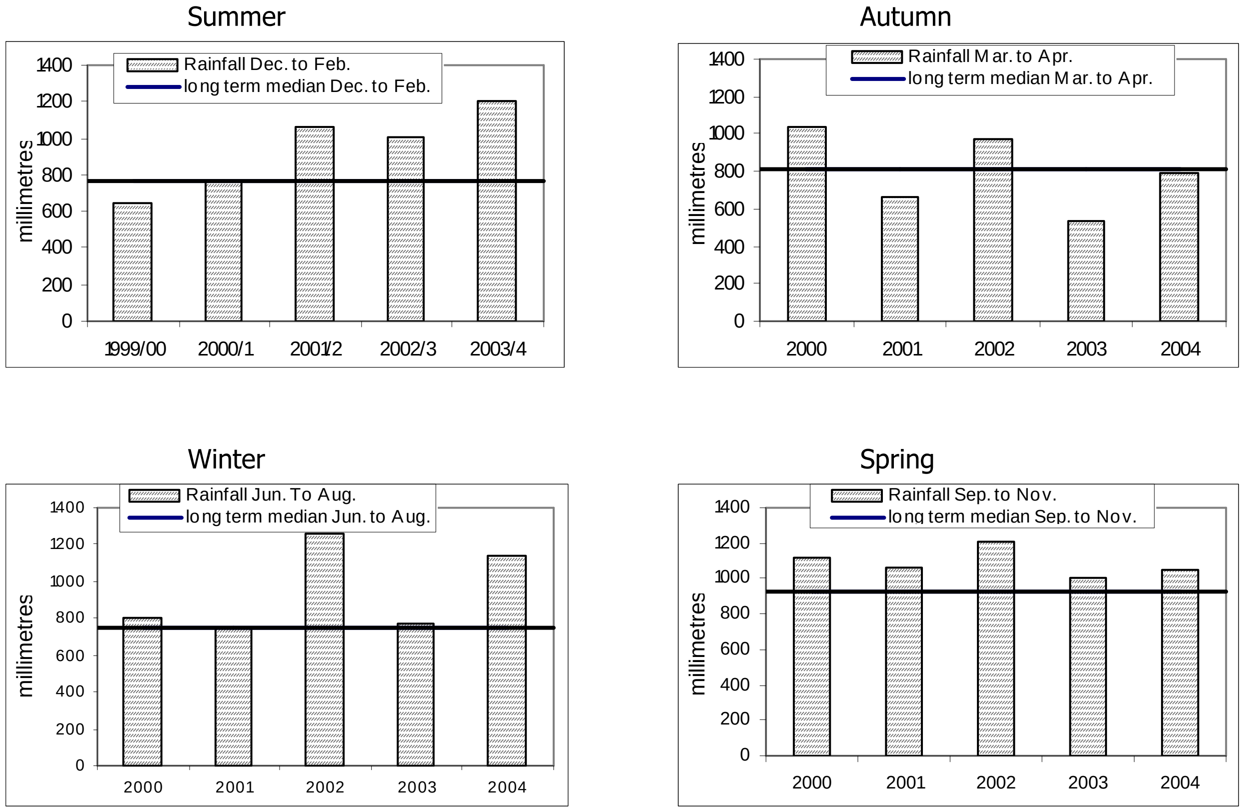

Figure 4.12: Seasonal rainfall plots for 2000 to 2004, Rotomanu 2

Seasonal anomalies that stand out for Rotomanu 2 were above average rainfall for the summers of 2001/02, 2002/03 and 2003/04. Also, the winters of 2002 and 2004 had notably more rainfall than usual, and all springs for the 5 years reviewed had above average rainfall. Below average rainfall occurred in the autumns of 2001 and 2003.

4.7 Inchbonnie

Table 4.7: Rainfall extremes 2000 to 2004, Inchbonnie

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	176	8-Oct	12	5-Jan	
2001	195	26-Mar	15	30-Jun	
2002	168	13-Jun	16	20-Jan	
2003	113	21-Nov	7	1-Aug	
2004	143	18-Jan	8	3-Mar	14-May

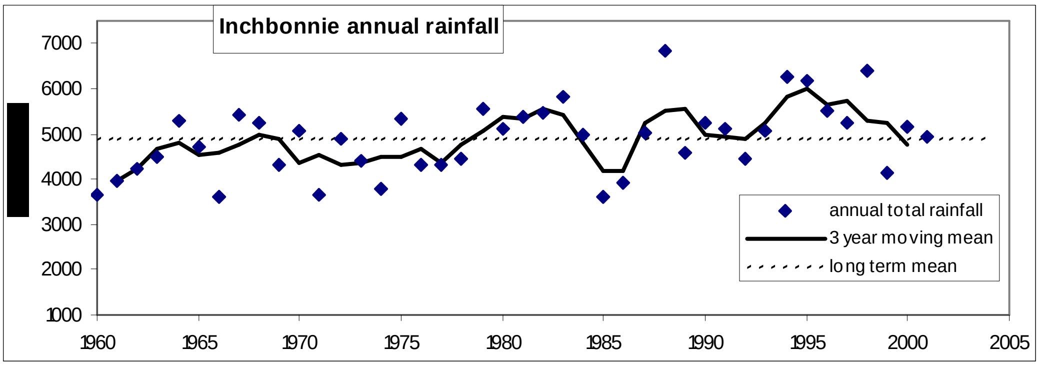

Figure 4.13: Annual rainfall totals to 2004 for Inchbonnie
(missing record 2002, 2003 and 2004)

Figure 4.13 shows annual rainfall at Inchbonnie was only available for 2000 and 2001 for the 5 year review period). Average rainfall was recorded for both these years.

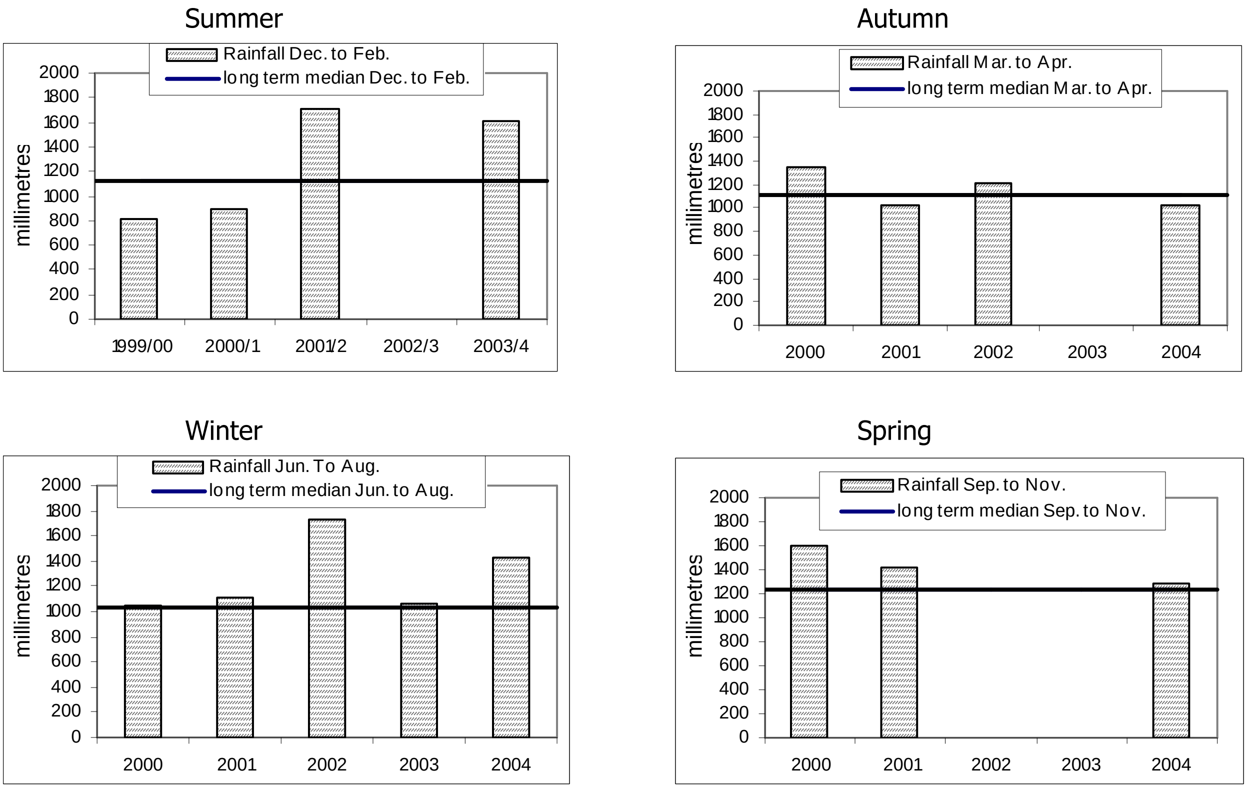

Figure 4.14: Seasonal rainfall plots for 2000 to 2004, Inchbonnie

For where there is data, seasonal anomalies that stand out for Inchbonnie were above average rainfall for the summers of 2001/02 and 2003/04, and for the 2002 and 2004 winters. Below average rainfall was received over the summers of 1999/00 and 2000/01.

4.8 Hokitika Airport

Table 4.8: Rainfall extremes 2000 to 2004, Hokitika Airport

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	110	19-Apr	9	9-Apr	1-Jul
2001	96	1-Jan	14	30-Jun	
2002	77	10-Feb	12	23-Jul	
2003	85	1-May	13	16-Mar	
2004	91	16-Mar	8	23-Apr	24-Aug

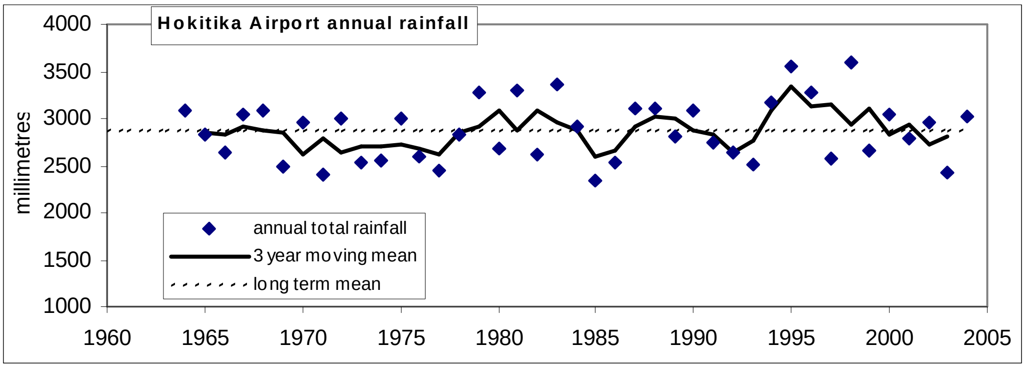

Figure 4.15: Annual rainfall totals to 2004 for Hokitika Airport

Figure 4.15 shows annual rainfall at Hokitika Airport was variable about the mean for the 5 years reviewed, with 2003 having significantly less rainfall than usual.

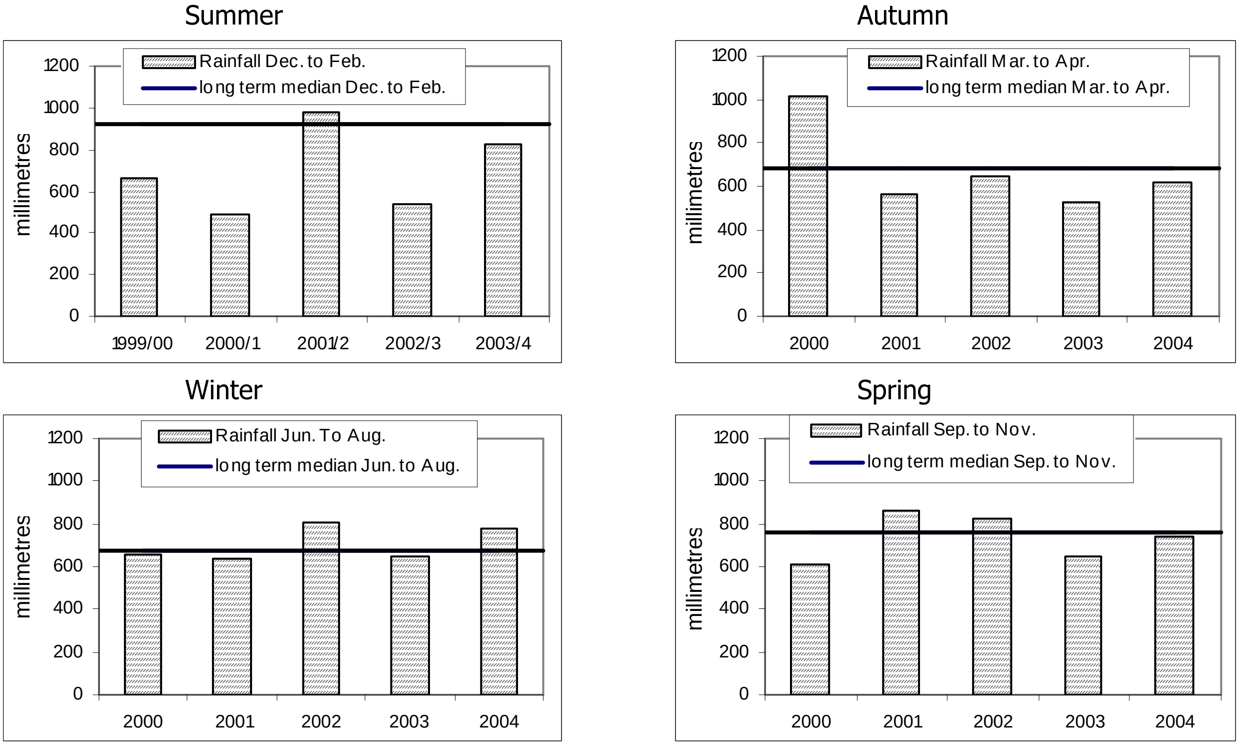

Figure 4.16: Seasonal rainfall plots for 2000 to 2004, Hokitika Airport

Seasonal anomalies that stand out for Hokitika Airport were below average rainfall for all autumns except that of 2000, and for the summers of 1999/00, 2000/01 and 2002/03. Summer rainfall in 2000/01 was particularly low.

4.9 Cropp at Cropp Hut

Table 4.9: Rainfall extremes 2000 to 2004, Cropp at Cropp Hut

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	448	6-Apr	14	4-Jan	
2001	415.5	19-Nov	10	2-Mar	
2002	343	1-Jan	13	8-Apr	
2003	422.5	1-May	19	7-Mar	
2004	462.5	8-Jan	6	3-Mar	26-Aug

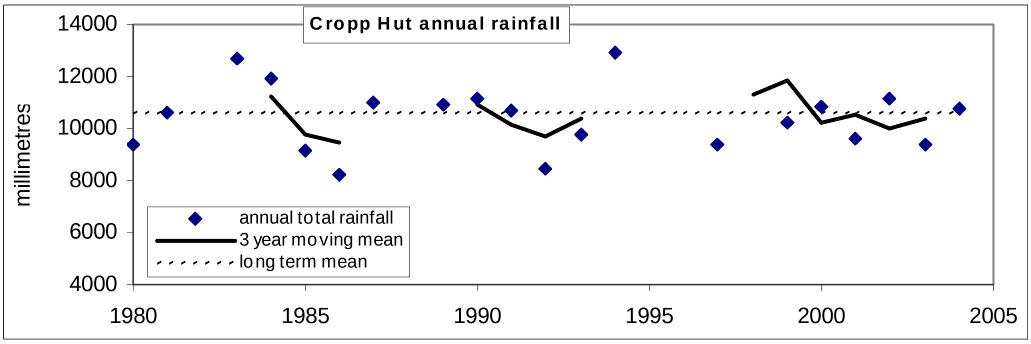

Figure 4.17: Annual rainfall totals to 2004 for Cropp at Cropp Hut
(missing record 1982, 1988, 1995, 1996)

Figure 4.17 shows annual rainfall at Cropp Hut was variable about the mean for the 5 years reviewed.

