IN THE MATTER OF	the Resource Management Act 1991
AND	
IN THE MATTER OF	Of applications for water permits to abstract water, and associated activities for 17 applicants in the Lower Waitaki

BRIEF OF EVIDENCE OF DAVID STEWART

Dated: August 2008

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 33 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 prepared or was involved in the preparation of several major reports defining water resources of various catchments in the Otago area and was also involved in the preparation of plans with respect to water resources allocation and use in this region.

4. I assisted in the assessment, management and post event analysis of the majority of significant floods that 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 for the Waitaki Catchment Water Allocation Regional Plan. I was part of the Whole of Government team and prepared and presented evidence on hydrology/irrigation practicalities/minimum flows to the Waitaki Catchment Water Allocation Board. I also presented similar evidence to the Board on behalf of the major irrigation schemes in the Lower Waitaki.

7. Although this is a district 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

8. My evidence will:

    - Review the surface water parts of the water balance information provided by URS New Zealand Limited to various hearings over the last 4 years;

    - Provide for consideration an alternative flow regime which may provide a realistic means of controlling irrigation abstractions from the lower Waitaki River.

9. Reports reviewed in the course of preparing this evidence include:

- "Lower Waitaki Hydrology Report" prepared by Hydrology Section Power Directorate MWD Wellington, November 1984 (ref. 1);

- "Final Draft Report Rev 08B Project Aqua Water balance" prepared for Meridian Energy Limited, June 2002 (ref.2);

- "Report North Bank Tunnel Concept Water Consents Water balance" prepared for Meridian Energy Limited by Sioban Hartwell of URS New Zealand Limited (September 2006) contained in the Appendices to accompany the applications for the North Bank Tunnel Concept water consent (ref. 3)

- Evidence by Sioban Hartwell to the North Bank Tunnel Concept hearing in 2007 (ref. 4)

- "Seven day mean annual low flow mapping of the tributaries of the Waitaki River" prepared by Suzanne Gabites and Graeme Horrell (2005) for Environment Canterbury (ref. 5)

Water Balance

General

10. This evidence concentrates on a review of the latest water balance information, versions of which have been presented to various hearings on the Waitaki River in the last few years. The purpose is to confirm that according to standard water balance procedures, there is an increase in flow between the Waitaki Dam and Black Point as claimed in the evidence to date. The Applicants sought this review as part of their consideration of minimum flow conditions which may apply to main-stem consents (if granted).

11. A review of the groundwater information previously presented in these water balance reviews will be provided by Dr Nicholas Ward of Pattle Delamore Partners.

12. The water balance of 2007 in Sioban Hartwell's evidence is very similar to that prepared in 2002 for Project Aqua except that updated flow data has been used where this is available.

13. The water balance requires information on flows in the tributaries contributing to the main river along with the main river flows. Figure 1 from Sioban Hartwell's evidence shows the tributaries being considered here. In this case the Waitaki River is represented by flow measurement at the Waitaki Dam. The total catchment area from the Dam to Black Point is about 1800 km^2.

