INTRODUCTION

1. My name is David William Stewart. I am a hydrological consultant and a director of Raineffects Limited.

2. I have a BSc in Physical Geography, Climatology and Mathematics from the University of Otago and 34 years experience in natural resource investigations and hydrology. Between 1974 and 1996 I was employed in various hydrology positions with the Otago Catchment Board and the Otago Regional Council. From 1992 to 1996 I was the Otago Regional Council's Manager of Hydrology. Since 1996 I have worked as an independent hydrological consultant.

3. While employed as an hydrologist by the Otago Regional Council, and its predecessor the Otago Catchment Board, I had involvement in the preparation and writing of the following reports which involved analysis and interpretation of climate and weather information:

   (a) Kakanui River Hydrology Investigation;

   (b) Waikouaiti River Catchment Resource Inventory;

   (c) Water Resources Inventory for the Clutha, Kawarau and Hawea Rivers;

   (d) Shag River Catchment Resource Description Issues and Options for Management.

4. I have assisted in the assessment, management and post event analysis of the majority of significant floods that have affected the Otago region between October 1978 and December 1994.

5. Since leaving the Council, I have undertaken many water resource assessments and hydrological investigations including impacts of resource development, analysed water plans (Otago Regional Council, Environment Canterbury, draft Waitaki Catchment Water Allocation Regional Plan), analysed major project plans for water use, (Project Aqua, Dunedin City Council water supply, Oceana Gold Taieri River water take, Rangitata River Water Conservation Order) and undertaken many water abstraction permit applications with the largest being the North Otago Irrigation Company/Lower Waitaki Irrigation Company applications to take 10 cumecs from the Waitaki River for irrigation which were subsequently granted.

6. I was involved in the hearings by the Special Tribunal for the application for a Water Conservation Order in respect to the Rangitata River and in the Environment Court hearings subsequent to that on the same matter. I was part of the team working for the Department of Conservation Christchurch Conservancy and prepared and presented evidence on hydrology/various flow regimes/minimum flows to the Special Tribunal and the Environment Court.

7. I also presented evidence on behalf of the Department of Conservation Christchurch Conservancy at the Hearing for the applications for resource consents to enable the continuance of the Rangitata Diversion race and its associated facilities. At that

hearing I presented evidence on information on the different types of rivers in Canterbury and their minimum flows and an analysis of the proposed minimum flow regime for the Rangitata River.

8. I am familiar with the Ashburton Community Water Trust/Central Plains Water Trust applications. In particular, I have read the following:

(a) The two sets of evidence prepared by Cliff Tipler.

(b) The evidence of Richard De Joux.

(c) John Bright's evidence

(d) Neal Borrie's evidence

9. Although this is a Regional Council hearing, I have prepared my evidence in compliance with the Code of Conduct for expert witnesses set out in the Environment Court's consolidated practice note dated 31 July 2006. I confirm that my evidence is within my area of expertise.

SCOPE OF EVIDENCE

10. My evidence will:

- Identify the difference in abstraction regimes between a run-of-the-river irrigation scheme and that for a run-of-the-river power generation scheme.
- I will do this firstly by comparing what the different flow regimes would be if they applied in the Rangitata River and secondly showing what the differences would be for initially an irrigation run-of-the-river scheme in the Rakaia River and subsequently a power generation run-of-the- river scheme in the Rakaia River.

11. The following references are made in my evidence: ACWT is the Ashburton Community Water Trust, CPW is the Central Plains Water Trust, EA is Electricity Ashburton, BCI is Barrhill Chertsey Irrigation, RDR is the Rangitata Diversion Race.

12. ACWT along with EA are proposing to build a run of the river hydroelectricity generation scheme on the south bank of the Rakaia River. The scheme capacity will be 40 cubic metres per second (cumecs).

13. BCI hold a consent for abstraction of up to 17 cumecs for irrigation and power generation. The BCI permit will be used through the hydro scheme. The BCI abstraction has a lower minimum flow than the ACWT abstraction and will be more reliable .

14. The BCI abstraction is not included in this review since it is an existing permit and the objective of this review is to show the significant difference between the ACWT abstraction for irrigation only and that power generation.

15. The remaining 23 cubic cumecs to make up the full 40 cumecs will come from the ACWT/CPW water permit to take water.

16. Before I deal with the Rakaia River abstractions, I would first like to use the RDR system, an existing run-of-the-river combined irrigation and power generation scheme in this area, to show the difference in flow abstraction regimes that could have occurred if power generation in this system was not initially included. I will then show the differences between the Rakaia River proposed abstraction regimes from it being an irrigation scheme abstracting only during the irrigation season to one of power generation with the requirement to abstract all year round.

17. Firstly I will provide a brief description of the RDR scheme. A good concise description of this scheme was provided in the decision from the Hearing for the "Applications for resource consents to enable the continuance of the Rangitata Diversion race and it's associated facilities"

18. This description is as follows:

> "The Rangitata Diversion Race is a 67km long canal which carries about 30 cubic metres per second of water, diverted from the Rangitata River at Klondyke, north west across the Mid-Canterbury Plains, to the Rakaia River at Highbank.
>
> A second intake on the South [Branch] of the Ashburton River diverts up to about 7 cubic metres of water, when it is available, from the river in to the Rangitata Diversion Race
>
> Three Community Irrigation Schemes, two hydroelectric power stations, Ashburton District Council stockwater race system and various private stockwater and irrigation schemes are supplied by the race…
>
> Irrigation has priority of supply during the irrigation season extending from September 10 to May 10 each year. During the rest of the year, Highbank power station … located at the Rakaia end of the`race, has priority of supply.
>
> The other power station, Montalto, [is] located 1.5kms downstream from the Mayfield-Hinds Irrigation Scheme…
>
> Major control structures built along the race include the Rangitata intake and sandtrap, checkgates, spillways and siphons passing under rivers and streams which cross the race."