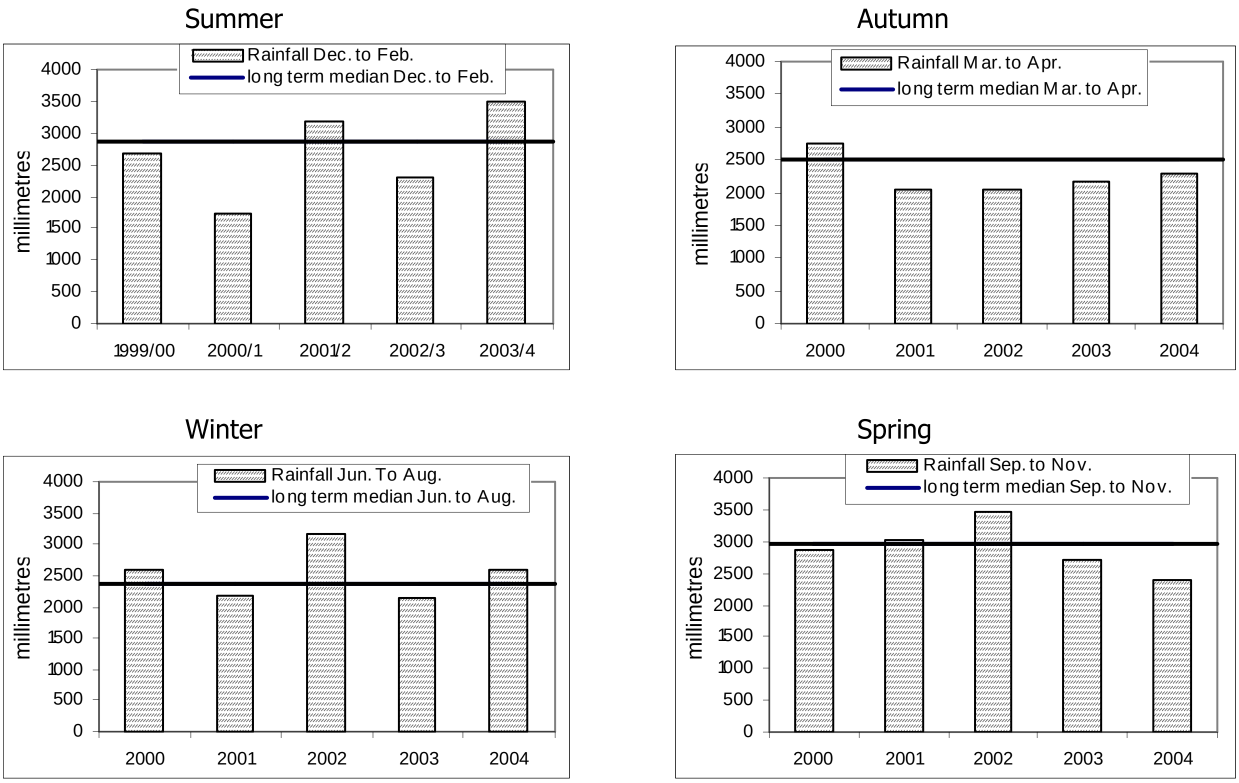

Figure 4.18: Seasonal rainfall plots for 2000 to 2004, Cropp at Cropp Hut

Seasonal anomalies that stand out for Cropp Hut were below average rainfall for all autumns except that of 2000, for the summers of 2000/01 and 2002/03 and for the winter of 2004. Above average rainfall occurred in summer2003/04, and winter and spring of 2002.

4.10 Ross

Table 4.10: Rainfall extremes 2000 to 2004, Ross

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	111	6-Apr	9	9-Apr	1-Jul
2001	112	5-Dec	20	30-Jun	
2002	127	22-Feb	13	21-Jan	
2003	136	21-May	16	8-Apr	
2004	105	8-Jan	8	24-Aug	

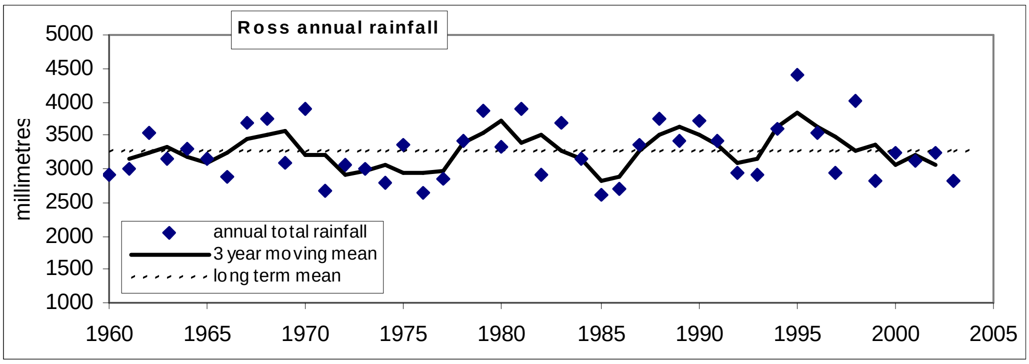

Figure 4.19: Annual rainfall totals to 2004 for Ross
(missing record 2004)

Due to missing record no annual rainfall total was available for Ross for 2004. For the remaining four years reviewed annual rainfall totals were average or below average. 2003 had especially low annual rainfall, compared to long-term averages.

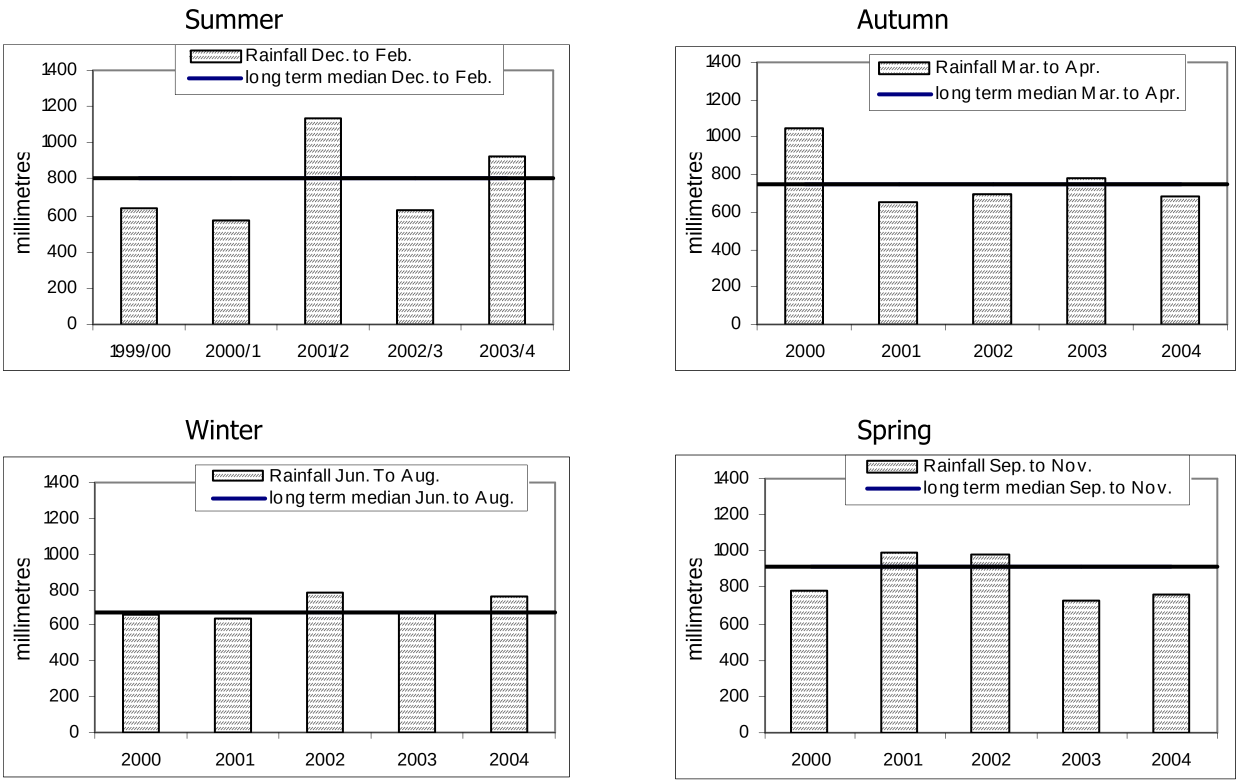

Figure 4.20: Seasonal rainfall plots for 2000 to 2004, Ross

Seasonal anomalies that stand out for Ross were below average rainfall for the summers of 1999/00, 2000/01 and 2002/03. Rainfall was also below average in the springs of 2000, 2003 and 2004. Above average rainfall was recorded in the summer of 2001/02 and the autumn of 2000.

4.11 Okarito

Table 4.11: Rainfall extremes 2000 to 2004, Okarito

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	127	19-Apr	13	5-Jan	
2001	134	1-Jan	29	30-Jun	
2002	98	22-Feb	11	21-Jan	
2003	145	21-Nov	15	9-Apr	
2004	116	29-Dec	8	23-Apr	24-Aug

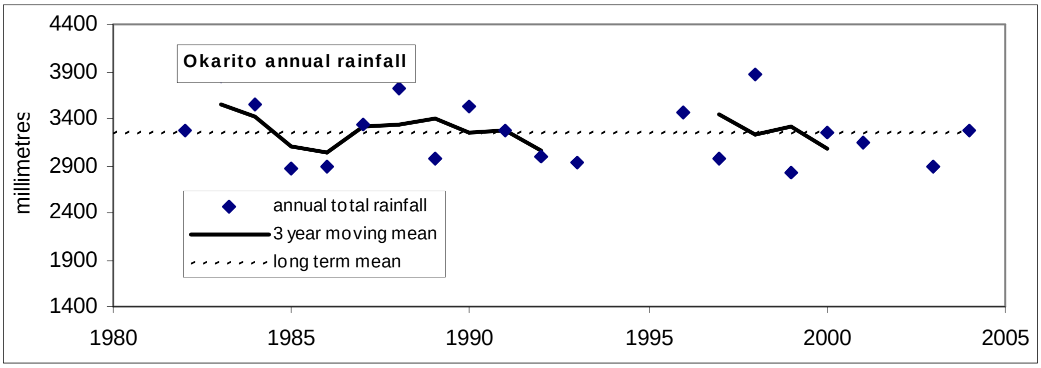

Figure 4.19: Annual rainfall totals to 2004 for Okarito (missing record 2002)

Due to missing record no annual rainfall total was available for Okarito for 2002. Figure 4.19 shows for the remaining years reviewed that annual total rainfall was at or below average. Rainfall in 2003 was especially low.

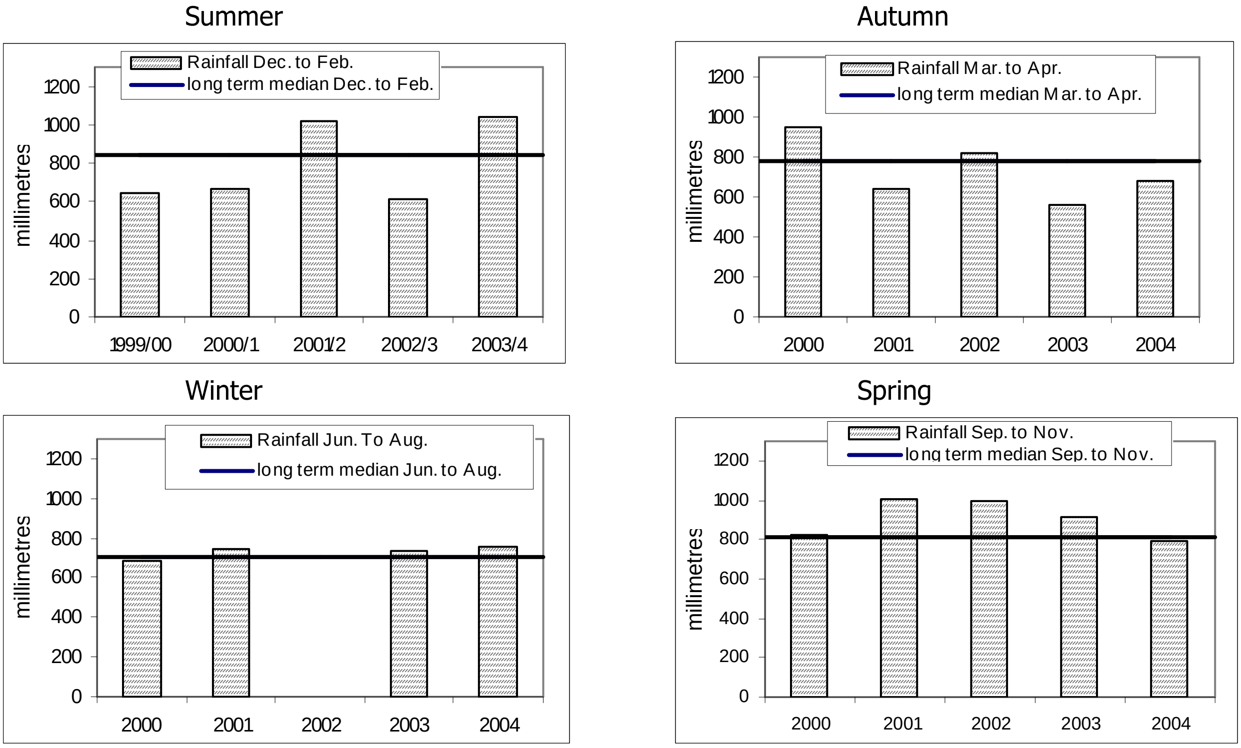

Figure 4.20: Seasonal rainfall plots for 2000 to 2004, Okarito

Seasonal anomalies that stand out for Okarito were below average rainfall for the summers of 1999/00, 2000/01 and 2002/03. Rainfall was also below average in the autumns of 2001 and 2003. Above average rainfall was recorded in the summer of 2001/02 and 2003/04, and spring 2001 and 2002.