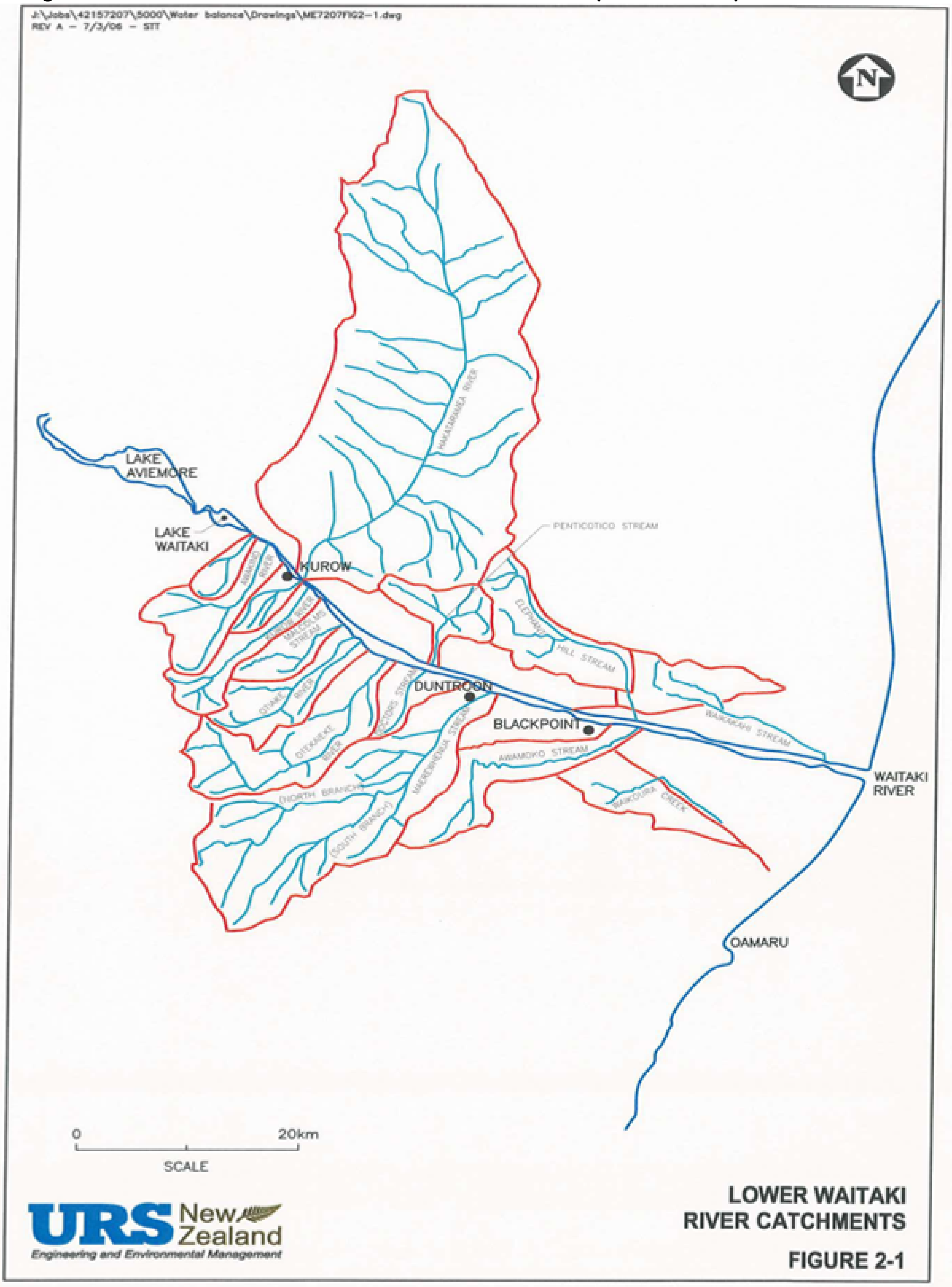
Flow Information

14. The mean monthly flow data for the Waitaki River used by URS in all studies are those measured at the Dam and not at the Kurow recorder. Comparisons of mean monthly flows over the same time periods for the Dam and the Kurow recorder show differences. However for the purposes of this review the starting flows for the water balance are not as important as the changes in flow between the Dam and Black Point due to inflows and groundwater gains and losses. These changes will be the same irrespective of the starting flows before any of these losses and gains.

15. The procedure used by URS to create flow series for tributaries downstream of the dam which contribute to flows in the Waitaki River is acceptable. Flow series in current or previously measured rivers were extended to cover the full record period being used in the study (July 1979 – December 2005) by correlation with other recorded flows in the area. The Hakataramea and Maerewhenua Rivers have recorded flows for the full period being studied while the Otekaieke has flow records from 1970 – 1995.

16. There are a number of other smaller tributaries that have had some spot gaugings done in them. These gaugings were correlated to flows at the same time in one of the above continuously monitored catchments, a relationship derived and subsequently a full record derived for these tributaries.

Figure 1. Lower Waitaki Catchments Dam to Black Point (URS Evidence)



17. There are also some small tributaries that have no gaugings done in them whatsoever and in these cases, the derived flow series are based on the catchment which is the closest in terms of rainfall, topography and geology to the small catchment being considered. While the information does not say so it is assumed that the flow series for these small catchments were derived simply by multiplying the flow series by the ratio of catchment areas. Table 1 shows the derived mean and median flows for the catchments in this reach.

Table 1. Calculated or Derived Mean Flows for Catchments Between the Dam and Black Point

Catchment	Relationship	Derived Flows (l/s)	
		Mean	Median
Hakataramea	Full record	6070	4500
Awakino	0.76 Otekaieke	1000	420
Malcolms	0.05 Otekaieke - 4	51	27
Kurow	0.49 Otekaieke	600	380
Otiake	0.54 Otekaieke	670	440
Otekaieke	0.40 Maerewhenua	1100	620
Maerewhenua	Full record	3060	1600
Little Awakino	0.03 Otekaieke - 2	30	20
Waitoura/Doctors	0.24 Otekaieke	270	17
Penticotico	0.67 Awamoko	70	30
Grassy Hills	0.07 Awamoko	10	3
Total Flows To Waitaki River		**12931**	**8057**

18. All but the flows for the Hakataramea River have irrigation takes subtracted from them. URS made estimates of daily take based on calculations described in reference 3 (p 2:10) and these were subtracted from the derived daily flows. Irrigation abstractions were not subtracted from the measured Hakataramea River flows because these measured flows are at the bottom end of the Hakataramea catchment and as such the flows measured are those after irrigation abstraction.