19. Records for the RDR scheme show that the maximum flow available from the Rangitata River is diverted every month into the scheme. There are different monthly minimum flows applying to the Rangitata. Importantly in the context of this hearing the RDR scheme diverts maximum flow irrespective of irrigation use because of the electricity generation capability of the scheme.

20. The Rakaia River benefits from water discharged by this scheme which can be up to about 27 cumecs. Table 1 shows the average monthly discharges for the Highbank Power Scheme which is at the Rakaia end of the RDR.

21. This table shows that the throughput of the power scheme is quite low during the irrigation season when irrigation has priority but is significantly higher in winter.

22. It should be noted that the reliability of flows in the RDR from the Rangitata River is significantly higher than that likely from the Rakaia River due to the different minimum flow regimes operating.

Table 1. Monthly Mean Flows Through RDR Highbank Power Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1983	1.322	0.000	4.350	9.447	0.000	0.000	0.000	3.971	24.238	24.358	10.005	11.621	7.443
1984	5.138	0.000	0.000	5.900	23.409	26.481	26.650	26.003	16.702	0.283	0.853	3.977	11.283
1985	0.000	0.000	0.000	0.000	15.211	26.270	26.285	25.840	21.702	1.390	2.987	12.921	11.050
1986	4.017	0.000	19.758	16.443	16.570	26.357	26.307	26.763	26.492	25.151	12.131	4.272	17.022
1987	0.000	0.000	3.242	10.156	25.599	26.127	26.330	25.916	18.199	8.970	1.742	2.465	12.396
1988	0.064	0.000	0.000	0.000	11.830	24.543	26.220	26.070	11.134	1.445	0.000	0.000	8.442
1989	0.000	0.000	0.247	0.378	23.722	26.094	25.456	21.026	13.224	7.070	0.122	0.000	9.778
1990	0.000	0.000	0.000	0.000	5.637	25.721	24.671	25.849	22.400	12.719	8.081	0.715	10.483
1991	0.000	3.024	0.580	7.144	22.436	21.470	18.037	23.972	24.043	7.724	6.943	5.081	11.704
1992	3.719	0.000	0.000	0.000	12.089	15.818	18.577	24.913	24.778	24.634	8.602	7.149	11.690
1993	0.536	0.000	0.000	0.000	8.678	25.414	24.321	21.160	12.666	6.261	0.000	0.000	8.253
1994	0.000	0.000	0.000	0.000	2.102	25.787	26.174	26.052	14.671	20.835	2.139	0.000	9.813
1995	0.000	0.000	0.000	16.041	25.256	24.007	23.697	24.072	24.247	25.040	11.016	1.228	14.550
1996	0.000	12.536	18.204	20.583	1.611	23.614	23.048	24.749	17.137	4.546	4.461	0.098	12.549
1997	6.416	8.896	7.978	19.145	23.335	22.757	23.144	24.183	20.891	11.602	0.000	0.000	14.029
1998	0.000	0.000	3.794	0.200	18.706	22.807	25.239	25.139	13.227	5.929	1.240	0.000	9.690
1999	0.000	0.000	8.677	16.410	9.365	26.210	26.274	25.584	20.873	9.868	15.413	9.071	13.979
2000	16.906	11.025	5.926	13.320	25.645	25.710	25.516	25.635	0.503	7.610	0.000	1.665	13.288
2001	0.000	0.000	0.000	0.000	16.113	23.630	22.768	24.542	10.227	0.032	0.007	0.000	8.110
2002	0.000	0.000	0.000	3.170	23.051	22.169	24.175	22.295	13.876	11.255	1.435	0.053	0.000
2003	0.000	0.000	0.162	24.148	25.872	19.634	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Min	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mean	1.815	1.690	3.472	7.737	16.011	22.887	22.042	22.559	16.725	10.320	4.151	2.872	10.264
Max	16.906	12.536	19.758	24.148	25.872	26.481	26.650	26.763	26.492	25.151	15.413	12.921	17.022

23. To show the differences in abstraction regimes I have prepared a series of sequential graphs (Figures 1 – 5) showing average monthly flows for the period 1980-2003 which illustrate the differences.

24. Figures 1 and 2 show the individual average monthly water usage for irrigation and power generation from the RDR. Figure 3 shows the two abstractions plotted on the same graph.

Figure 1. Monthly Average Irrigation Abstraction For The RDR

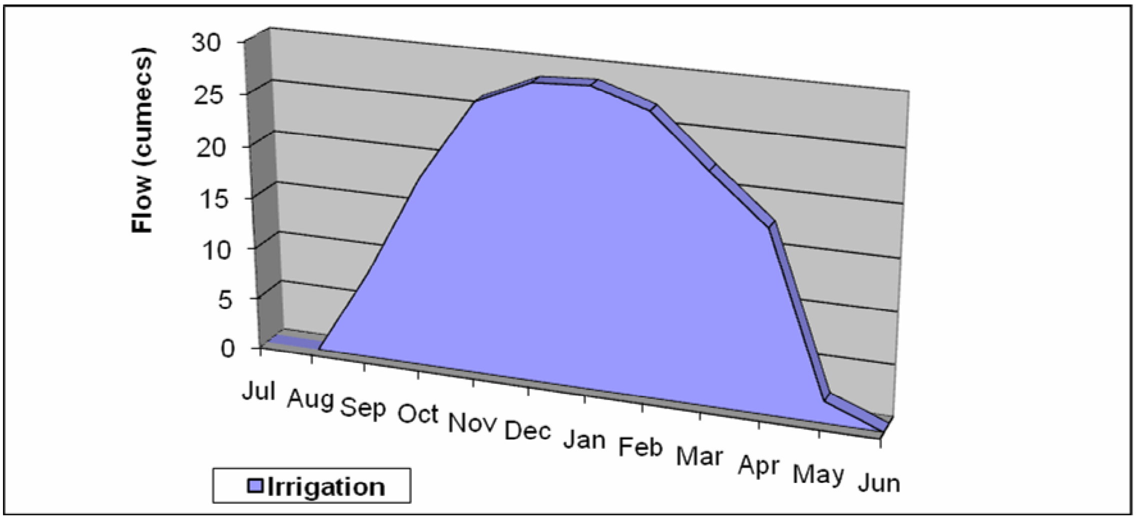


Figure 2. Monthly Average Water Usage For Power Generation (Highbank)