4.12 Franz Joseph

Table 4.12: Rainfall extremes 2000 to 2004, Franz Joseph

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	218	24-Jun	8	2-Jul	2-Aug
2001	208	19-Nov	19	30-Jun	
2002	302	1-Jan	12	3-Jul	
2003	250	1-May	16	8-Apr	
2004	219	29-Dec	8	24-Aug	

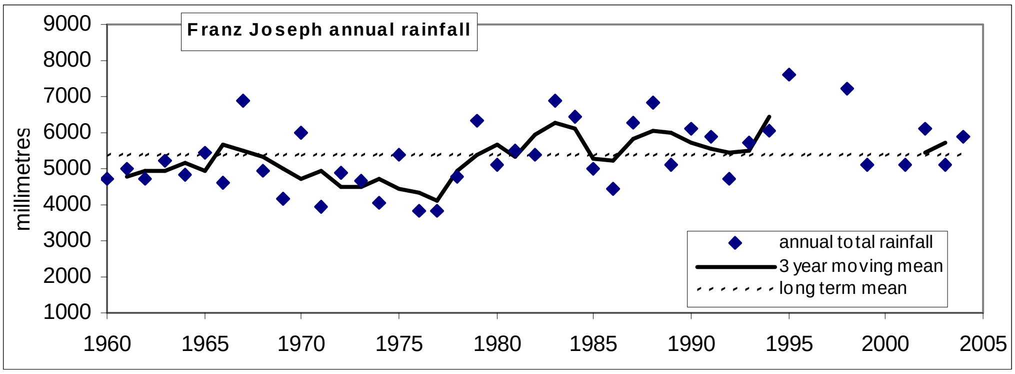

Figure 4.21: Annual rainfall totals to 2004 for Franz Joseph
(missing record 2000)

Due to missing record no annual rainfall total was available for Franz Joseph for 2000. Figure 4.21 shows for the remaining years reviewed that annual total rainfall was variable about the mean.

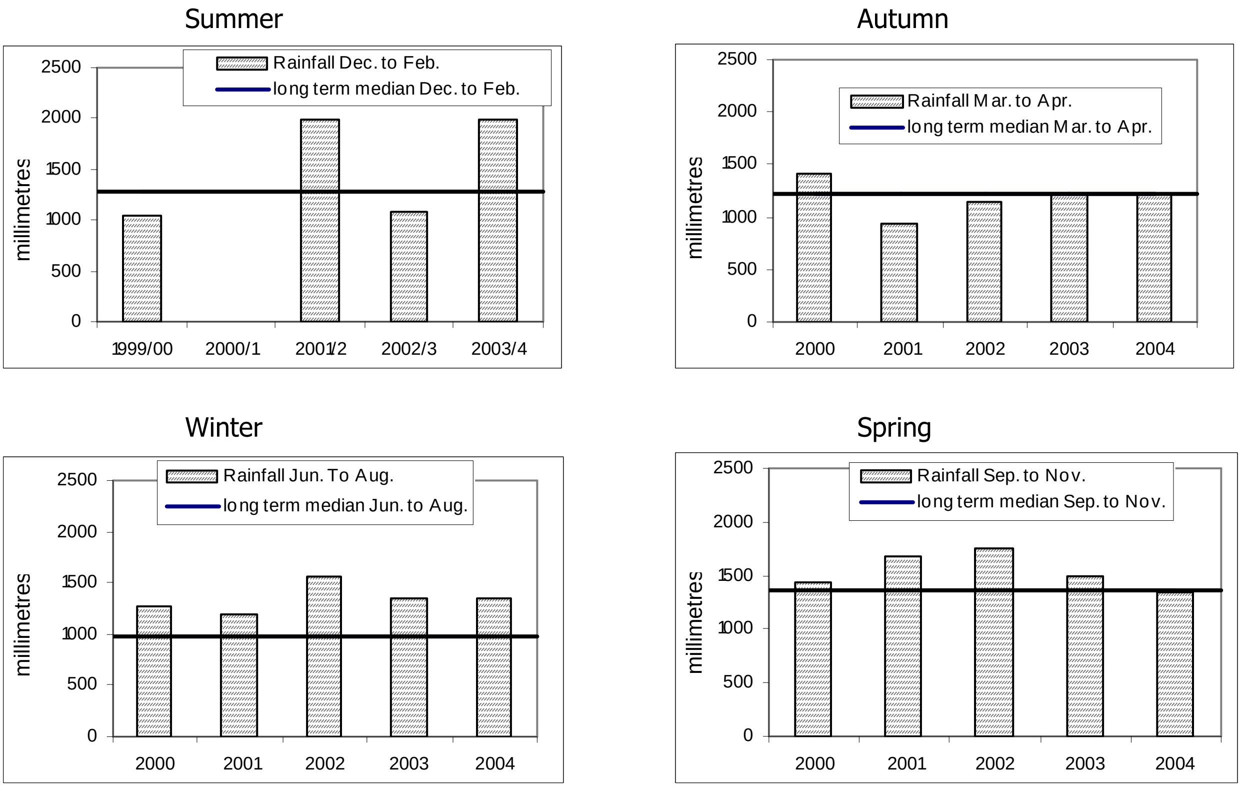

Figure 4.22: Seasonal rainfall plots for 2000 to 2004, Franz Joseph

Seasonal anomalies that stand out for Franz Joseph were below average rainfall for the summers of 1999/00 and 2002/03, and at or below average rainfall for all autumns except 2000. Above average winter rainfall was recorded for all years reviewed, as well as spring 2001 and 2002.

4.13 Paringa

Table 4.13: Rainfall extremes 2000 to 2004, Paringa

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	295	24-Jun	17	4-Jan	
2001	220	14-Jun	30	29-Jun	
2002	185	19-Sep	14	8-Apr	
2003	150	26-Aug	25	7-Mar	
2004					

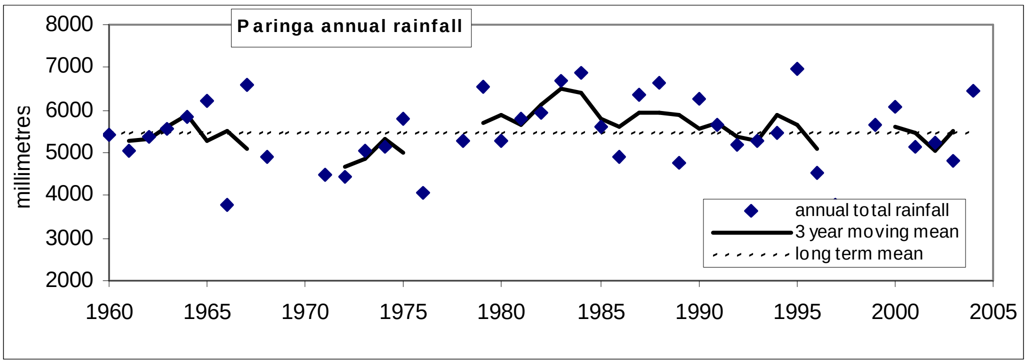

Figure 4.23: Annual rainfall totals to 2004 for Paringa

Figure 4.23 shows annual total rainfall for Paringa, for the five years reviewed, was variable about the mean. Rainfall recorded in 2004 was significantly higher than long-term average .

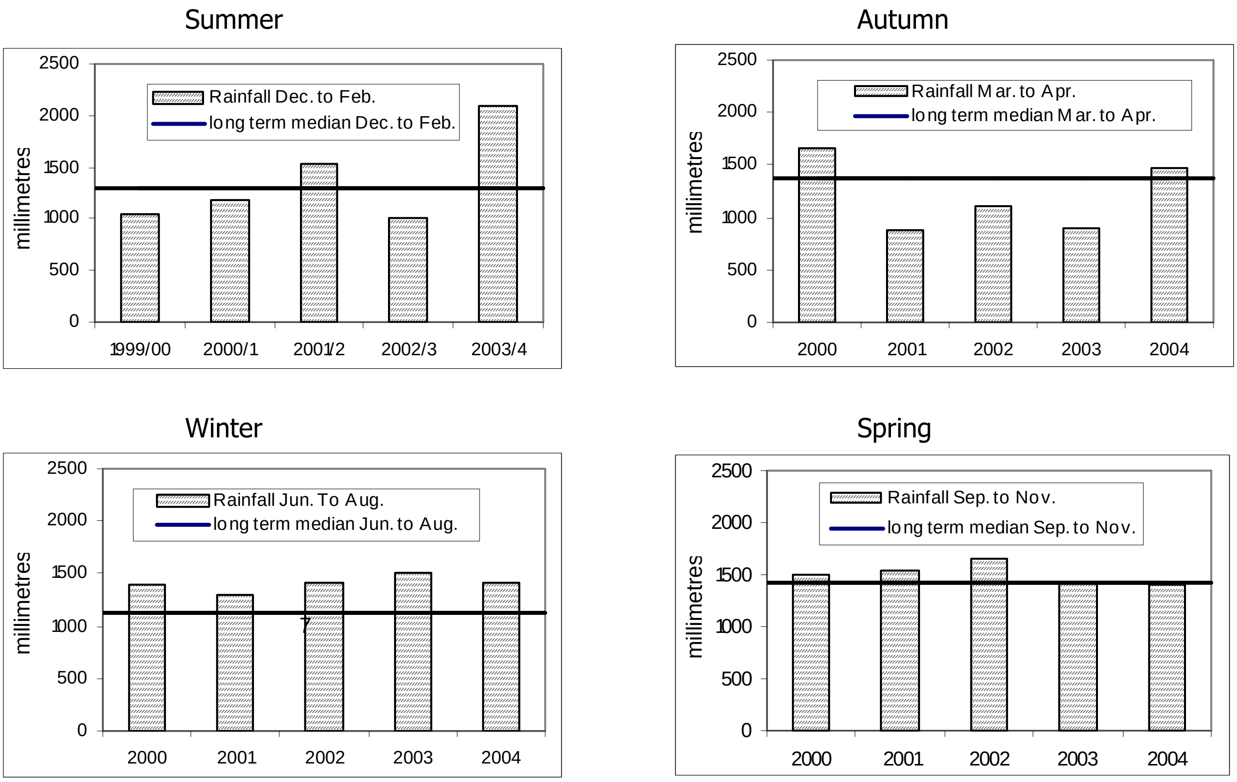

Figure 4.24: Seasonal rainfall plots for 2000 to 2004, Paringa

Seasonal anomalies that stand out for Paringa were especially high rainfall for the summer of 2003/04 and above average rainfall for all five winter periods reviewed. At or below average rainfall was recorded for all autumns except 2000, and rainfall in the summers of 1999/00 and 2002/03 was also below average. Spring rainfall was remarkably average for all years reviewed.

4.14 Mahitahi (Bruce Bay)

Table 4.14: Rainfall extremes 2000 to 2004, Mahitahi (Bruce Bay)

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	186	23-Jun	17	4-Jan	
2001	185	1-Dec	19	30-Jun	
2002	150	25-Oct	16	20-Jan	
2003	136	1-May	24	8-Mar	
2004	168	8-Jan	missing record	-	

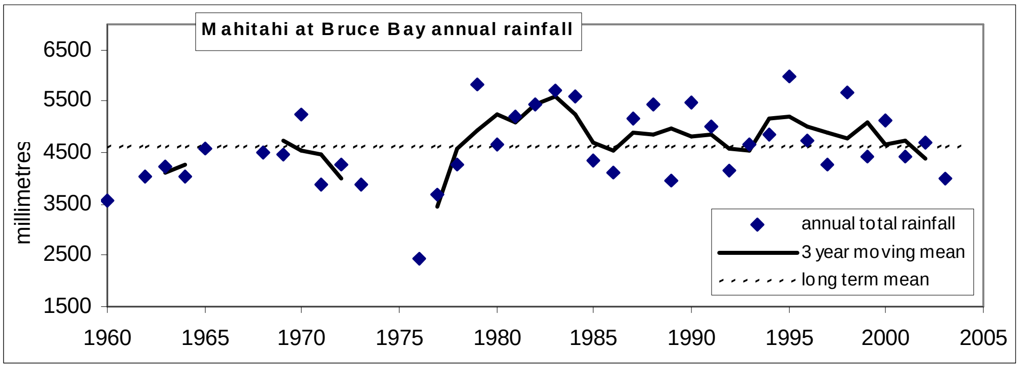

Figure 4.25: Annual rainfall totals to 2004 for Mahitahi (Bruce Bay) (missing record 2004)

Due to missing record no annual rainfall total was available for Mahitahi for 2004. Figure 4.21 shows for the remaining years reviewed that annual total rainfall was variable about the mean, with annual rainfall for 2003 being significantly lower than average.

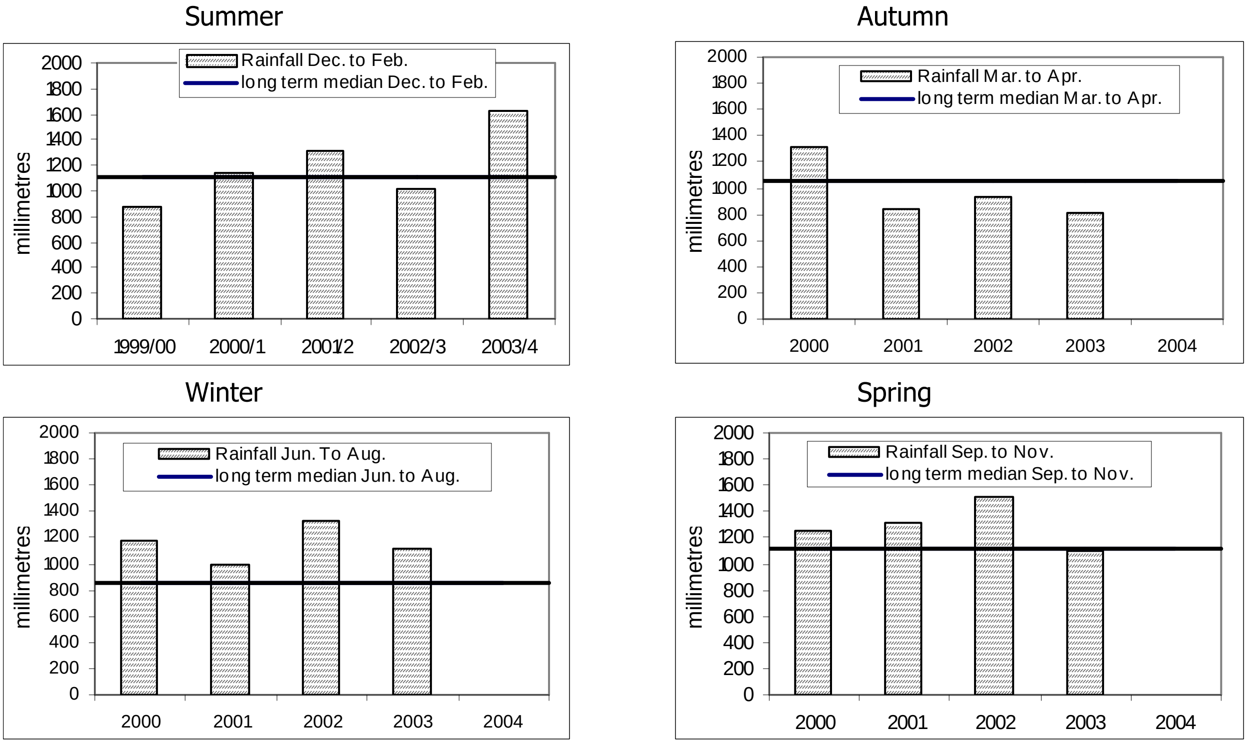

Figure 4.26: Seasonal rainfall plots for 2000 to 2004, Mahitahi (Bruce Bay)

Seasonal anomalies that stand out for Mahitahi were above average rainfall for the summer of 2003/04 and spring 2002. All winter periods where data was available had above average rainfall – especially 2000 and 2002. Noticeably lower than average rainfall was recorded in the summers of 1999/00 and 2002/03, and in the autumns of 2001, 2002 and 2003.