19. URS did make an estimate of stock water usage and came up with a total for the entire reach Dam to the Sea of 15.7 l/s. They then decided that it was too small to matter and so excluded it from the calculations. I concur with their reasoning.

Groundwater Losses and Gains

20. Groundwater losses and gains are being reviewed by Nicholas Ward of Pattle Delamore Partners (PDP) separately so at this point I will note that according to the URS water balance there is a net gain by the river to Black Point of about 1.7 cumecs. This is less than the 2-4 cumec overall gain as calculated by PDP but it is still showing an overall gain by the river from groundwater alone. After discussion with Dr Ward, it appears that some of the parameters used in the URS water balance which is largely unchanged since the first version in 2002, have been updated. This means that the increase due to groundwater gains alone have gone from 1.7 cumecs in the URS water balance to about 4 cumecs which is a substantial increase.

Issues With the URS Water balance

21. There is some inconsistency in the figures in the water balance evidence and reports throughout the last 7 years. The creek Waitoura/Doctors does not appear in the small catchments map. The catchment labelled Doctors Stream is in fact Waikoura Creek on the NZMS 260 series 1:50000 and this is not listed as having estimates of flow done for it. Malcolms Creek is identified on the URS Lower Waitaki River Catchments map included with this evidence and in the various discussions including how to derive flows for it but its flow estimate is not included in any of the tables. I have included it here and simply used its derived relationship with the Otekaieke to calculate its mean and median flows.

22. In addition, correlations being used by URS are those derived in 1984 by Ian Jowett in the MWD report cited above (Reference 1). More information in the form of spot gaugings in many tributaries and longer continuous flow records for the Hakataramea, Maerewhenua, and Otekaieke Rivers are now available and an update of the relationships between the various continuously measured, occasionally measured and unmeasured streams would be useful. There may not be much change in the relationships as Mr Jowett had at least 13 years of continuous flow data to work with but an update using new information would confirm the relationships.

Conclusions on the Water Balance

23. The surface water section of the water balance prepared by URS has been prepared logically using standard techniques for extending existing records where required and deriving records where none exist. It is not cost effective or logical for any Regional Council to try to measure every river and stream under its jurisdiction and the techniques used to derive flows are an acceptable method for doing so.

24. The URS method for calculating the groundwater gains and losses to and from the Waitaki River between the dam and Black Point has been assessed by Nicholas Ward of Pattle Delamore Partners as being acceptable and that there is, on average, an increase of about 13 cumecs between the Dam and Black Point, of which about 4 cumecs is from groundwater. Much of this groundwater contribution will be from surface water losses which equate to about 2.1 cumecs according to the URS estimates. The 13 cumecs increase coincides with the total of the mean flows in Table 1 of this evidence.

25. I conclude that there is inflow to the Waitaki River in the reach between the Dam and Black Point. Some of this will be as groundwater from losses in the streams and creeks as detailed in Table 1 but irrespective of how it gets there, it contributes to the flows in the Waitaki River. The estimated mean flow entering the river in this reach is small compared to the mean flow of the Waitaki River (around 3%) but it is important to the irrigators in this same reach of the Waitaki River. The total existing and applied for irrigation permits in this reach is 7.65 cumecs. In addition, there is an application for a small hydro generation scheme of 4.2 cumecs which will be abstracted and returned to the river in the reach Dam to Black Point. The water will be out of the river for approximately only 2 km and because this water leaves the river only briefly and is wholly returned, I have excluded it from the total allocation in this reach.

Alternative Flow Regime

Purpose

26. The purpose of this part of my evidence is to provide an alternative approach to managing allocation to that proposed by the Applicants for the Hunter Down Irrigation Scheme.

27. Under the Hunter Down's application, Meridian Energy Limited (MEL) and South Canterbury Irrigation Trust (SCIT) propose:

(a) That the minimum flow for the lower Waitaki River downstream of the Dam is 100 cumecs between the Dam and the Sea.

(b) That the purpose of the Hunter Downs Irrigation Scheme (HDI) ramping conditions is to ensure that a minimum flow of $100m^3/s$ from the dam to the sea is maintained;

(c) The HDI ramping conditions are presented as an alternative management approach to that under Table 3 of the Waitaki Catchment Water Allocation Regional Plan (the Plan); and