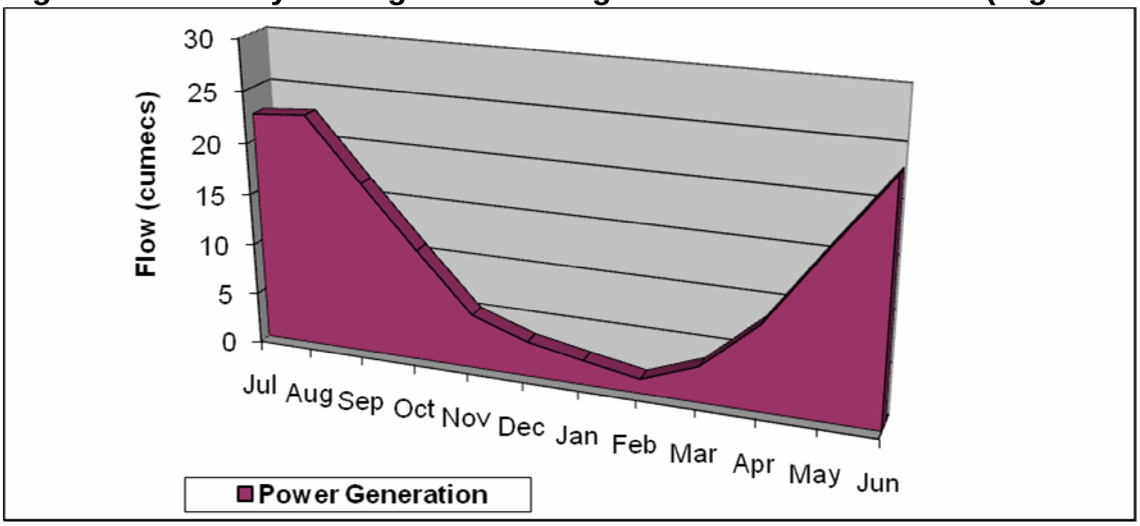


Figure 3. Monthly Average Irrigation and Power Generation

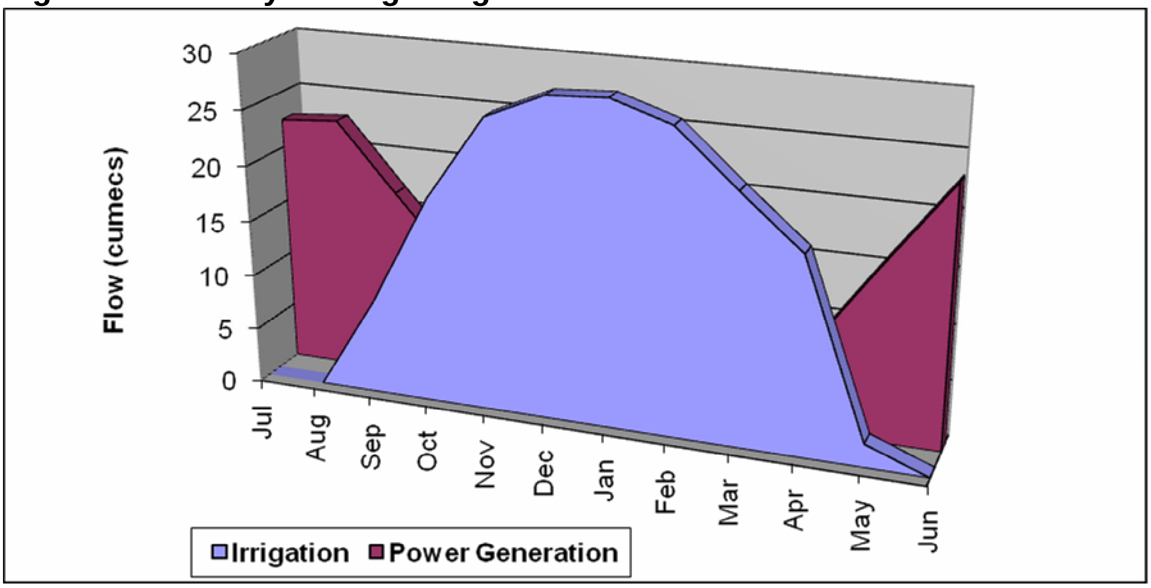


Figure 4 shows the irrigation and power generation plotted on the same graph along with a graph showing the two abstractions added together which is the actual abstraction from the Rangitata River. Figure 5 shows only the irrigation abstraction and the combined overall abstraction.