4.15 Haast AWS

Table 4.15: Rainfall extremes 2000 to 2004, Haast AWS

Calendar year	Maximum 24 hour rainfall (millimetres)	Start date of maximum 24 hour rainfall	Longest number of days without rainfall	Start date of longest number of days without rainfall	Start date of longest number of days without rainfall (if more than one date)
2000	118	24-Jun	8	8-Nov	
2001	140	23-Jan	18	30-Jun	
2002	89	18-Sep	6	18-Jan	12-Jul and 23-Jul
2003	84	21-Nov	14	16-Mar	
2004	103	26-Jan	9	22-Apr	

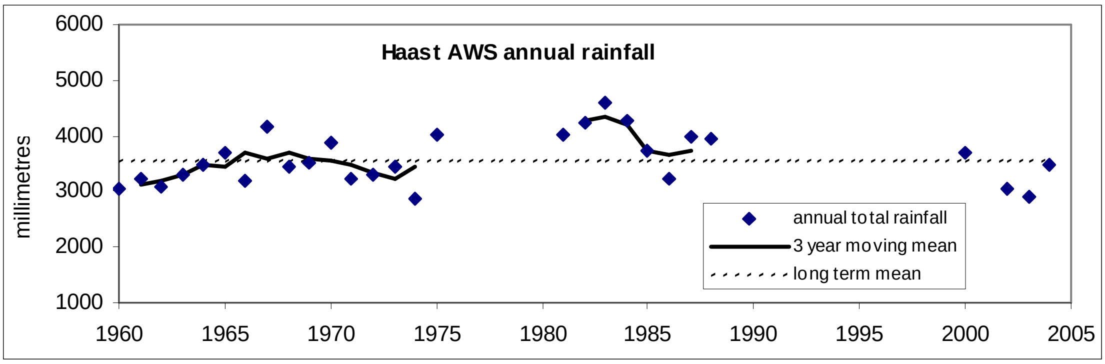

Figure 4.27: Annual rainfall totals to 2004 for Haast AWS
(missing record 2001)

Due to missing record no annual rainfall total was available for Haast AWS for 2001. Figure 4.21 shows for the remaining years reviewed that annual total rainfall was average for 2000 and 2004, and below average for 2002 and 2003.

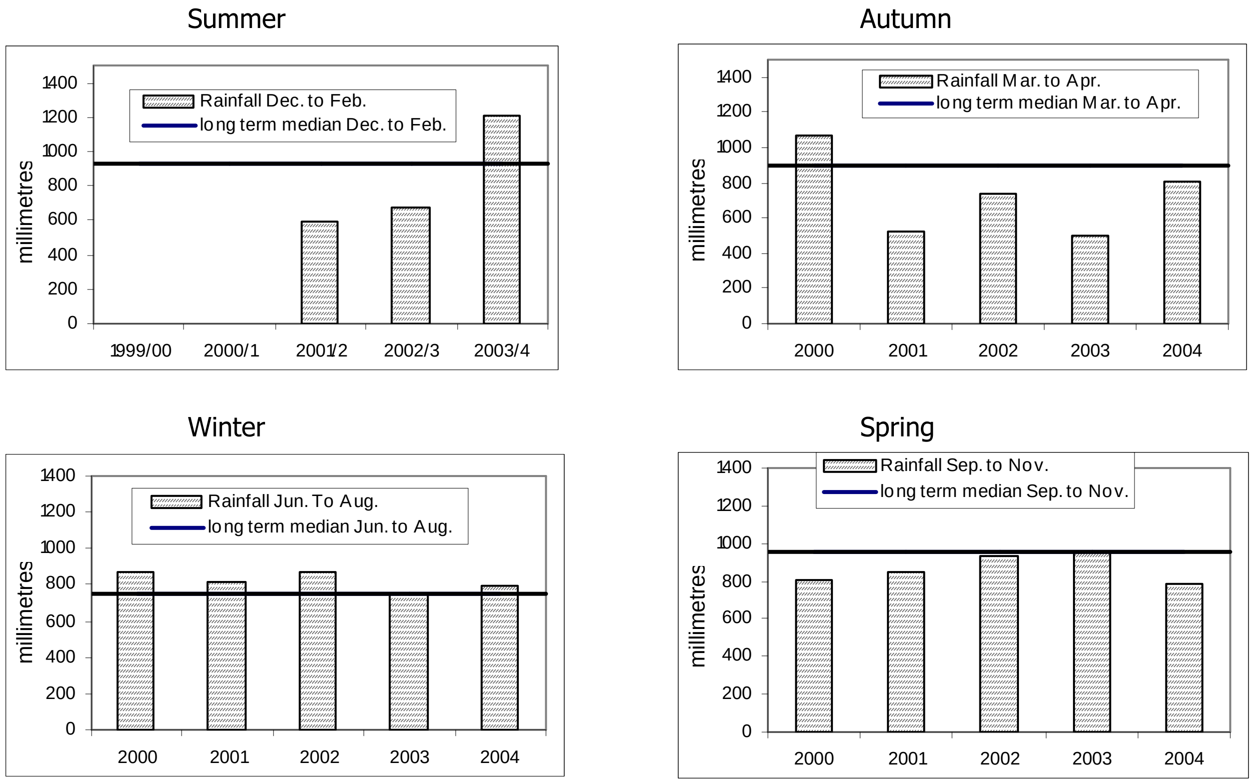

Figure 4.28: Seasonal rainfall plots for 2000 to 2004, Haast AWS

Seasonal anomalies that stand out for Haast AWS were below average rainfall for the summers of 2001/02 and 2002/03 and for all autumns except that of 2000. Spring rainfall was at or slightly below average for all years reviewed. The summer of 2003/04 had above average rainfall.

5. River Flow Results

The following section presents flow data for 18 nominated flow stations from 2000 to 2004; in relation to long-term flows presented by Bowis and Faulkner in 2000. Annual mean flows and extreme flow statistics are presented. Periods of missing record do occur for some stations, which are made evident in the results. It is important to reiterate that flow data is always subject to possible future change, and that presented here is the most accurate to our knowledge at this given point time.

5.1 Mean flows for the entire reporting period.

As an initial overview of flows for 2000 to 2004, mean flows for the entire reporting period (5 years) were calculated for each site. The flows are presented in Figure 5.1 as deviations from the long-term mean flow. North of Hokitika township mean flows for the five year period was generally within 5% of the long-term site average. The exceptions in terms of negative flow deviations were the Tiropahi River and Pattinsons Creek. Both these waterways drain the Paparoa Range. However, rivers reviewed south of Hokitika all had a mean flow over the 2000-2004 period that was less than the long-term average for the site. The flow at Cropp River at Cropp Hut was 20% lower for the 2000-2004 period than the long-term mean since records began in 1980.

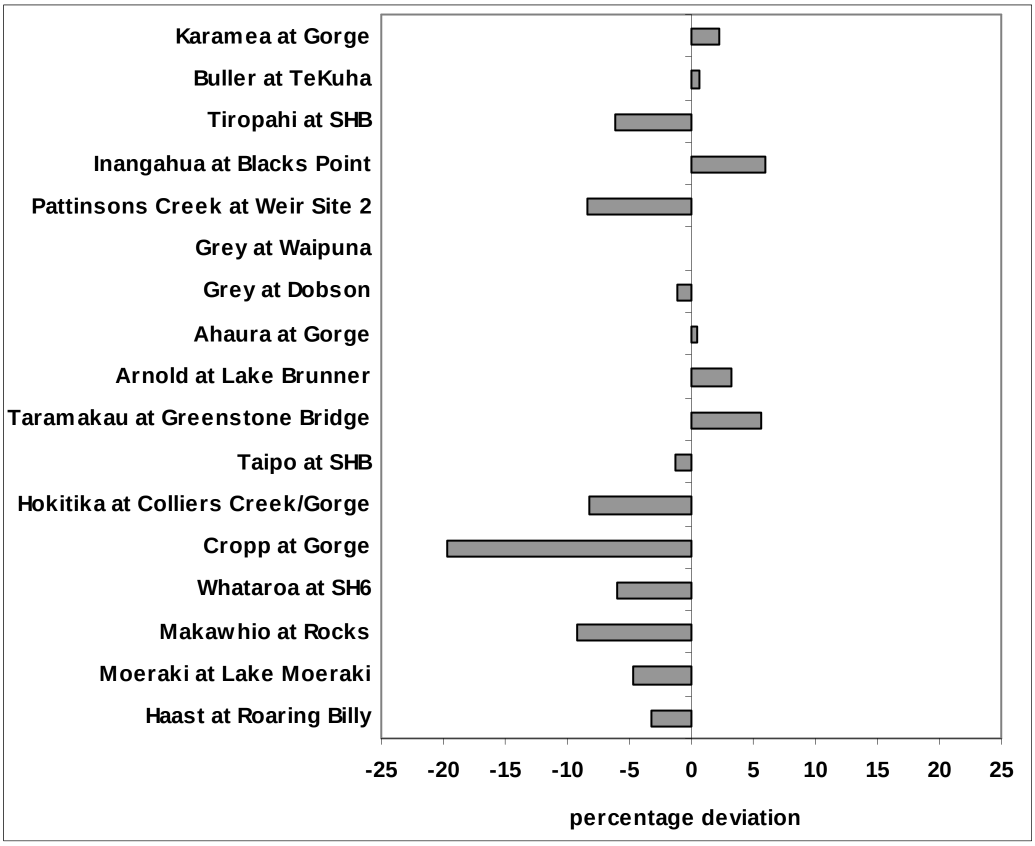

Figure 5.1: 2000 to 2004 mean flow, as a percentage deviation from long term mean flow.

5.2 Karamea River at Gorge

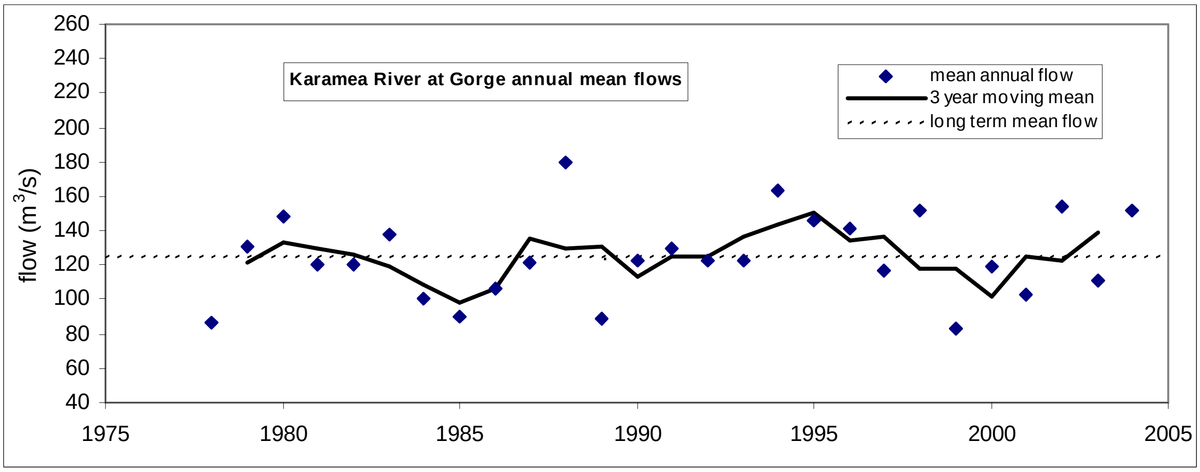

Figure 5.2: Annual mean flows for Karamea River at Gorge

Figure 5.2 shows annual mean flows, for the reporting period, at the Karamea River at Gorge site were variable about the long-term mean. Mean flows for 2002 and 2004 were noticeably higher than usual.

Table 5.1: Extreme flows 2000 to 2004, Karamea River at Gorge

Maximum flows — Flows are in m^3/s

mean annual flood		1978 to 1999	2042
highest recorded Q		1978 to 1999	3166 (19/10/98)
maximum flows 2000 to 2004			estimated return period in years
2000	2359	28-Dec-2000	4
2001	2560	26-Jan-2001	5.7
2002	1943	17-Jun-2002	less than mean annual flood
2003	1926	7-Jun-2003	less than mean annual flood
2004	1772	21-Feb-2004	less than mean annual flood

Minimum flows

mean annual 7 day low flow:	1978 to 1999	27
minimum 7 day low flow:	1978 to 1999	17 (11/4/85)

annual minimum 7 day flows 2000 to 2004		estimated return period in years
2000	22.7 at interval beginning 6-Mar-2000 06:00:00	4.9
2001	19.3 at interval beginning 19-Mar-2001 05:00:00	9.4
2002	27.9 at interval beginning 16-Feb-2002 10:45:00	more than mean annual low flow
2003	21.2 at interval beginning 17-Apr-2003 17:00:00	6.6
2004	28.0 at interval beginning 24-Apr-2004 23:45:00	more than mean annual low flow

5.3 Buller River at Te Kuha

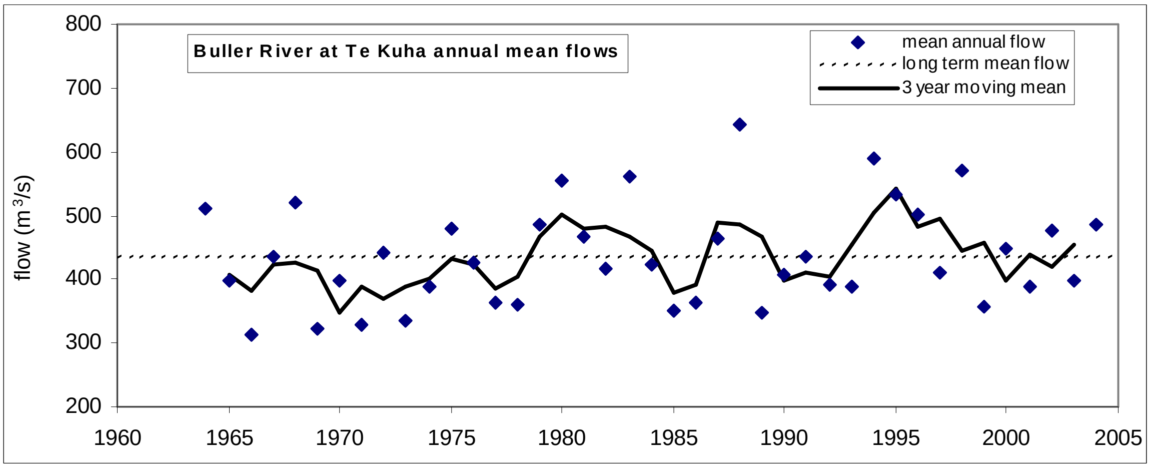

Figure 5.3: Annual mean flows for Buller River at Te Kuha

Figure 5.3 shows annual mean flows, for the reporting period, at the Buller River at Te Kuha site were variable about the long-term mean.