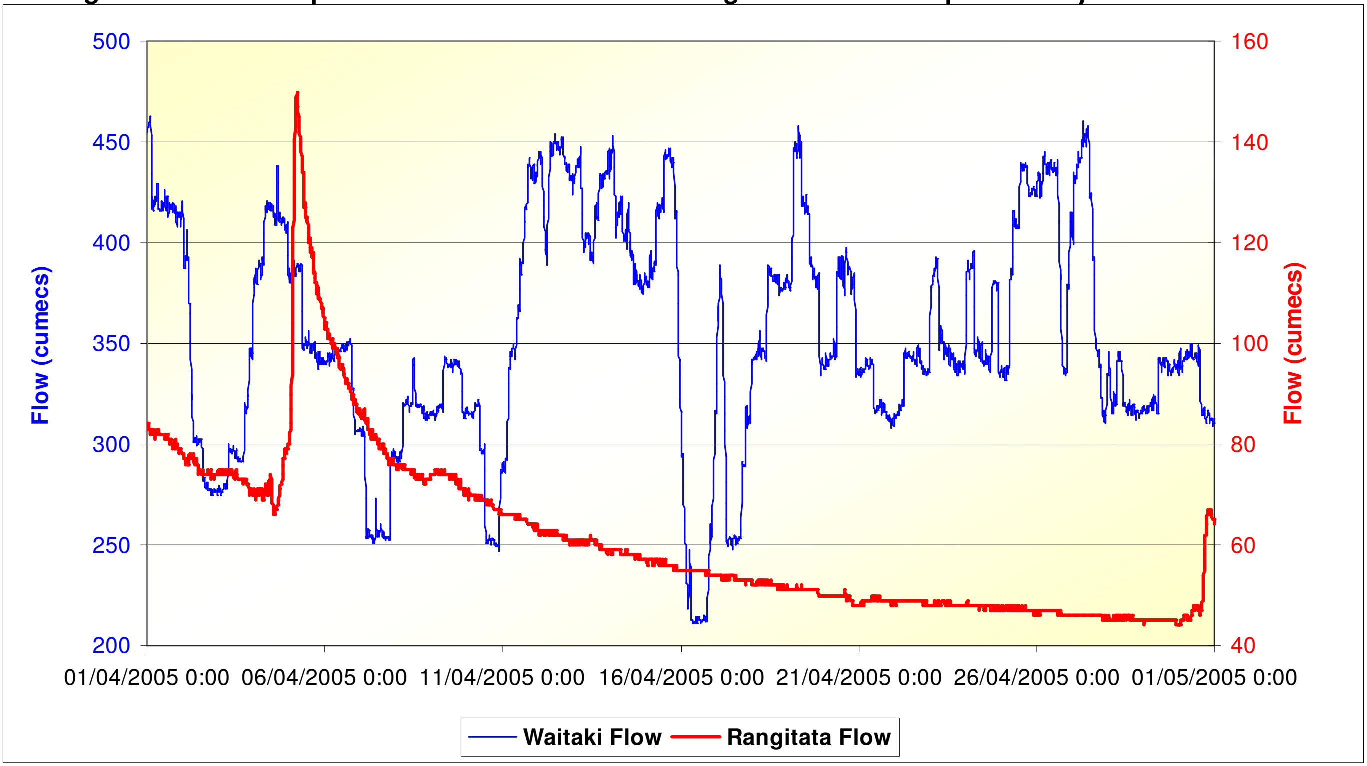
(d) That HDI provided a greater reliability of supply than Table 3 of the Plan.

28. This report adopts 100 cumecs as the minimum flow for the River between the Dam and the Sea. It considers whether there are alternative flow regimes (other than the HDI proposal) to manage abstraction within this reach.

Lower Waitaki River Flows

29. The Lower Waitaki River does not have natural flow at any time of the year. Most of the water passing through the Waitaki Dam is under controlled release by Meridian Energy Ltd (MEL). A comparison with the Rangitata for the same data period shows clearly that the flows in the Waitaki bear no semblance of natural flow. Figure 2 shows this for a selected period in 2005 when the Rangitata experienced a minor fresh and then declined steadily in a standard recession. The Waitaki shows no sign of the fresh but instead fluctuates wildly during the period being displayed. These fluctuations are typical of the flows in the Lower Waitaki and this is due entirely to power generation at the series of hydro generation dams from Tekapo to Waitaki.

Figure 2. Flow Comparison Between Waitaki and Rangitata Rivers – 1 April – 1 May 2005



The Minimum Flow and Irrigation Abstraction – the Problem

30. Up until now the focus of the analyses in the Waitaki has generally been with the use of hourly flow records either at the Waitaki Dam or at Kurow. This includes analyses of the frequency of restrictions to irrigation based on the hourly flows and the various amounts of water being or to be used for irrigation. This may be because the Waitaki Catchment Water Allocation Regional Plan (the Plan) states "A <u>minimum flow</u> from Waitaki Dam to the sea of 150 m3/s..." and "All flows in the Lower Waitaki River determined for the purposes of this item xvii are to be ... based on 1-hour rolling averages" (Table 3 of the Plan). I do note however that the irrigation restrictions identified by the AgriBusiness Group Butcher Partners Ltd in Annex C of the Hunter Downs irrigation Proposal did use 24 hour flows but these flows were those derived using the Plexos model and initial indications from the limited information made available shows that the plexus model daily flows can vary by as much as 20 cumecs from the actual measured flows.