Figure 4. Monthly Average Irrigation, Power Generation and Combined Irrigation and Power Generation

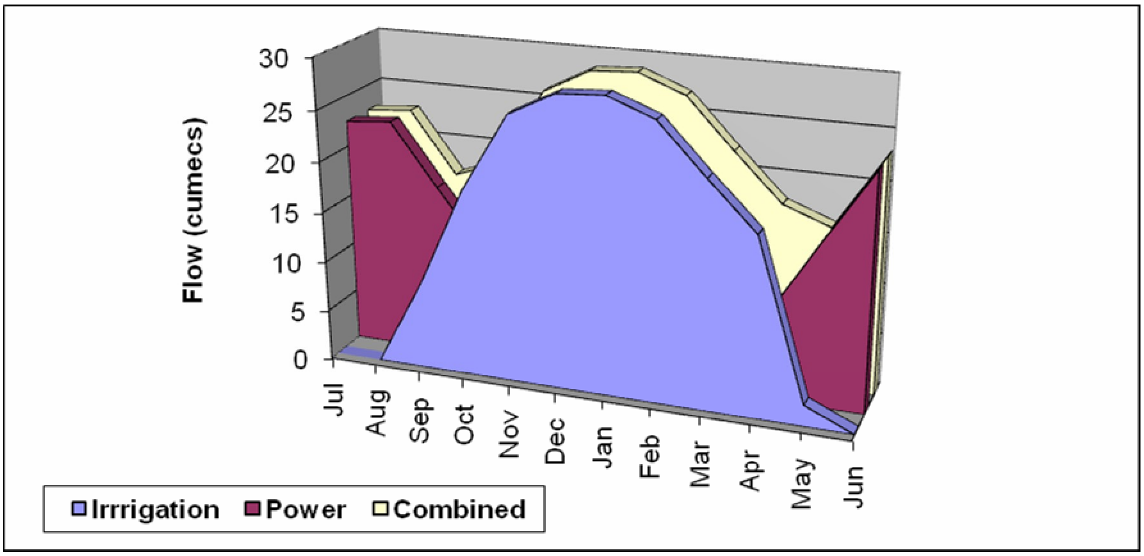
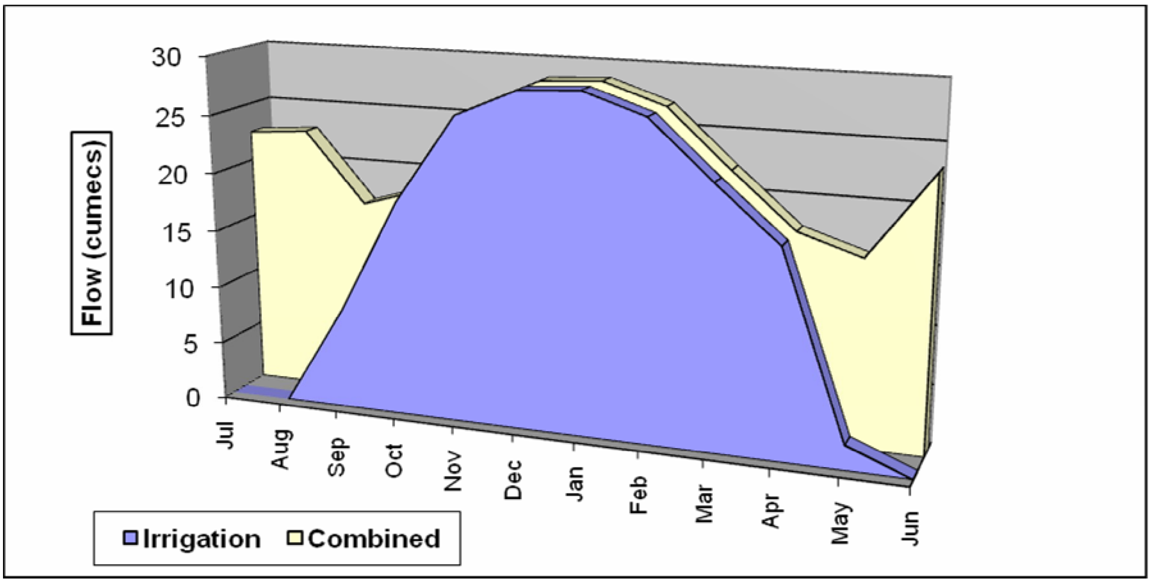


Figure 5. Monthly Average Irrigation and Combined Irrigation and Power Generation



25. The point from this series of graphs is that the abstraction for irrigation only during the irrigation season is quite different to the total abstraction for a power generation scheme which operates all year round and Figure 5 shows this quite clearly. The summer pattern of abstraction is the same but April through to September the abstraction regime for a power generation scheme is markedly different.

26. Looking now at the Rakaia River, the initial proposal by ACWT was for an irrigation scheme with abstraction over the irrigation season. This subsequently changed to a run-of-the-river power generation scheme. However at this point there are no "use" consents lodged by ACWT for irrigation – though these are apparently forecasted. The nature and extent of this proposals is unknown.

27. A series of graphs similar to those prepared for the RDR is likely to show the difference in abstraction regimes between a run-of-the-river irrigation scheme and a run-of-the-river power generation scheme abstracting water from the Rakaia River.

28. Two analyses are undertaken here as there are two scenarios that could develop. Firstly the analysis is based on the water for ACWT being used on the same basis as the demand series for CPW. The second analysis assumes that if the water is available for irrigation in the Rakaia River then it will be taken. Both analyses were undertaken using mean daily flows.