Table 5.2: Extreme flows 2000 to 2004, Buller River at Te Kuha

Maximum flows — Flows are in m^3/s

mean annual flood	1964 to 1999	4894	
highest recorded Q	1964 to 1999	8498 (31/8/70)	

maximum flows 2000 to 2004			Estimated return period in years
2000	4518	27-Jul-2000	less than mean annual flood
2001	5185	6-Dec-2001	2.8
2002	4612	14-Jun-2002	less than mean annual flood
2003	3912	19-Sep-2003	less than mean annual flood
2004	4231	15-Aug-2004	less than mean annual flood

Minimum flows

mean annual 7 day low flow:	1964 to 1999	108
minimum 7 day low flow	1964 to 1999	71 (12/3/78)

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	95.2 at interval beginning 25-Mar-2000 23:00:00	5
2001	86.9 at interval beginning 19-Mar-2001 02:30:00	8.8
2002	115.5 at interval beginning 9-Mar-2002 18:00:00	more than mean annual low flow
2003	89.8 at interval beginning 24-Apr-2003 03:00:00	7.2
2004	115.3 at interval beginning 24-Apr-2004 21:30:00	more than mean annual low flow

5.4 Tiropahi River at SHB

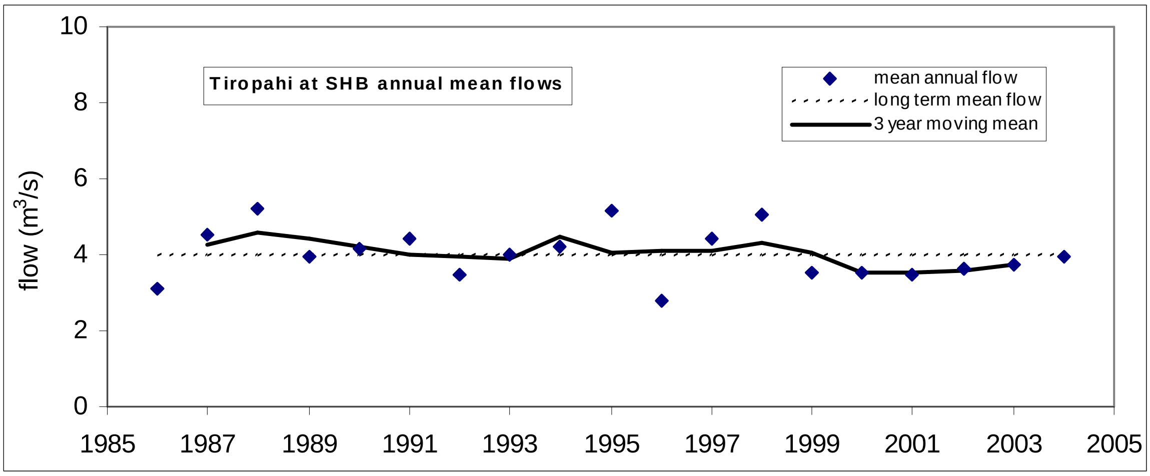

Figure 5.4: Annual mean flows for Tiropahi River at SHB

Figure 5.4 shows annual mean flows, for the reporting period, at the Tiropahi River at SHB site were below average. This is with the exception of 2004, which had an average mean flow. However, the annual means flows for 2000 to 2004 still fell well within the range of annual mean flows measured since 1986.

Table 5.3: Extreme flows 2000 to 2004, Tiropahi River at SHB

Maximum flows

Flows are in m^3/s

mean annual flood	1986 to 1999:	183
highest recorded Q	1986 to 1999:	286 (24/3/89)

maximum flows 2000 to 2004			Estimated return period in years
2000	131.0	4-Apr-2000	less than mean annual flood
2001	178.2	20-Nov-2001	less than mean annual flood
2002	154.3	27-Jun-2002	less than mean annual flood
2003	237.0	30-Jun-2003	6.2
2004	198.2	9-Jan-2004	3.0

Minimum flows

mean annual 7 day low flow:	1986 to 1999:	0.316
minimum 7 day low flow	1986 to 1999:	0.216 (15/1/95)

This is superceded by annual minima from 2000 to 2003

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	0.163 at interval beginning 15-Jan-2000 03:00:00	35
2001	0.063 at interval beginning 6-Mar-2001 18:00:00	more than 100 years
2002	0.155 at interval beginning 15-Feb-2002 22:45:00	41
2003	0.119 at interval beginning 22-Mar-2003 00:45:00	83
2004	0.495 at interval beginning 20-Apr-2004 16:15:00	more than mean annual low flow

5.5 Inangahua River at Blacks Point

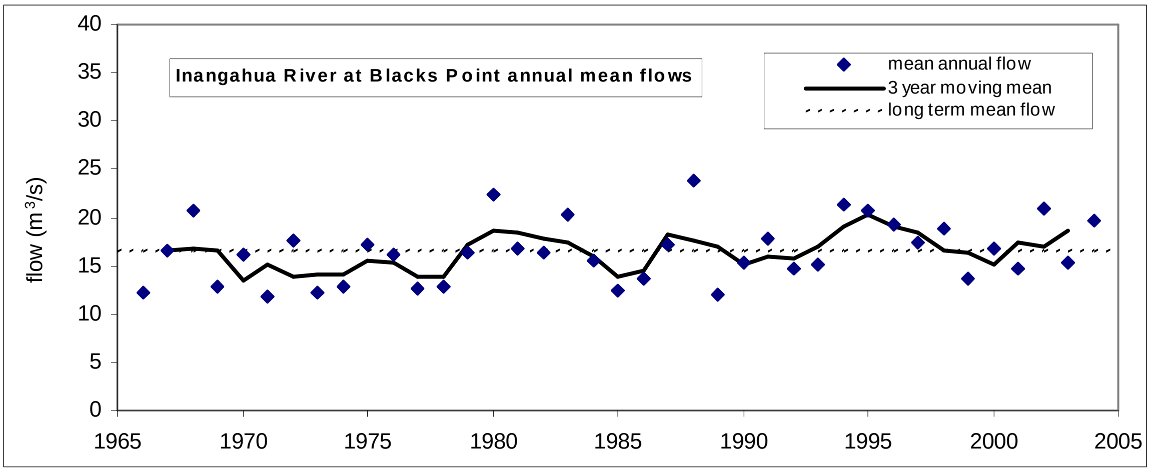

Figure 5.5: Annual mean flows for Inangahua River at Blacks Point

Figure 5.5 shows annual mean flows, for the reporting period, at the Inangahua River at Blacks Point site were variable about the long-term mean. The mean flow for 2002 was noticeably higher than usual.

Table 5.4: Extreme flows 2000 to 2004, Inangahua River at Blacks Point

Maximum flows — Flows are in m^3/s

mean annual flood	1966 to 1999	450
highest recorded Q	1966 to 1999	988 (14/4/74)

maximum flows 2000 to 2004			Estimated return period in years
2000	478	27-Jul-2000	2.8
2001	290	6-Dec-2001	less than mean annual flood
2002	381	27-Jun-2002	less than mean annual flood
2003	271	18-Sep-2003	less than mean annual flood
2004	492	9-Jan-2004	3.1

Minimum flows

mean annual 7 day low flow:	1966 to 1999	2.327
minimum 7 day low flow	1966 to 1999	1.412 (24/02/73)

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	1.76 at interval beginning 14-Mar-2000 14:15:00	8.4
2001	1.69 at interval beginning 7-Mar-2001 12:00:00	9.9
2002	2.12 at interval beginning 16-Feb-2002 03:45:00	3.6
2003	1.88 at interval beginning 17-Apr-2003 21:00:00	6.2
2004	3.01 at interval beginning 26-Apr-2004 05:45:00	more than mean annual low flow

5.6 Pattinsons Creek at Weir Site 2

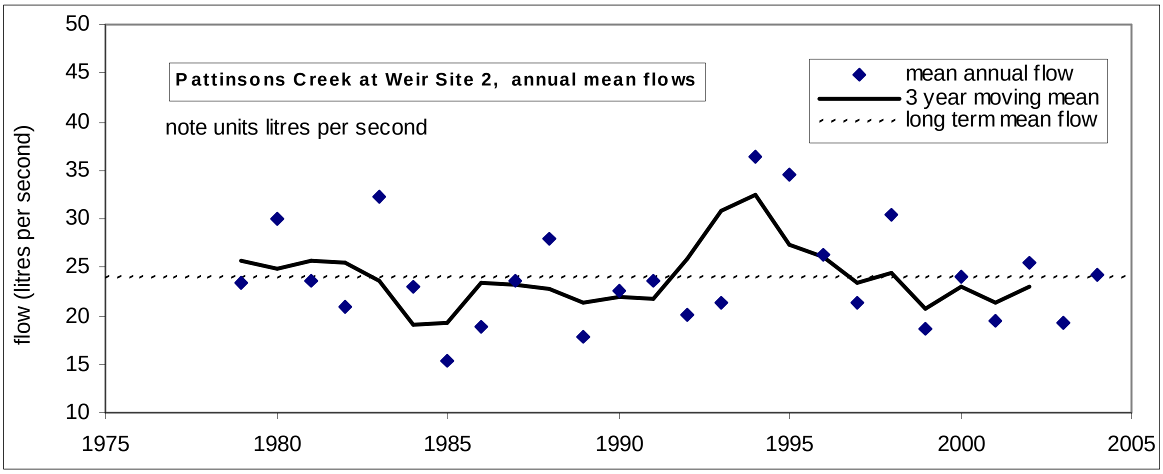

Figure 5.6: Annual mean flows for Pattinsons Creek at Weir Site 2

Figure 5.6 shows annual mean flows, for the reporting period, at Pattinsons Creek at Weir site 2 were average to below average.

Table 5.5: Extreme flows 2000 to 2004, Pattinsons Creek at Weir Site 2

Maximum flows

mean annual flood	1979 to 1999	819	Flows are in litres per second
highest recorded Q	1979 to 1999	1755 (9/7/83)	

maximum flows 2000 to 2004			Estimated return period in years
2000	505	9-Sep-2000	less than mean annual flood
2001	546	16-Jun-2001	less than mean annual flood
2002	1068	27-Jun-2002	4.4
2003	879	1-Jul-2003	2.7
2004	738	30-Dec-2004	less than mean annual flood

Minimum flows

mean annual 7 day low flow:	1979 to 1999	1.412	
minimum 7 day low flow	1979 to 1999	0.374	(10/04/1985)
		this superceded by 2001	

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	0.676 at interval beginning 15-Jan-2000 06:30:00	8.4
2001	0.332 at interval beginning 19-Mar-2001 21:30:00	16.3
2002	0.753 at interval beginning 16-Feb-2002 01:15:00	7.3
2003	0.784 at interval beginning 24-Apr-2003 23:15:00	6.9
2004	2.55 at interval beginning 26-Apr-2004 05:00:00	more than mean annual low flow

5.7 Grey River at Waipuna

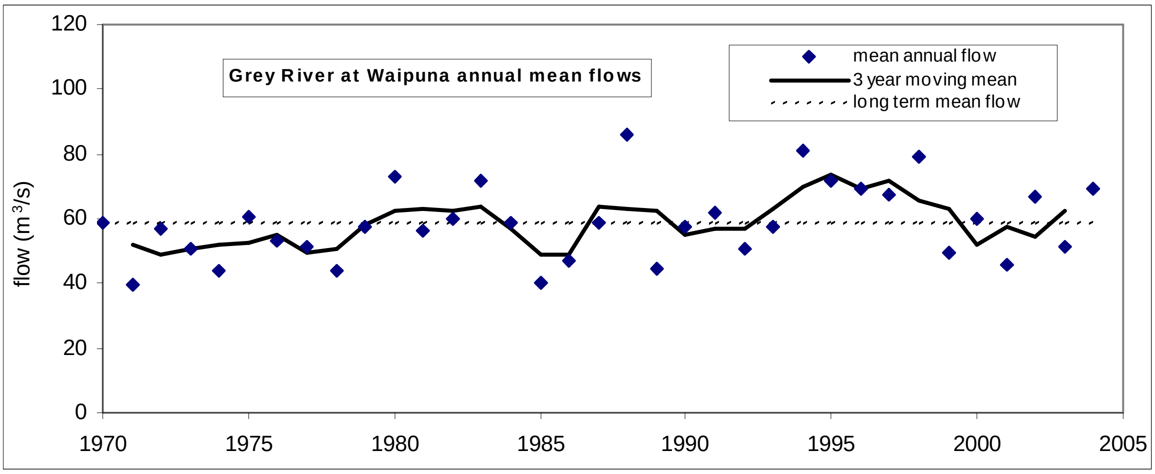

Figure 5.7: Annual mean flows for Grey River at Waipuna

Figure 5.7 shows annual mean flows, for the reporting period, at the Grey River at Waipuna site were variable about the long-term mean. Annual mean flows were noticeably lower than usual in 2001, and noticeably higher than usual in 2004.

Table 5.6: Extreme flows 2000 to 2004, Grey River at Waipuna

Maximum flows Flows are in m^3/s

mean annual flood	1970 to 1999:	924
highest recorded Q	1970 to 1999:	2075 (18/01/77)

maximum flows 2000 to 2004			Estimated return period in years
2000	1164	27-Jul-2000	5.1
2001	945	3-Dec-2001	2.5
2002	950	20-Mar-2002	2.5
2003	744	18-Sep-2003	less than mean annual flood
2004	1056	9-Jan-2004	3.5

Minimum flows

mean annual 7 day low flow:	1964 to 1999	15.8	
minimum 7 day low flow	1964 to 1999	10.4 (16/3/78)	this superceded by 2003 low flow

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	10.3 at interval beginning 15-Jan-2000 11:00:00	10.9
2001	10.6 at interval beginning 19-Mar-2001 16:30:00	10
2002	13.8 at interval beginning 16-Feb-2002 05:00:00	3.9
2003	8.2 at interval beginning 17-Apr-2003 13:30:00	21
2004	18.8 at interval beginning 26-Apr-2004 09:15:00	more than mean annual low flow

5.8 Ahaura River at Gorge

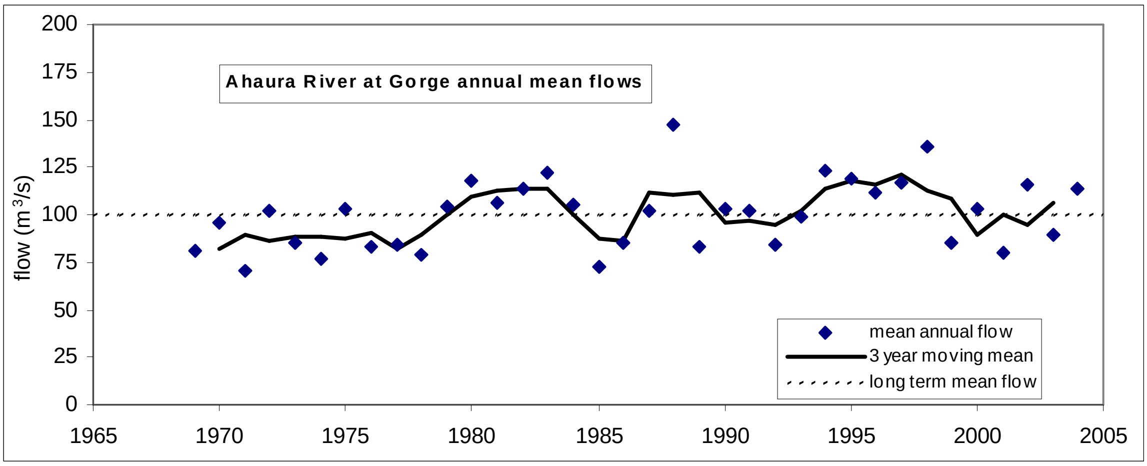

Figure 5.8: Annual mean flows for Ahaura River at Gorge

Figure 5.8 shows annual mean flows, for the reporting period, at the Ahaura River at Gorge site were variable about the long-term mean.