31. The Rakaia and Waimakariri Rivers are natural rivers and have natural flow recessions. This means that restrictions to irrigation can be predicted several days out if there is no rain in the interim. However environmental flows in both these rivers are based on the previous average 24 hour flow. In the case of the Waitaki River, there is no means of flow prediction by irrigators as to what the flows are going to be on an hourly basis or daily basis. Flows in the Lower Waitaki River are determined by the generation requirements of MEL to meet their customer demand which changes every day and throughout the day. This creates a problem for irrigators and large irrigation schemes in the Lower Waitaki. Although flows can change on an hourly basis, irrigators cannot operate their irrigation schemes and systems on this basis. Furthermore, the distance between the flow recorder and the abstraction site would somehow need to be calculated and the appropriate restriction be implemented at some time after the

measurement at the Kurow recorder. This would result in an incredibly complicated system with very little likelihood of being implemented successfully.

The Minimum Flow Converted Into a Usable Form for the Lower Waitaki

32. The solution may be that the minimum flow becomes a mean flow over a longer time period such as 24, 48 or 72 hours. While the Plan states the minimum flow is 150 m^3/s and it is based on a 1-hour rolling average, it does not state that the minimum flow is the 1-hour rolling average. There is no reason why the minimum flow cannot be the 24, 48, or 72-hour mean flow for the whole Lower Waitaki River based on the 1-hour rolling average flow. **Tables 2 and 3** show examples of the hourly values for 2 periods of record in early 2004. In the first 5 days of this period, hourly flows dropped to around 150 cumecs and remained there for more than 24 hours. In the second period of data, the hourly values fell to around 150 – 160 cumecs only briefly and were restored to flows in excess of 200 cumecs within the 24 hour period.

Table 2. Hourly Flows At Kurow January 2004

9 Jan		10 Jan		11 Jan		12 Jan		13 Jan	
Hour	Flow (m^3/s)	Hour	Flow (m^3/s)	Hour	Flow (m^3/s)	Hour	Flow (m^3/s)	Hour	Flow (m^3/s)
1	304	1	206	1	146	1	170	1	389
2	292	2	189	2	147	2	169	2	383
3	265	3	179	3	147	3	170	3	382
4	246	4	175	4	148	4	172	4	384
5	247	5	174	5	149	5	171	5	386
6	249	6	171	6	149	6	171	6	388
7	251	7	162	7	149	7	173	7	389
8	251	8	153	8	150	8	175	8	391
9	250	9	151	9	149	9	175	9	391
10	245	10	150	10	149	10	176	10	392
11	232	11	147	11	148	11	176	11	398
12	209	12	143	12	147	12	186	12	415
13	184	13	138	13	148	13	200	13	433
14	175	14	134	14	149	14	214	14	438
15	179	15	130	15	148	15	230	15	437
16	180	16	132	16	148	16	251	16	434
17	177	17	137	17	149	17	299	17	431
18	178	18	141	18	151	18	358	18	430
19	192	19	142	19	154	19	380	19	430
20	205	20	142	20	158	20	376	20	429
21	212	21	142	21	162	21	381	21	430
22	227	22	141	22	166	22	381	22	432
23	231	23	142	23	169	23	373	23	431
24	221	24	144	24	170	24	381	24	432

33. **Table 2** shows that the hourly flows dropped below 190 cumecs on 9 January for 6 hours. During this 6 hour period, flows were quite variable. On 10, 11 and 12 January, flows were less than 190 cumecs for 59 consecutive hours and again they were quite variable for much of this period varying from 189 cumecs to as low as 130 cumecs. The estimated demand for a full 90

cumec allocation (derivation of this is described later in the report) during this period was between 87 and 88 cumecs. Assuming this demand, there would have been varying restrictions throughout most of the 5 day period.

34. **Table 3** shows a different scenario to Table 1 in that on 17, 18 and 19 January, flows began the day well above the 190 cumec flow, dropped quickly to flows between 140 and 160 cumecs and then varied around that flow. Before the 24 hour period was up, flows were restored to well above 200 cumecs again. They quickly dropped to about 150 cumecs on 17 January and varied between 150 and 163 cumecs for 14 hours before returning again to flows in excess of 250 cumecs. On 18 January they steadily dropped to 160 cumecs and then rose quickly above the 190 cumec flow within a few hours. On 19 January, they steadily dropped to about 148 cumecs and remained around that flow for several hours before quickly rising above the 190 cumec flow again before the 24 hour period was up. The estimated demand for a full 90 cumec allocation during this period was between 87 and 88 cumecs. Assuming this demand, there would have been varying restrictions throughout 3 days of the 5 day period.