29. For the first analysis undertaken on the Rakaia River data to determine the likely difference between the two abstraction regimes, a series of assumptions was made. These assumptions are all to do with abstraction from the Rakaia River. The assumptions are:

a) The monthly minimum flows and allocations are all controlled by the National Water Conservation (Rakaia River) Order 1988.

b) CPW will not allow any of its water to be used by ACWT during the irrigation season

c) According to the evidence of Mr Neal Borrie of Aqualinc Research Ltd in evidence to this hearing dated April 2008, assuming Synlait does not have priority for its 6 cumecs, there is 35.5 cumecs available to be taken by ACWT and CPW from the Rakaia River.

d) The maximum ACWT abstraction available during the irrigation months (October – May) is 15.5 cumecs.

e) Of the 35.5 cumecs available to ACWT during the non-irrigation months, only 23 cumecs is abstracted at maximum under the joint ACWT/CPW consent because 17 cumecs is already available under the BCI consent and the race to the power station has a maximum capacity of 40 cumecs.

f) Irrigation demand is as detailed in the URS supplied data series of daily irrigation demand for the CPW scheme for the period 1 June 1967 to 31 May 2001.

g) There is no water available to CPW from the Rakaia River from 1 June to 30 September.

h) Daily irrigation demand for ACWT was calculated by deriving a potential area that could be irrigated from 15.5 cumecs (estimated as 25833 ha assuming 0.6l/s/ha) and scaling the URS demand series based on the ratio of the derived ACWT area to the projected 60000 ha for CPW.

i) For power generation, ACWT will always take the maximum amount of water available to it(15.5 cumecs) when it is available.

30. The analysis was undertaken over the full period of the URS supplied demand data.

31. Unlike the RDR analysis, the irrigation demand and the power demand were analysed separately to illustrate the potential abstraction under either regime. The power generation demand was based on the assumption that if the water was available it would be used for power generation.

32. On the basis that Highbank uses whatever water is available, it is assumed that the ACWT power scheme will do the same with whatever water is available from the Rakaia River.

33. Figures 6 – 10 show the different abstractions possible for irrigation and power generation under the first analysis scenario.

Figure 6. Estimated Monthly Average ACWT Irrigation (Demand Series)