Table 5.7: Extreme flows 2000 to 2004, Ahaura River at Gorge

Maximum flows — Flows are in m^3/s

mean annual flood	1969 to 1999	1294
highest recorded Q	1969 to 1999	2308 (11/2/97)

maximum flows 2000 to 2004			Estimated return period in years
2000	1578	9-Oct-2000	4.2
2001	1515	5-Feb-2001	3.7
2002	1426	18-Jun-2002	3
2003	763	3-Oct-2003	less than mean annual flood
2004	1439	9-Jan-2004	3.1

Minimum flows

mean annual 7 day low flow:	1969 to 1999	25.7
minimum 7 day low flow	1969 to 1999	17.2 (15/2/71)

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	25.3 at interval beginning 15-Jan-2000 09:00:00	2.5
2001	22.3 at interval beginning 22-Jul-2001 01:15:00	4.5
2002	24.8 at interval beginning 16-Feb-2002 09:30:00	2.8
2003	22.2 at interval beginning 24-Apr-2003 13:00:00	4.6
2004	34.7 at interval beginning 25-Apr-2004 10:00:00	more than mean annual low flow

5.9 Grey River at Dobson

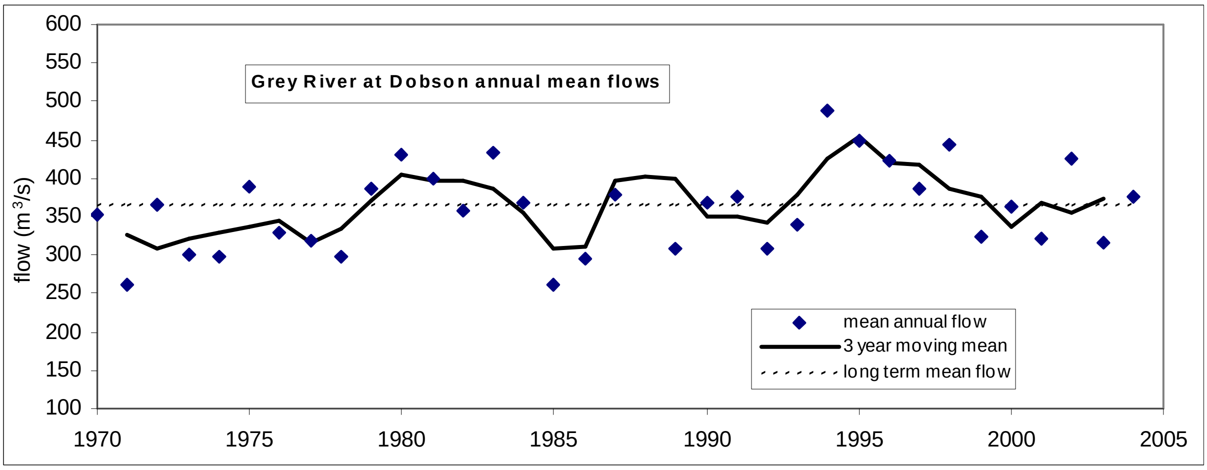

Figure 5.9: Annual mean flows for Grey River at Dobson

Figure 5.9 shows annual mean flows, for the reporting period, at the Grey River at Dobson site were variable about the long-term mean. The mean flow for 2002 was noticeably higher than usual.

Table 5.8: Extreme flows 2000 to 2004, Grey River at Dobson

Maximum flows

Flows are in m3/s

mean annual flood	1969 to 1999:	3827
highest recorded Q	1969 to 1999:	5951 (16/12/97)

maximum flows 2000 to 2004			Estimated return period in years
2000	3810	28-Dec-2000	less than mean annual flood
2001	3343	7-Dec-2001	less than mean annual flood
2002	3517	18-Jun-2002	less than mean annual flood
2003	3222	1-Jul-2003	less than mean annual flood
2004	3224	9-Jan-2004	less than mean annual flood

Minimum flows

mean annual 7 day low flow:	1969 to 1999:	93
minimum 7 day low flow	1969 to 1999:	69 (27/2/72)

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	76.6 at interval beginning 15-Jan-2000 08:45:00	5
2001	69.5 at interval beginning 19-Mar-2001 21:45:00	7.1
2002	76.6 at interval beginning 16-Feb-2002 04:45:00	5.0
2003	70.1 at interval beginning 17-Apr-2003 21:15:00	6.9
2004	85.3 at interval beginning 26-Apr-2004 08:15:00	3.3

5.10 Arnold River at Moana

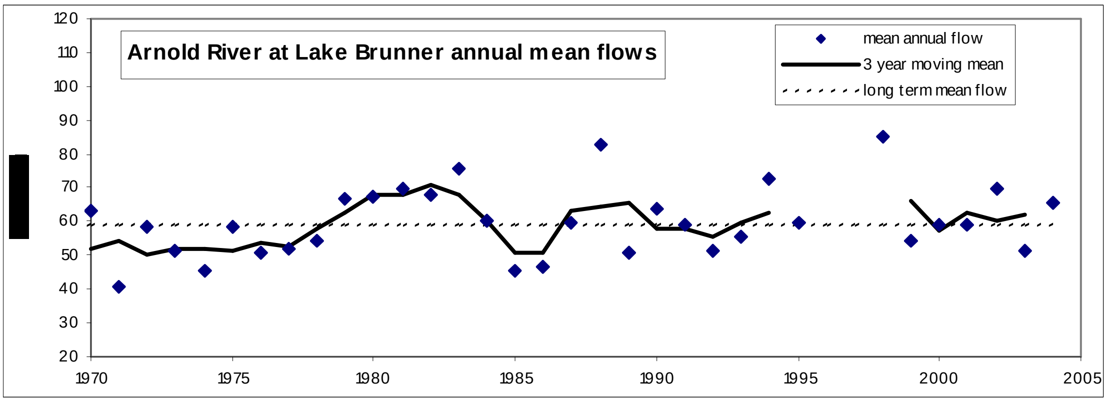

Figure 5.10: Annual mean flows for Arnold River at Lake Brunner

Figure 5.10 shows annual mean flows, for the reporting period, at the Arnold River at Lake Brunner were variable about the long-term mean.

Table 5.9: Extreme flows 2000 to 2004, Arnold River at Lake Brunner

Maximum flows

Flows are in m^3/s

mean annual flood	1969 to 1999:	209.9
highest recorded Q	1969 to 1999:	343 (10/1/94)

maximum flows 2000 to 2004			Estimated return period in years	
2000	251	9-Oct-2000	5.2	
2001	311	7-Dec-2001	19.7	second largest flow on record
2002	280	18-Jun-2002	9.8	
2003	159	1-Jul-2003	less than mean annual flood	
2004	147	22-Feb-2004	less than mean annual flood	

Minimum flows

mean annual 7 day low flow:	1969 to 1999:	22.4
minimum 7 day low flow	1969 to 1999:	16.9 (11/9/89)

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	19.6 at interval beginning 15-Jan-2000 12:15:00	5.5
2001	21.2 at interval beginning 19-Mar-2001 22:30:00	3.3
2002	24.2 at interval beginning 16-Feb-2002 09:00:00	more than mean annual low flow
2003	21.7 at interval beginning 24-Apr-2003 16:00:00	2.8
2004	26.5 at interval beginning 26-Apr-2004 20:45:00	more than mean annual low flow

5.11 Taramakau River at Greenstone Bridge

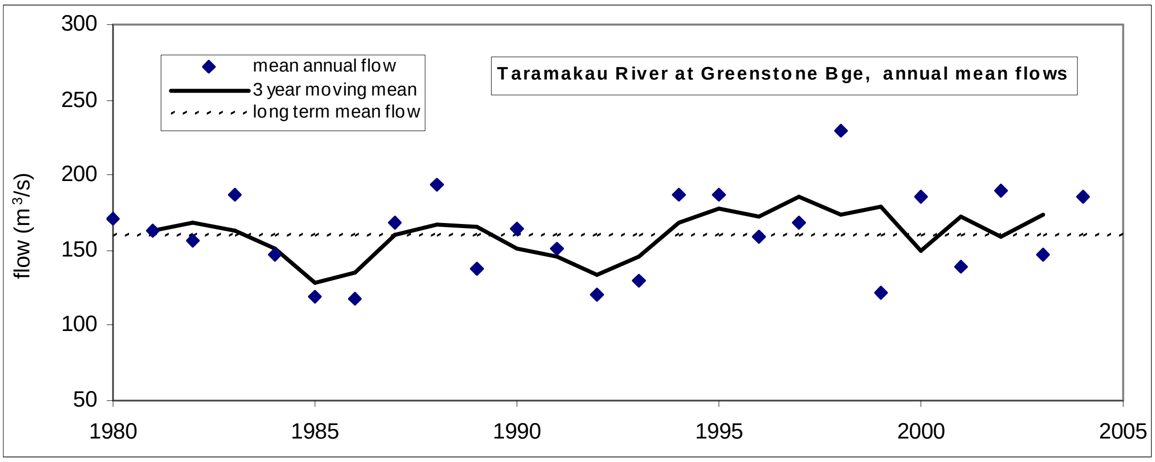

Figure 5.11: Annual mean flows for Taramakau River at Greenstone Bridge

Figure 5.11 shows annual mean flows, for the reporting period, at the Taramakau River at Greenstone Bridge site were variable about the long-term mean.

Table 5.10: Extreme flows 2000 to 2004, Taramakau River at Greenstone Bridge

Maximum flows

Flows are in m^3/s

mean annual flood	1980 to 1999:	2381
highest recorded flow	1980 to 1999:	4564 (25/12/82)

maximum flows 2000 to 2004			Estimated return period in years
2000	2818	27-Jul-2000	3.9
2001	2119	9-Jun-2001	less than mean annual flood
2002	3143	2-Jan-2002	6
2003	2657	2-May-2003	3.2
2004	2055	9-Jan-2004	less than mean annual flood

Minimum flows

mean annual 7 day low flow:	1980 to 1999:	40
minimum 7 day low flow:	1980 to 1999:	25 (13/01/1981)

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	60.2 at interval beginning 12-Mar-2000 12:00:00	more than mean annual low flow
2001	43.2 at interval beginning 18-Mar-2001 10:45:00	more than mean annual low flow
2002	42.8 at interval beginning 16-Feb-2002 02:00:00	more than mean annual low flow
2003	39.9 at interval beginning 20-Aug-2003 04:30:00	2.4
2004	58.0 at interval beginning 31-Jul-2004 00:15:00	more than mean annual low flow

5.12 Taipo River at State Highway Bridge

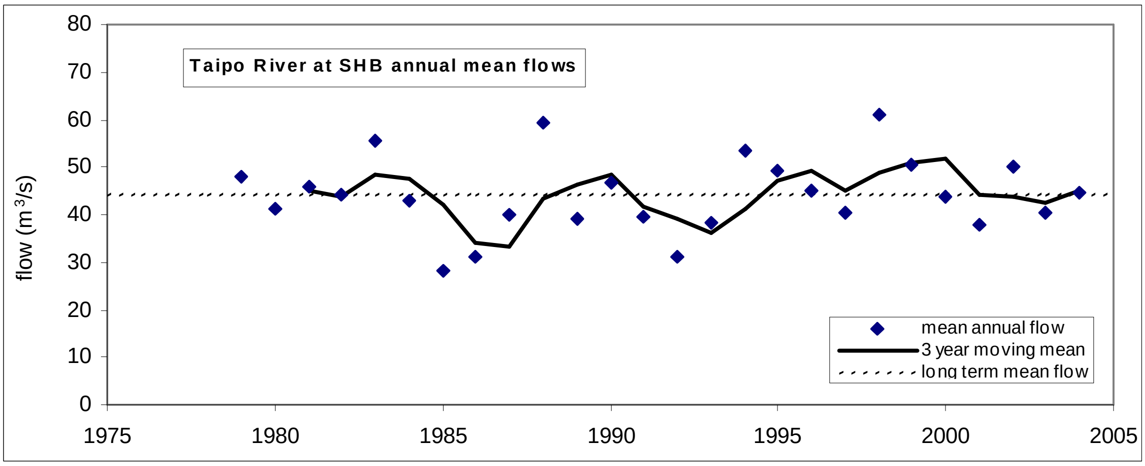

Figure 5.12: Annual mean flows for Taipo River at State Highway Bridge

Figure 5.10 shows annual mean flows, for the reporting period, at the Tapio River at SHB site were variable about the long-term mean. There were no years that were significant outliers.

Table 5.11: Extreme flows 2000 to 2004, Taipo River at State Highway Bridge

Maximum flows

Flows are in m^3/s

mean annual flood	1979 to 1999:	747
highest recorded flow	1979 to 1999:	1082 (22/01/1982)

maximum flows 2000 to 2004			Estimated return period in years
2000	628	4-Apr-2000	less than mean annual flood
2001	464	27-Mar-2001	less than mean annual flood
2002	660	2-Jan-2002	less than mean annual flood
2003	565	2-May-2003	less than mean annual flood
2004	637	9-Jan-2004	less than mean annual flood

Minimum flows

mean annual 7 day low flow:	1979 to 1999:	13.96
minimum 7 day low flow:	1979 to 1999:	10.4 (11/4/1985)

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	15.4 at interval beginning 28-Apr-2000 03:15:00	more than mean annual low flow
2001	12.6 at interval beginning 18-Mar-2001 11:45:00	4.4
2002	15.3 at interval beginning 16-Feb-2002 00:45:00	more than mean annual low flow
2003	12.9 at interval beginning 23-Apr-2003 23:00:00	3.8
2004	14.2 at interval beginning 25-Aug-2004 06:30:00	more than mean annual low flow

5.13 Hokitika River at Colliers Creek/Gorge

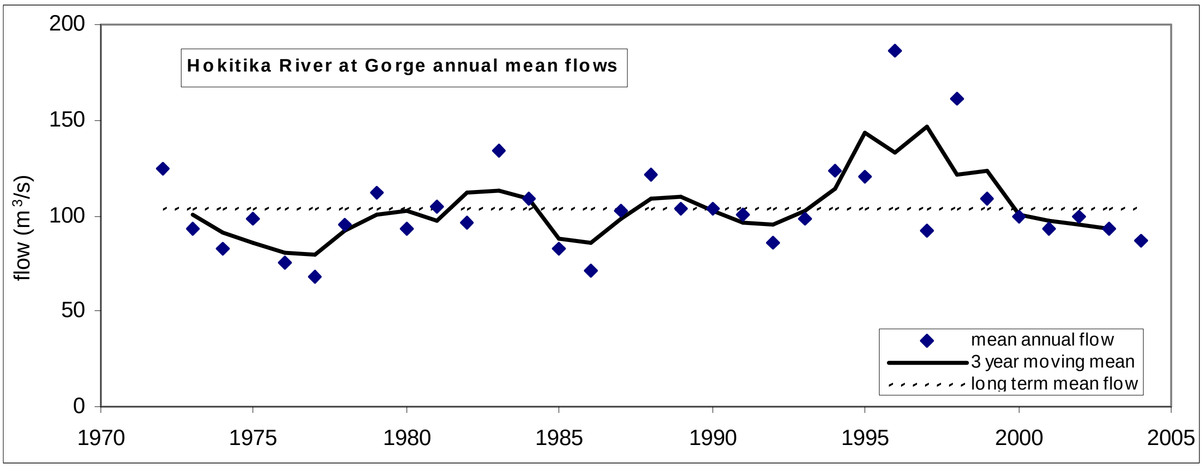

Figure 5.13: Annual mean flows for Hokitika River at Colliers Creek/Gorge

Figure 5.13 shows annual mean flows, for the reporting period, at the Hokitika River at Colliers Creek/Gorge site were all below average. However, the annual mean flows for 2000 to 2004 still fell well within the range of annual mean flows measured since 1972.