Table 3 Hourly Flows At Kurow January 2004

16 Jan		17 Jan		18 Jan		19 Jan		20 Jan	
Hour	Flow (m^3/s)	Hour	Flow (m^3/s)	Hour	Flow (m^3/s)	Hour	Flow (m^3/s)	Hour	Flow (m^3/s)
1	408	1	343	1	337	1	367	1	353
2	409	2	315	2	349	2	329	2	387
3	413	3	284	3	332	3	290	3	412
4	416	4	252	4	302	4	252	4	422
5	419	5	224	5	270	5	207	5	417
6	420	6	197	6	245	6	174	6	392
7	423	7	169	7	218	7	158	7	365
8	425	8	153	8	191	8	151	8	343
9	424	9	150	9	175	9	148	9	329
10	423	10	158	10	169	10	149	10	324
11	422	11	164	11	168	11	148	11	324
12	418	12	163	12	166	12	148	12	321
13	413	13	163	13	162	13	148	13	320
14	413	14	161	14	160	14	148	14	332
15	412	15	155	15	164	15	148	15	342
16	410	16	151	16	187	16	148	16	343
17	408	17	150	17	220	17	147	17	342
18	407	18	149	18	244	18	151	18	339
19	407	19	149	19	274	19	170	19	337
20	406	20	159	20	308	20	204	20	337
21	407	21	199	21	349	21	240	21	338
22	407	22	245	22	387	22	279	22	328
23	395	23	270	23	395	23	314	23	308
24	369	24	300	24	387	24	331	24	293

35. It can be concluded that under the two alternative flow sharing regimes (the HDI proposal and the abandoned GST/Chapman Tripp draft agreements) being investigated, it would have been

particularly complicated and virtually impossible to implement restrictions in both of these periods.

36. **Table 4** shows the same flow periods as Tables 2 and 3. It shows that for the period 9 - 13 January, with a 24 or 48 hour mean flow as the minimum and a 90 cumecs demand, there still would have been 2 days of shortfall. For the 72 hour period, here would have been one day of shortfall. For the period 16 – 20 January, while there would have been significant restriction on an hourly basis, under the 24, 48 and 72 hour mean flows, there would be no restriction.

Table 4. Average 24, 48, and 72 Hour Flows At Kurow January 2004 and Irrigation Demand

Day	24 Hour Mean Flow (m^3/s)	48 Hour Mean Flow (m^3/s)	72 Hour Mean Flow (m^3/s)	Calculated Demand (m^3/s)
09 January	225	270	292	88
10 January	153	189	245	87
11 January	152	152	190	87
12 January	246	199	182	87
13 January	411	329	248	88
16 January	411	430	435	87
17 January	201	306	374	87
18 January	257	229	306	89
19 January	206	231	238	88
20 January	348	277	258	88

70/90 Cumec Demand Series for Lower Waitaki Irrigation

37. In order to test whether the minimum flow can be managed for operational purposes on a 24, 48, or 72 hour basis, a daily demand series needed to be derived for the Lower Waitaki assuming either 70 or 90 cumecs was being used for irrigation. The difference between the two flows is the inclusion of HDI. Using demand curves based on existing demand patterns allows a more realistic approach to the water requirements for irrigation in this area.

38. Dr Peter Brown of Aqualinc Research Ltd derived a demand series for the period September 1992 to May 2008 using the actual demand series available for the MGIICL (Morven Glenavy Ikawai Irrigation Co. Ltd) and LWIS (Lower Waitaki Irrigation Schemes). It is assumed that the 31.9 cumecs combined demand series[1] will be representative of all irrigation in the Lower Waitaki valley. Dr Brown's states that this demand series is likely to be conservative because new irrigation will be based on more efficient application systems and more expensive water. He states:

"Assuming the demand pattern for all future irrigators is the same as the combined relative demand (that is demand as a proportion of the peak rate of take) from Morven Glenavy Ikawai Irrigation Co. Ltd (MGIICL) and Lower Waitaki Irrigation Scheme (LWIS) will result in an over-estimate of the supply/demand deficit. This is because new irrigation will have a lower relative

[1] Being 17 cumecs for the LWIS excluding the Steward Settlement data and 14.9 cumecs for the MGIICL including Bells pond and Stonewall intakes.

demand, particularly during the shoulders of the season. For example, the relative demand from North Otago Irrigation Company (NOIC) is 65% less than the combined MGIICL and LWIS relative demand during the shoulder months of September, October, March and April. Demand patterns from new irrigation, such as the Hunter Downs irrigation proposal, can be expected to be similar to the NOIC demand patterns. Lower relative demand during the shoulders of the season is a result of the higher efficiency of newer irrigation, regulatory constraints (i.e. consent conditions requiring efficient irrigation and/or seasonal water limits), and high pumping costs."