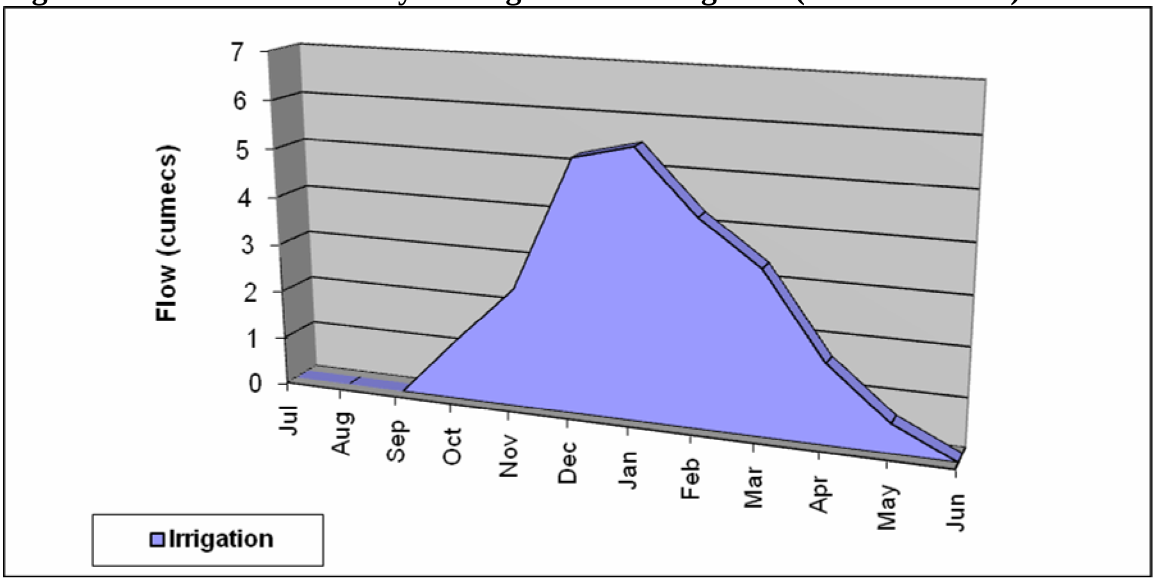


Figure 7. Estimated Monthly Average ACWT Power Generation

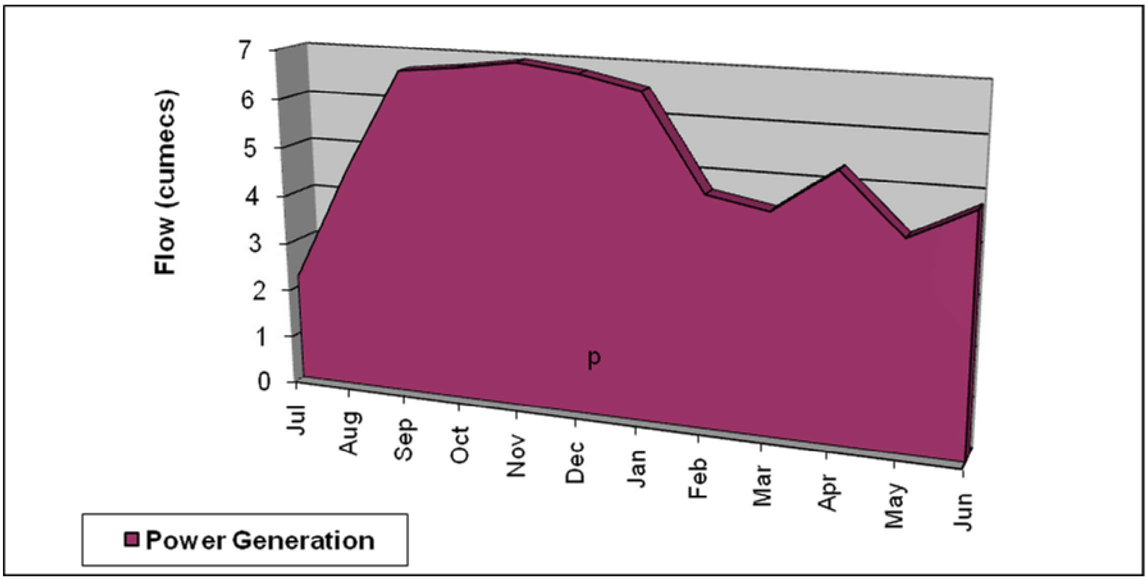
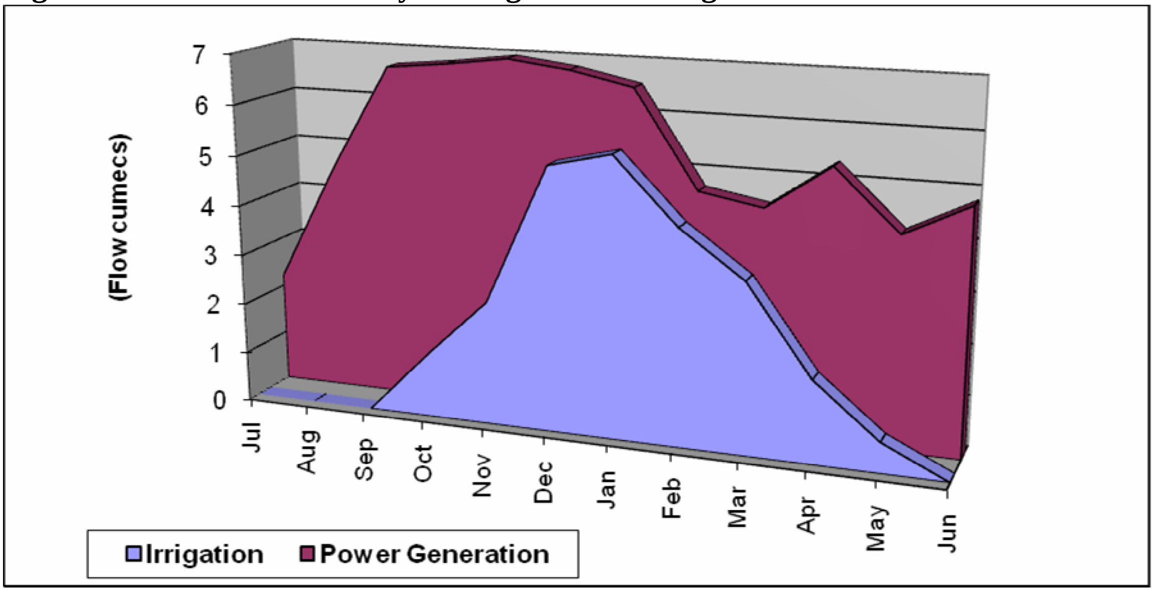


Figure 8. Estimated Monthly Average ACWT Irrigation and Power Generation



34. It is very obvious from Figure 8 that the proposed power abstraction regime is significantly different to an irrigation abstraction based a use when there is a demand as detailed in the supplied demand series for CPW irrigation.

35. Table 2 shows the mean flows for the two abstractions for each 12 month period from 1967/68 to 1998/99. This table shows that except for the very dry seasons of 1967/68 and 1976/77, the difference in mean flows is significant and the power abstraction mean flow is generally at least 2 times that of the irrigation only abstraction. The mean flows for the total record period in this table show a significant difference between the two abstractions.

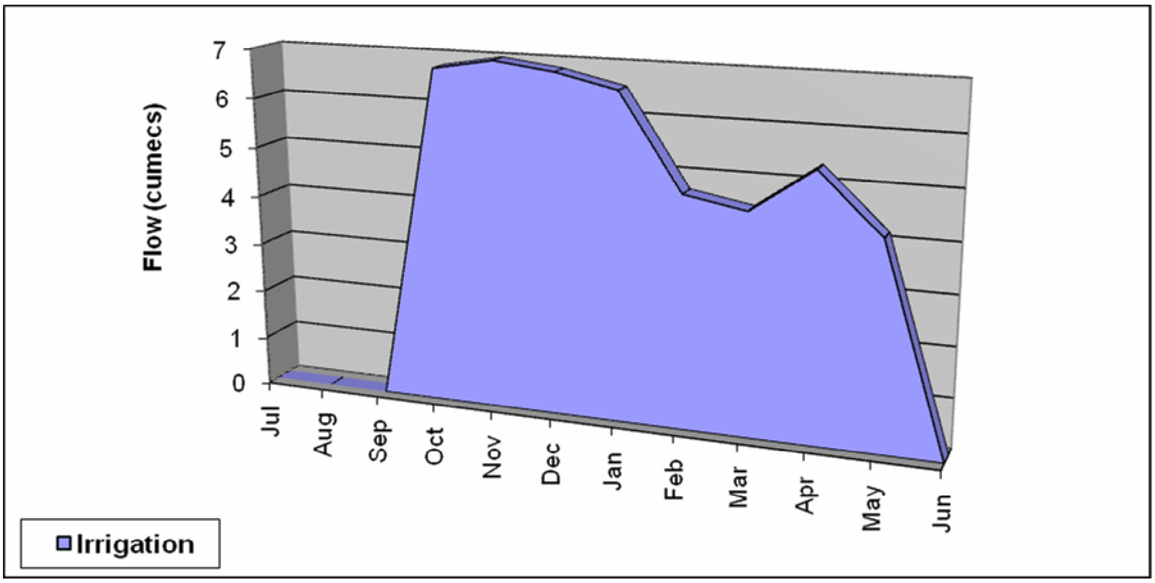
Table 2. Annual Mean Flows – Various Abstraction Regimes

	Irrigation Only	Power Generation Plus Irrigation
1967/68	4.76	6.32
1968/69	1.27	3.28