Table 5.12: Extreme flows 2000 to 2004, Hokitika River at Colliers Creek/Gorge

Maximum flows

Flows are in m^3/s

mean annual flood	1972 to 1999:	1749
highest recorded flow	1972 to 1999:	2447 (9/01/1994)

maximum flows 2000 to 2004			Estimated return period in years
2000	1990	27-Jul-2000	
2001	2101	6-Dec-2001	
2002	2042	4-Jan-2002	*not available*
2003	2092	2-May-2003	
2004	2820	9-Jan-2004	

Minimum flows

mean annual 7 day low flow:	1972 to 1999:	23
minimum 7 day low flow:	1972 to 1999:	14 (10/7/1991)

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	33.2 at interval beginning 14-Jan-2000 19:00:00	more than mean annual low flow
2001	21.3 at interval beginning 21-Jul-2001 12:15:00	3.1
2002	27.3 at interval beginning 28-Jul-2002 02:00:00	more than mean annual low flow
2003	20.0 at interval beginning 24-Apr-2003 00:15:00	3.9
2004	missing record	

5.14 Cropp River at Gorge

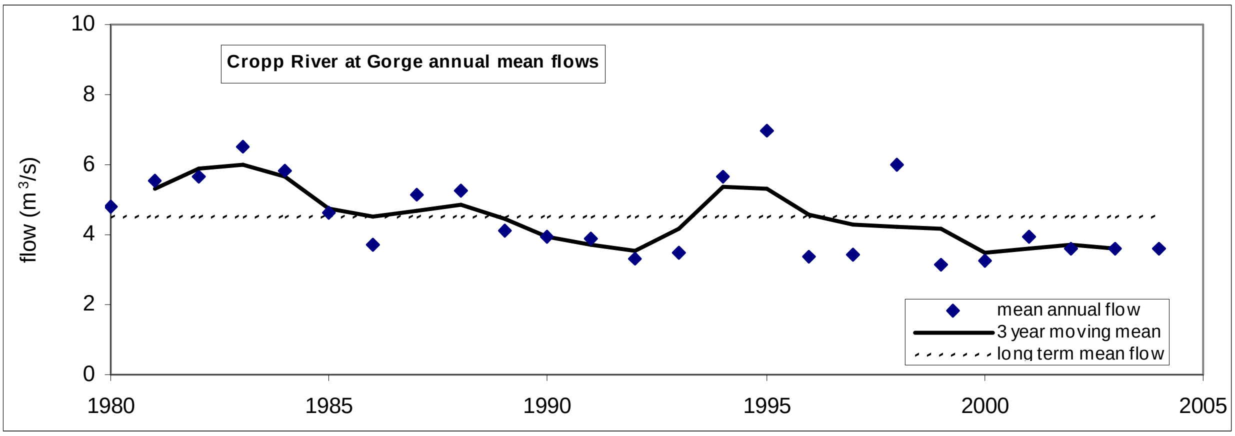

Figure 5.14: Annual mean flows for Cropp River at Gorge

Figure 5.14 shows annual mean flows, for the reporting period, at the Cropp River at Gorge site were all significantly below average. This pattern is part of a trend of declining annual mean flows for the site over the last ten years.

Table 5.13: Extreme flows 2000 to 2004, Cropp River at Gorge

Maximum flows

Flows are in m^3/s

mean annual flood	1980 to 1999:	164
highest recorded flow	1980 to 1999:	352 (19/05/1988)

maximum flows 2000 to 2004			Estimated return period in years
2000	154	22-Jan-2000	less than mean annual flood
2001	143	10-Apr-2001	less than mean annual flood
2002	126	2-Jan-2002	less than mean annual flood
2003	105	1-Feb-2003	less than mean annual flood
2004	139	8-Jan-2004	less than mean annual flood

Minimum flows

mean annual 7 day low flow:	1980 to 1999:	1.054	
minimum 7 day low flow:	1980 to 1999:	0.641 (26/7/96)	this superceded by 2004

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	0.923 at interval beginning 14-Jan-2000 11:45:00	4.2
2001	0.703 at interval beginning 21-Jul-2001 05:30:00	13.1
2002	0.777 at interval beginning 15-Feb-2002 12:25:00	8.9
2003	0.825 at interval beginning 19-Aug-2003 07:25:00	6.9
2004	0.550 at interval beginning 19-Jul-2004 13:45:00	30

5.15 Whataroa River at SH6

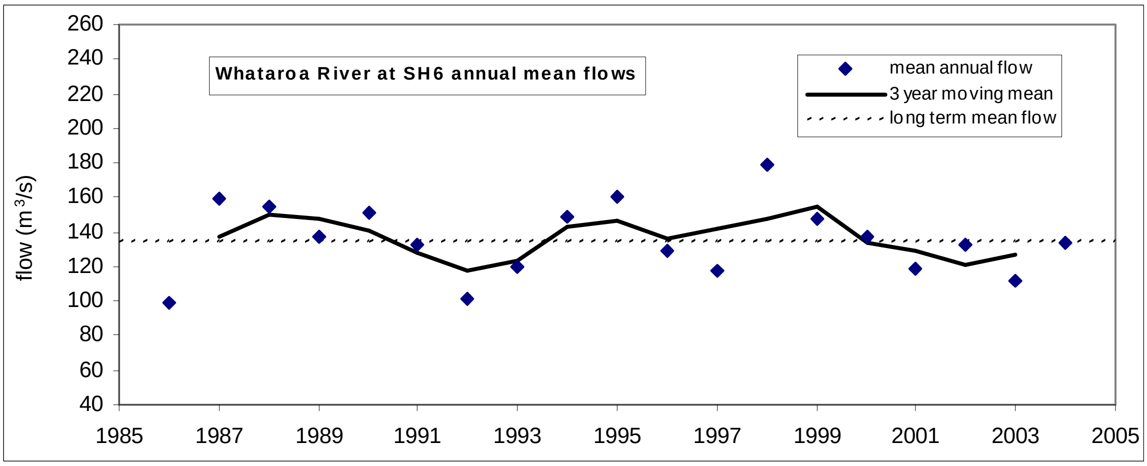

Figure 5.15: Annual mean flows for Whataroa River at SH6

Figure 5.15 shows annual mean flows, for the reporting period, at the Makawhio River at Rocks site were variable about the mean.

Table 5.14: Extreme flows 2000 to 2004, Whataroa River at SH6

Maximum flows

Flows are in m^3/s

mean annual flood	1986 to 1999:	2822
highest recorded flow	1986 to 1999:	3952 (9/1/94)

maximum flows 2000 to 2004			Estimated return period in years
2000	2519	28-Dec-2000	less than mean annual flood
2001	2038	27-Mar-2001	less than mean annual flood
2002	3060	3-Jan-2002	3.1
2003	1859	18-Feb-2003	less than mean annual flood
2004	3181	9-Jan-2004	3.7

Minimum flows

mean annual 7 day low flow:	1986 to 1999:	29
minimum 7 day low flow	1986 to 1999:	17 (1/8/95)

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	38.1 at interval beginning 30-Aug-2000 13:15:00	more than mean annual low flow
2001	19.6 at interval beginning 21-Jul-2001 11:15:00	6.5
2002	30.7 at interval beginning 13-Jul-2002 14:15:00	more than mean annual low flow
2003	26.4 at interval beginning 19-Aug-2003 04:30:00	3.0
2004	25.7 at interval beginning 31-Jul-2004 00:45:00	3.3

5.16 Makawhio River at Rocks

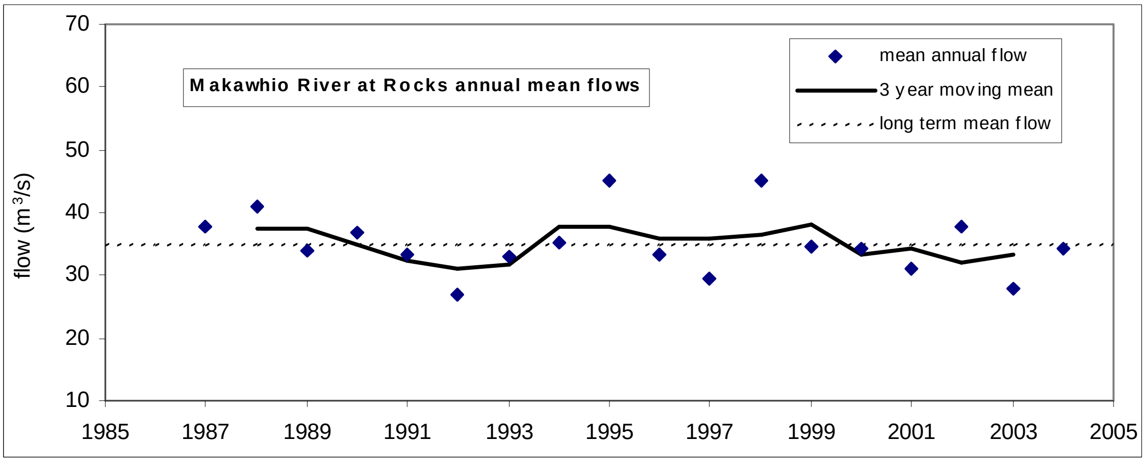

Figure 5.16: Annual mean flows for Makawhio River at Rocks

Figure 5.16 shows annual mean flows, for the reporting period, at the Makawhio River at Rocks site were variable about the mean. The mean flow for 2003 was noticeably lower than usual.

Table 5.15: Extreme flows 2000 to 2004, Makawhio River at Rocks

Maximum flows — Flows are in m^3/s

mean annual flood	1987 to 1999:	860
highest recorded Q	1987 to 1999:	1163 (4/2/87)

maximum flows 2000 to 2004			Estimated return period in years
2000	693	25-Jun-2000	less than mean annual flood
2001	892	19-Nov-2001	3.2
2002	799	3-Jan-2002	less than mean annual flood
2003	855	18-Feb-2003	less than mean annual flood
2004	869	9-Jan-2004	2.6

Minimum flows

mean annual 7 day low flow:	1987 to 1999:	7.00
minimum 7 day low flow	1987 to 1999:	5.25 (3/6/92)

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	7.26 at interval beginning 2-Aug-2000 16:45:00	more than mean annual low flow
2001	5.36 at interval beginning 21-Jul-2001 11:15:00	8.3
2002	9.00 at interval beginning 28-Jul-2002 03:15:00	more than mean annual low flow
2003	5.52 at interval beginning 17-Apr-2003 05:30:00	7.2
2004	6.95 at interval beginning 24-Apr-2004 17:45:00	2.4

5.17 Moeraki River at Lake Moeraki

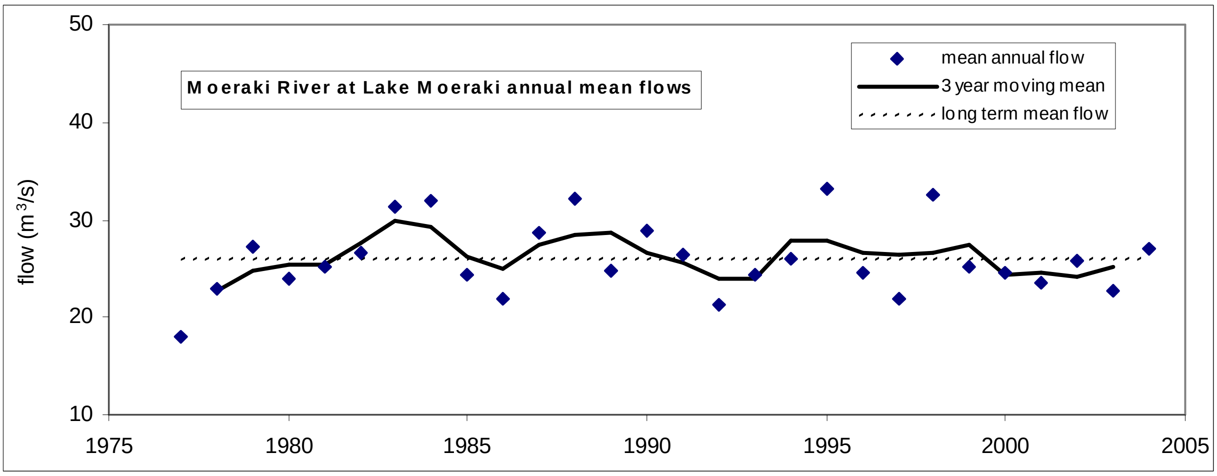

Figure 5.17: Annual mean flows for Moeraki River at Lake Moeraki

Figure 5.17 shows annual mean flows, for the reporting period, at the Moeraki River at Lake Moeraki site were average to below average. There were no years that were significant outliers.