24, 48 or 72 Hour Mean Flows as the Minimum Flow in the Lower Waitaki River

Rivers with natural flow regimes compared to rivers with highly modified flow regimes

39. In rivers such as the Rakaia, the 24 hour mean flow is, to a certain extent, predictive of what is happening in that river. That is because the Rakaia is a natural river with no artificial interference in its flow regime. Natural rivers have a natural recession curve where flows fall at a steadily reducing rate when no rain occurs and there is no abstraction. This means that when flows are falling at this rate, the next days' flow can be predicted based on the previous day's flow. By contrast, the Lower Waitaki hourly, daily, 48 hour or 72 hour flows are not predictive at all of what flows are likely in the river in the subsequent time period.

40. Using mean flows to manage irrigation is for operational purposes; it is not a predictive tool.

Deciding the period of mean flow

41. A mean flow allows a rational and feasible method for large scale irrigation downstream of a series of power generation stations to operate without major complication. As many of the lower flows, especially those in December and January are likely to be due to reduced electricity demand over the holiday period when usually inflows to the storage lakes are good, a small operational change by MEL could eliminate these shortfalls and this would be a trade-off for the irrigators providing timely advice of their requirements.

42. If minimum flow conditions in the River are managed around a 24 mean flow, this has significant operational advantages for downstream users. However, there is a risk (a statistical risk as it is entirely dependent on the operation of the Dam) that flows at the mouth may fall below 100 cumecs). The timing, frequency, and duration of these potential shortfalls are considered in the following section.

43. It should be noted here that while there may be some minor adjustments to flows on occasions and there is a minimum flow provision of 100 cumecs, MEL have repeatedly stated that their mode of operation is not likely to change. Therefore the current fluctuating flow patterns will remain in the river. The frequency of flows less than 150 cumecs may change especially downstream of the HDI intake. Currently flows less than 150 cumecs downstream of the proposed HDI intake occur for about 3% of the time.[2] Following HDI being implemented this is

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[2] Roddy Henderson's hydrology report which formed part of the resource consent application for water-only consents for a North Bank Tunnel Concept,

likely to increase to about 4% of the time. Therefore here should be no increased threat to riparian margins and river mouth closures This will remain unchanged until NBTC becomes operational.

44. However, given the greater likelihood of flows going below 100 cumecs downstream of Bells Pond using 48 and 72 hour flows, it was decided that only 24 hour mean flows would be analysed from this point on.

Analysis of 16 Irrigation Seasons Using the Derived Demand series and Comparing With 24 Hour Mean Flows in the Lower Waitaki River

45. The derived demand series for Lower Waitaki irrigation discussed in **Section 4** above was compared to the mean 24 hour flows in the Waitaki for the seasons 1992/93 – 2007/08 inclusive, essentially a comparison between demand and supply to identify periods of shortfall for irrigation. Two abstractions were modelled including first, the combined allocation excluding HDI of 70 cumecs and secondly, the Plan total allocation of 90 cumecs (which includes HDI). The shortfalls were compared to the actual or median inflows between the Dam and Black Point as detailed in "Appendix 16 Water Balance" provided by URS to the NBTC hearing in 2007. Siobhan Hartwell of URS provided a record from 1979 to 2005 of daily inflows in the Dam to Black Point reach. These were the actual inflows. Median inflows from Appendix 16 were then used for the period January 2006 to May 2008. The likely shortfalls after these inflows are also provided. **Table 5** shows a summary of the results of modelling 70 cumecs using the LWIC/MGIICL demand.

Table 5. Irrigation Shortfall Assuming 100 m^3/s Minimum Flow and 70 m^3/s Abstraction

Date	Shortfall (m^3/s)	Actual or Median Inflow Dam to Black Point (m^3/s)	Shortfall After inflow (m^3/s)	Date	Shortfall (m^3/s)	Actual or Median Inflow Dam to Black Point (m^3/s)	Shortfall After inflow (m^3/s)
11-Dec-93	-1.102	6.8	0.0	11-Jan-04	-11.500	14.4	0.0
23-Oct-94	-1.300	12.2	0.0	18-Mar-06	-6.377	13	0.0
5-Nov-94	-7.019	8.9	0.0	19-Mar-06	-6.133	13	0.0
1-Apr-97	-0.990	17.9	0.0	24-Sep-06	-9.509	11	0.0
6-Nov-97	-6.019	5.0	-1.0	25-Sep-06	-1.504	11	0.0
28-Dec-03	-0.447	7.1	0.0	27-Oct-07	-16.926	10	-6.9
10-Jan-04	-14.003	14.4	0.0	28-Oct-07	-15.538	10	-5.5

46. From **Table 5** there were 14 days of shortfall before the addition of the actual or median inflows between the Dam and Black Point and 4 days of shortfall after the addition of these flows. In the first 11 seasons there were 5 days of shortfall and 9 days in the last 9 seasons. By month, there were 2 days of shortfall in September, 3 in October, 2 in November, 2 in December, 2 in January, 0 in February, 2 in March, 1 in April and 0 in May.