1969/70	1.19	2.99
1970/71	0.45	4.37
1971/72	1.38	3.73
1972/73	1.47	4.97
1973/74	1.55	3.48
1974/75	1.22	4.23
1975/76	1.39	4.97
1976/77	1.93	2.48
1977/78	1.58	3.34
1978/79	1.54	6.40
1979/80	2.46	8.64
1980/81	2.40	7.74
1981/82	2.63	5.03
1982/83	2.42	5.14
1983/84	1.94	6.91
1984/85	2.47	5.86
1985/86	1.21	5.00
1986/87	2.31	5.84
1987/88	1.57	4.00
1988/89	4.58	9.65
1989/90	2.04	3.99
1990/91	2.63	4.90
1991/92	1.64	4.09
1992/93	1.58	5.95
1993/94	1.35	4.31
1994/95	2.84	8.38
1995/96	2.69	8.41
1996/97	1.92	4.53
1997/98	4.13	5.77
1998/89	1.75	7.49
Mean	2.07	5.37

36. The second analysis assumes that if the water is available for irrigation in the Rakaia River then it will be taken as opposed to it only being taken if the demand from the demand series shows that it is required.

Figure 9. Estimated Monthly Average ACWT Irrigation (Abstract All)



Flow (cumecs)
7
6
5
4
3
2
1
0
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Irrigation

Figure 10. Estimated Monthly Average ACWT Power Generation

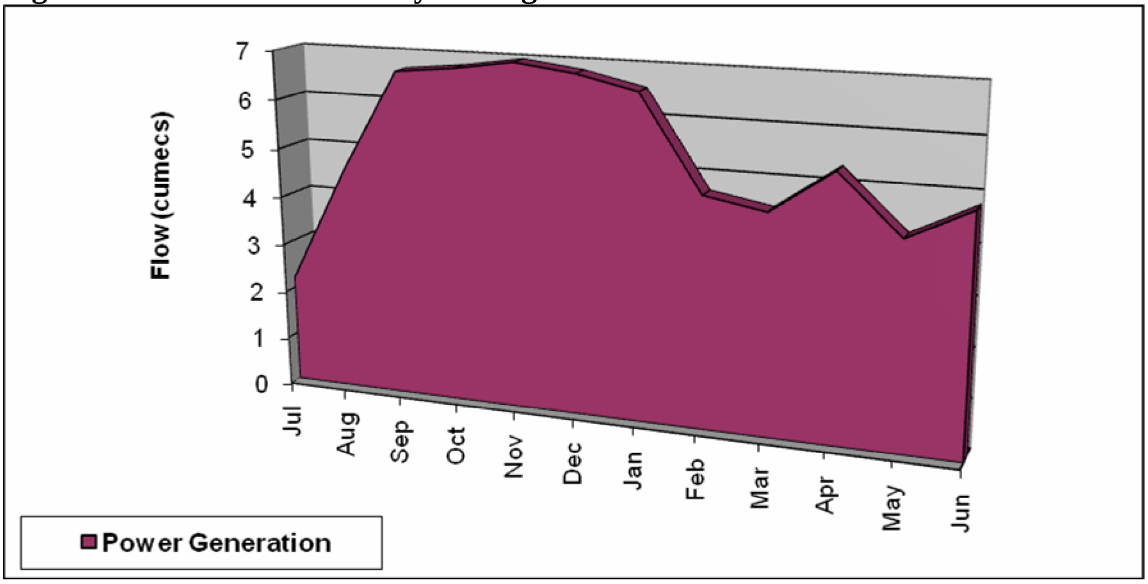
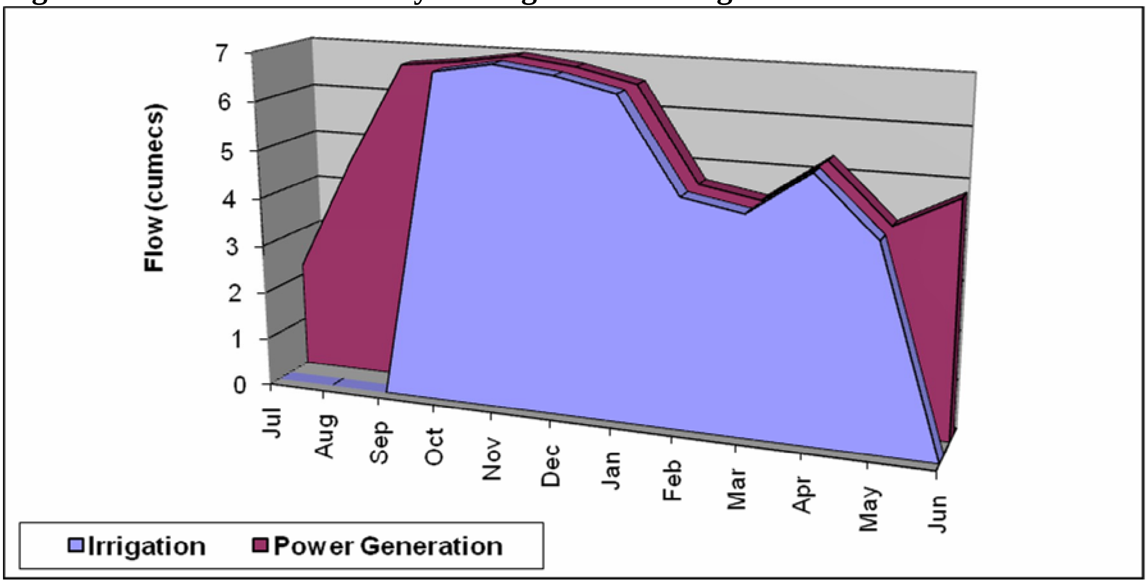


Figure 11. Estimated Monthly Average ACWT Irrigation and Power Generation



37. Under this second scenario the difference in flow regimes is not as marked as it was under the first scenario but there is still a significant difference in the winter months when there is no irrigation but still large abstraction for power generation.