Table 5.16: Extreme flows 2000 to 2004, Moeraki River at Lake Moeraki

Maximum flows

Flows are in m^3/s

mean annual flood	1977 to 1999:	403
highest recorded Q	1977 to 1999:	591 (13/12/95)

maximum flows 2000 to 2004			Estimated return period in years
2000	354	24-Jun-2000	less than mean annual flood
2001	313	19-Nov-2001	less than mean annual flood
2002	363	19-Sep-2002	less than mean annual flood
2003	268	30-Jun-2003	less than mean annual flood
2004	412	29-Dec-2004	2.6

Minimum flows

mean annual 7 day low flow:	1977 to 1999:	5.46
minimum 7 day low flow	1977 to 1999:	4.20 (5/6/92)

annual minimum 7 day flows 2000 to 2004		Estimated return period in years
2000	3.92 at interval beginning 14-Jan-2000 06:35:00	11.0
2001	5.47 at interval beginning 19-Jul-2001 09:35:00	more than mean annual low flow
2002	5.30 at interval beginning 15-Feb-2002 17:14:06	2.7
2003	5.49 at interval beginning 28-Mar-2003 13:45:00	more than mean annual low flow
2004	5.69 at interval beginning 22-Dec-2004 00:05:00	more than mean annual low flow

5.18 Haast River at Roaring Billy

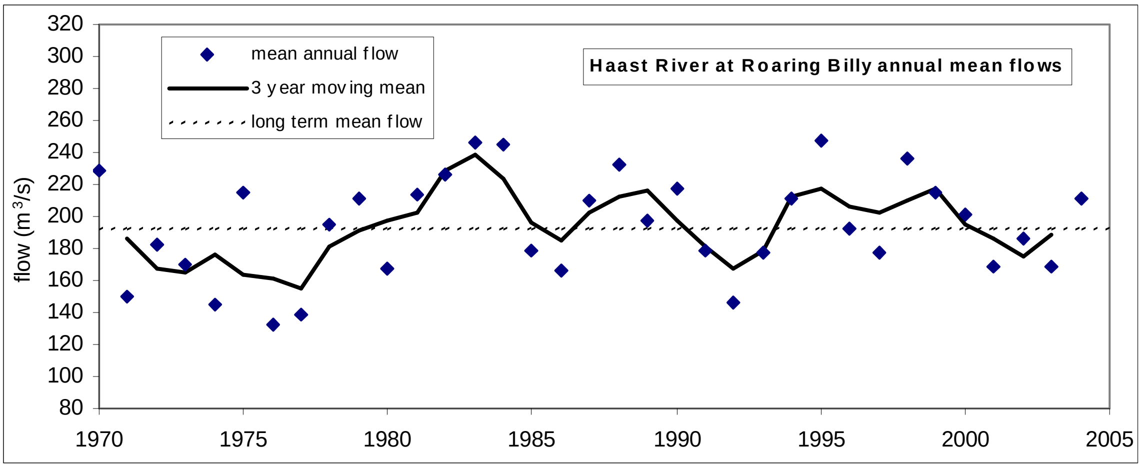

Figure 5.18: Annual mean flows for Haast River at Roaring Billy

Figure 5.18 shows annual mean flows, for the reporting period, at the Haast River at Roaring Billy site were variable about the mean. All annual flows from 2000 to 2004 fell well within the range of annual flows measured at the site since 1970.

Table 5.17: Extreme flows 2000 to 2004, Haast River at Roaring Billy

Maximum flows			Flows are in m^3/s
mean annual flood		1971 to 1999: 3720	
highest recorded Q		1971 to 1999: 6330 (12/5/78)	
maximum flows 2000 to 2004			Estimated return period in years
2000	4320	28-Dec-2000	3.8
2001	2820	5-Dec-2001	less than mean annual flood
2002	4645	3-Jan-2002	5.1
2003	3433	6-Dec-2003	less than mean annual flood
2004	4528	9-Jan-2004	4.6
Minimum flows			
mean annual 7 day low flow:		1971 to 1999: 41	
minimum 7 day low flow		1971 to 1999: 30 (10/7/91)	
annual minimum 7 day flows 2000 to 2004			Estimated return period in years
2000	65.4 at interval beginning 30-Aug-2000 13:15:00		more than mean annual low flow
2001	37.5 at interval beginning 21-Jul-2001 13:00:00		3.9
2002	41.6 at interval beginning 17-Apr-2002 17:15:00		more than mean annual low flow
2003	43.9 at interval beginning 24-Apr-2003 09:15:00		more than mean annual low flow
2004	50.5 at interval beginning 24-Apr-2004 22:15:00		more than mean annual low flow

6. Summary

In this section deviations in climate, rainfall and river flows for 2000 to 2004, as shown in the previous sections, are summarised. Patterns between sites and across each of the 5 years are compared in relation to long term expected normals.

Temperatures :

For all sites the mean temperature for the 5 years from 2000 to 2004 was the same as long-term expected mean temperatures as calculated by Bowis and Faulkner to 2000. However, some anomalies did occur within this:

- There was a general pattern of warmer temperatures in autumn and early winter (especially May and June) for all 5 years. This occured for all sites with the exception of Arapito (Karamea)
- Temperatures were significantly higher than average in spring and summer (September to December) 2001. For Franz Joseph and Haast this period of higher than average temperatures extended into January and February of 2002.
- 2004 was noticeably cooler over winter (namely July and August) for all sites. February, March and April were also cooler in 2004 in Reefton, Hokitika and Westport.

Sunshine:

Sunshine hours were available for only 3 out of the 7 climate sites reported on.

- Sunshine hours were slightly above average for all years from 2000 to 2004 for Arapito (Karamea)
- Sunshine hours were slightly above average in Hokitika and Greymouth for the years 2000 to 2003 inclusive, and average for 2004.

Frost Occurrence

Number of frost days per month were available for five of the seven sites reported on. Anomalies in frost occurrence were consistent between Westport, Reefton, Greymouth and Hokitika, but not Arapito (Karamea).

- 2000: Generally fewer frosts over winter (June, July, August). This was especially so for Arapito (Karamea), Westport and Greymouth.
- 2001: Charaterised by a greater number than average frost days in July (with the exception of Arapito), and fewer than average frost days for August. A lack of frosts in August 2001 is consistent with above average temperatures that followed for spring and summer, as detailed above.
- 2002: Charaterised by significantly fewer frosts for June, July and August for all sites except Arapito (Karamea).
- 2003: No significant deviation in frost occurrence from long-term normals. However, all sites had fewer than usual frost days in June; especially in Hokitika and Greymouth (consistent with higher temperatures recorded in June of all years from 2000 to 2004)
- 2004: Characterised by fewer than average frost days in June, but more than average frost days in most places for the months of July and August.

Rainfall

- Annual rainfall anomalies displayed a definite geographical pattern from 2000 to 2004. For gauges south of and including Greymouth, annual rainfall was variable about the sites long-term mean annual rainfall, with no obvious deviations. However the remaining northern gauges (Punakaiki, Reefton, Westport and Arapito) generally recorded lower than average annual rainfall for 2000 to 2004. This was especially true for 2000 and 2001. Reefton EWS showed the most significant reduction in annual rainfall for the reporting period (see Figure 4.5)

- The maximum 24 hour rainfall for each of the sites occurred over a range of storms. This reflects the large area and diverse topography of the West Coast region. Most maximums fell in 2000, 2001 or 2004. Noticeably, 163mm of rain was recorded in Greymouth for the 24 hours starting 23 January 2003. This supercedes the previous maximum 24 hour rainfall of 160mm for Greymouth, reported by Bowis and Faulkner (2000),
- The longest period without rainfall for the majority of sites occurred during the late summer/early winter of 2001. This included 24 days without rain at Reefton and 30 days without rain at Paringa. For Arapito (Karamea), Cropp Hut, and Mahitahi (Bruce Bay) the longest period without rain (over the reporting period) occurred in autumn 2003.

- Seasonal rainfall anomalies have been presented as they are often more use to the reader than a calendar year total.

    - Summer (December/January/February):
      Summer 2003/04 was significantly wetter for all sites. Summer 2001/02 was also notably wetter than usual. Below average summer rainfall was evident for sites south of Hokitika during 1999/00, 2000/01 and 2002/03.
    - Autumn (March/April/May): There was a highly consistent pattern of below average autumn rainfall from 2001 to 2004 (inclusive). This negative anomaly was particularly evident in 2001 and 2003. Generally autumn 2000 was wetter than average.
    - Winter (June/July/August): North of Franz Joseph winter rainfall was average over the reporting period – the 2000 and 2001 winters being slightly drier and the 2002 and 2004 winters being slightly wetter. South of Franz Joseph all rain gauges recorded above average rainfall for all 5 winters.
    - Spring (September/October/November): Spring rainfall from 2000 to 2004 fluctuated about the long-term mean. Punakaiki and Haast recorded below average rainfall for all five springs, with a wet spring in 2002 for Paringa and Mahitihi (Bruce Bay).

River Flows

Mean river flows across the entire reporting period (Figure 5.1) were generally near their respective long-term mean flows for rivers north of Hokitika. Whereas rivers south of Hokitika had mean flows during 2000 to 2004 that were significantly below their long-term means. However, when considering floods and low flows it was evident that the rivers north of Hokitika had more extreme flows.

Annual mean flows for 2001 and 2003 were below average for all sites. In fact, south of Hokitika township, annual mean flows for all the 5 years considered were either at or below average. This excludes the 2002 mean flow for the Moeraki River and the 2004 mean flow for the Haast River – both of which were slightly above average. Annual mean flows for the Cropp and Hokitika rivers were significantly lower than the long-term site average for each of the five years. All rivers north of Hokitika township had above average annual flows in 2002 and 2004.

Flood activity was not marked over 2000 to 2004. The maximum flow for many sites over the entire 5 years did not exceed the mean annual flood (expected maximum flow for any given year). Like rainfall the timing of the largest recorded flow was variable from one site to the next; due to the large area and complex topography of the region.

Floods with an estimated return period of 5 years of more occurred at the following locations:

- Karamea River at Gorge, 26/01/2001, 2560 m^3/s, estimated return period of 5.7 years
- Tiropahi River at SHB, 30/06/2003, 237 m^3/s, estimated return period of 6.2 years
- Grey River at Waipuna, 27/07/2000, 1164 m^3/s, estimated return period of 5.1 years
- Arnold River at Lake Brunner, 9/10/2000, 251 m^3/s, estimated return period of 5.2 years
  Arnold River at Lake Brunner, 7/12/2001, 311 m^3/s, estimated return period of 19.7 years[1]
  Arnold River at Lake Brunner, 18/06/2002, 280 m^3/s, estimated return period of 9.8 years
- Taramakau River at Greenstone Bridge, 21/01/2002, 3143 m^3/s, estimated return period of 6 years

No significant floods with an estimated return period of 5 years or more occurred south of the Taramakau River.

<u>Low flows</u> were a more prevalent phenomena from 2000 to 2005.
Almost all sites north of the Taramakau River recorded low flows with an estimated return period of 5 years or greater in 2000, 2001 and 2003. Exceptions were the Ahaura River at Gorge and the Arnold River at Lake Brunner. Low flows (seven day mean) with an estimated return period of 10 years or more were recorded at:

- Tiropahi River at SHB. Low flows having an estimated return period of 35 years or more were recorded in 2000, 2001, 2002 and 2003. All annual low flows for these four years were significantly lower than the previous recorded minimum (1986 to 1999) of 216 l/s. The 7-day minimum of 63 l/s in March 2001 is by far the most remarkable low flow from the 5 years period.
- Accordingly, the flow recorded at Pattinsons Creek at Weir, in March 2001, had an estimated return period of 16 years, and was lower than the previous minimum recorded between 1979 and 1999.
- The Grey River at Waipuna had low flows in January 2000 and March 2001 with estimated return periods of 11 and 10 years, respectively. The minimum flow of 8.2 m^3/s, recorded at the site in April 2003, had an estimated return period of 21 years. This supercedes the previous minimum of 10.4 m^3/s, recorded between 1964 and 1999.

Generally, low flows south of the Taramakau River were not as severe as those observed in the north. Low flows in these southern rivers tend to occur in winter, and arise due to different weather patterns than those that produced the very low flows in the northern half of the region from 2000 to 2004. However, notable low flows in the Cropp River in 2001, 2002 and 2003 reflect lower than average rainfall over this period. The low flow of 0.550 m^3/s, recorded in July 2004, reflects a combination of low autumn rainfall and colder temperatures for winter 2004 (see temperature and frost results for Hokitika Airport). This low flow was estimated to have a 30-year return period and superceded the 1980-1999 minimum of 0.641 m^3/s. A flow minimum with an estimated 8-year return period was recorded at Makawhio River at Rocks in July 2001.

7. Conclusion

The 2000 to 2004 period was characterised by average to dry conditions. With little water abstraction on the West Coast, river flows generally reflect prevailing weather conditions. Therefore, where deviations away from long-term expected flows cannot be explained by climate, human induced change may be indicated. Possible human induced change to West Coast river flows is most likely to arise from landuse change; such as bush clearing, plantation forestry or drainage (including humping and hollowing). This is discounting dam construction, where impacts on flows are predictable and obvious.

[1] The peak flow of 311 m^3/s recorded on the Arnold River at Lake Brunner on 7/12/2001 is the second highest recorded flow for the site since records started in 1969

Hydrometric conditions for the reporting period in summary were:

- 2000: Average temperatures, except for above average autumn temperatures. Total sunshine hours for the year were above average. There were fewer frosts. Average (southern region) to below average (northern region) annual rainfall, with both dry summer (1999/00) and winter seasons. Annual mean river flows were generally average although quite low flows were recorded in January – reflecting the dry conditions at the time.
- 2001: A warm autumn and above average temperatures across the region from September to December. Total sunshine hours for the year were above average. Annual rainfall was especially low in the northern part of the region, and about average in the south. However, summer (2000/01) and autumn rainfall were also below average in the south. Annual mean flows were well below average for all rivers in the region for 2001, with some remarkably low flows recorded north of the Taramakau River.
- 2002: Average temperatures, except for above average autumn temperatures. Total sunshine hours for the year were above average, and fewer frosts were recorded at all sites. Annual rainfall was average to above average, with summer (2001/02) winter and spring all receiving above average rainfall. Annual mean flows remained average to slightly below average in the southern part of the region, but above average annual mean flows were recorded in the north. Extreme low flow events were not prevalent.
- 2003: Average temperatures, except for above average autumn temperatures. Total sunshine hours for the year were above average. Annual rainfall totals for 2003 were below average throughout the region. Autumn, and for the southern part of the region summer (2002/03), was especially dry. Accordingly, annual mean flows were below average for all sites, and a number of low flows with estimated return periods of five years or more were recorded on rivers north of the Taramakau River.
- 2004: Above average autumn temperatures and below average winter temperatures. The number of recorded frost days in July and August were above average in most places. Annual rainfall was average to above average across the region, with wetter than usual periods in summer (2003/04) and winter. Annual mean flows were average to above average. Extreme events (floods or low flows) were not prevalent.

By considering flow patterns for the review period with the concurrent weather conditions it is evident that the flows can be largely, if not entirely, explained by the weather. The very extreme flows recorded in 2001 and 2003 arose due to extended periods of below average rainfall, in combination with above average sunshine hours and temperatures (although low flows can arise from very cold conditions were catchment headwaters are subject to freezing).

To further this conclusion, the most extreme low flows were recorded in the Tiropahi River and Pattinsons Creek, with rain gauges in this vicinity recording below average annual rainfall for each of the five years from 2000 to 2004. These rivers drain adjacent flanks of the Paparoa Range, so the recorded low flows are independent of each other in terms of them being potentially associated with landuse change – another point that supports the conclusion that flow patterns for the reporting period were driven by climatic factors.

Flow patterns were also characterised by reduced flood frequency and magnitude, with many sites in the southern part of the region not recording any flows for the five year period greater than a "mean annual flood" (maximum flow expected in any given year). This is consistent with the climatic conditions described above.

In terms of the meteorological anomalies apparent over the reporting period - on an annual basis much of New Zealand's weather is driven by high and low pressure systems, and local sea surface temperatures. However, larger scale atmospheric processes and circulations are also important. These circulations are known to have cycles from years to tens of years, and it is widely accepted that they produce cycles of weather that prevail for similar lengths of time. The emission of greenhouse gases and enhanced greenhouse effect is also thought to have influenced the climate in recent years. Further discussion on these climate controls are beyond the scope of this report, but the reader should enquire with the author at the West Coast Regional Council if he or she wishes to pursue this area of interest.

8. References

Bowis. S, and Faulkner. F, 2000. Hydrometric and Meteorological Data Summary Report to 2000. Unpublished Technical Report. West Coast Regional Council