38. Table 3 shows the mean flows for the two abstractions for each 12 month period from 1967/68 to 1998/99. This table shows that except for the very dry seasons of 1967/68 and 1976/77, the difference in mean flows is significant.

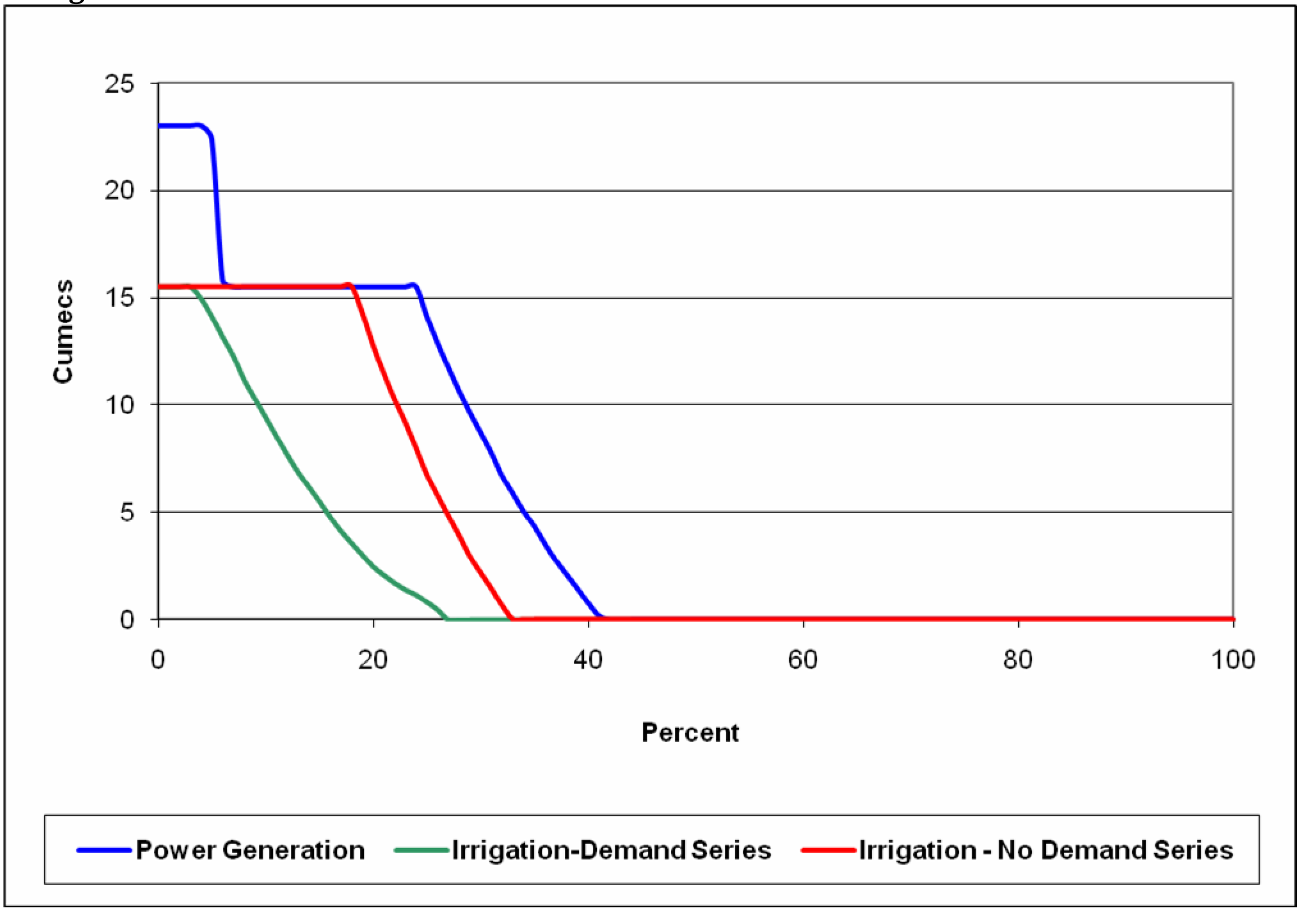
Table 3. Annual Mean Flows – Various Abstraction Regimes

	Irrigation Only	Power Generation Plus Irrigation
1967/68	4.87	5.91
1968/69	2.85	3.28
1969/70	1.74	2.99

1970/71	1.36	4.37
1971/72	3.46	3.73
1972/73	3.36	4.97
1973/74	3.09	3.48
1974/75	3.41	4.23
1975/76	2.97	4.97
1976/77	2.48	2.48
1977/78	2.89	3.34
1978/79	3.72	6.40
1979/80	5.89	8.64
1980/81	3.89	7.74
1981/82	4.55	5.03
1982/83	4.75	5.14
1983/84	4.52	6.91
1984/85	3.91	5.86
1985/86	2.78	5.00
1986/87	4.67	5.84
1987/88	2.96	4.00
1988/89	6.20	9.65
1989/90	3.54	3.99
1990/91	3.65	4.90
1991/92	2.39	4.09
1992/93	3.75	5.95
1993/94	3.61	4.31
1994/95	5.94	8.38
1995/96	6.40	8.41
1996/97	3.99	4.53
1997/98	4.72	5.77
1998/89	3.63	7.49
Mean	3.81	5.37

39. Figure 12 shows flow duration curves for the abstraction regimes. It shows that under irrigation only, abstraction of various flows could occur for 26% of the time under the CPW demand series, for 31% of time under the no-demand series while that for the irrigation plus power generation could occur for about 41% of the time.

Figure 12. Flow Duration Curves for Various Derived Abstraction Scenarios



40. The conclusion from all the graphs and applicable tables is that the two regimes of irrigation only and power generation are quite different.