47. On average over the 16 seasons, there would be less than 1 day per year where, if the shortfall was not made up, flows would have fallen below 100 cumecs but **only** in the 16 km reach downstream of the last intake down to the sea. This reduces to 3 days out of 16 seasons if the

inflow between the Dam and Black Point is taken into account. Over the remaining 54 km of the Lower Waitaki River upstream of Bells Pond, flows would be in excess or well in excess of the 100 cumec minimum flow.

48. **Table 6** shows a summary of the results of modelling 90 cumecs using the LWIC/MGIICL demand. In other words demand now including the sizeable 20 cumec take by HDI.

Table 6. Irrigation Shortfall Assuming 100 m^3/s Minimum Flow and 90 m^3/s Abstraction

Date	Shortfall (m^3/s)	Median Inflow Dam to Black Point (m^3/s)	Shortfall After inflow (m^3/s)	Date	Shortfall (m^3/s)	Median Inflow Dam to Black Point (m^3/s)	Shortfall After inflow (m^3/s)
26-Dec-92	-0.729	13.0	0.0	30-Dec-03	-6.677	8.8	0.0
27-Dec-92	-5.755	13.4	0.0	2-Jan-04	-18.084	5.7	-11.1
11-Dec-93	-16.021	6.8	-6.0	10-Jan-04	-32.637	11.5	-25.6
12-Dec-93	-13.743	6.3	-3.7	11-Jan-04	-29.818	9.8	-22.8
13-Dec-93	-12.687	7.5	-2.7	24-Jan-04	-0.482	27.0	0.0
14-Dec-93	-13.067	7.4	-3.1	25-Jan-04	-4.881	23.6	0.0
22-Oct-94	-8.379	11.8	0.0	29-Jan-05	-11.850	4.2	-4.9
23-Oct-94	-17.703	12.2	-7.7	11-Jan-06	-11.310	7	-4.3
24-Oct-94	-10.295	13.1	0.0	23-Jan-06	-3.590	7	0.0
5-Nov-94	-25.800	8.9	-17.8	27-Jan-06	-4.214	7	0.0
29-Sep-96	-7.362	9.3	0.0	11-Feb-06	-1.023	7	0.0
8-Dec-96	-10.154	17.1	0.0	12-Feb-06	-5.646	7	0.0
31-Mar-97	-2.466	18.5	0.0	18-Feb-06	-0.210	7	0.0
1-Apr-97	-12.160	17.9	0.0	17-Mar-06	-15.569	13	-2.6
19-Oct-97	-0.495	8.8	0.0	18-Mar-06	-25.118	13	-12.1
6-Nov-97	-23.943	5.0	-15.9	19-Mar-06	-24.946	13	-11.9
7-Nov-97	-5.625	5.0	-0.6	16-Apr-06	-9.742	11	0.0
16-Nov-97	-0.384	8.2	0.0	17-Apr-06	-7.854	11	0.0
27-Dec-97	-3.476	3.9	0.0	21-Sep-06	-12.393	11	-1.4
31-Oct-98	-9.455	17.0	0.0	23-Sep-06	-9.105	11	0.0
5-Dec-98	-4.111	5.5	0.0	24-Sep-06	-27.087	11	-16.1
31-Oct-99	-16.484	6.0	-6.5	25-Sep-06	-18.824	11	-7.8
5-Dec-99	-6.558	7.8	0.0	7-Oct-06	-2.030	10	0.0
26-Dec-99	-5.791	25.7	0.0	8-Oct-06	-11.018	10	-1.0
6-Dec-03	-0.510	5.4	0.0	14-Oct-06	-16.794	10	-6.8
7-Dec-03	-2.847	5.2	0.0	15-Oct-06	-11.170	10	-1.2
14-Dec-03	-10.381	4.4	-0.4	26-Oct-06	-7.787	10	0.0
20-Dec-03	-1.474	4.6	0.0	27-Oct-06	-7.951	10	0.0
26-Dec-03	-11.068	6.4	-1.1	28-Oct-06	-8.403	10	0.0
27-Dec-03	-15.620	6.9	-5.6	29-Oct-06	-8.092	10	0.0
28-Dec-03	-19.036	7.1	-9.0	27-Oct-07	-34.166	10	-24.2
29-Dec-03	-3.062	8.2	0.0	28-Oct-07	-36.810	10	-26.8

49. From **Table 6** there were 64 days of shortfall. If actual and median inflows between the Dam and Black Point are accounted for this falls to 29 days of shortfall.

50. In the first 11 seasons there were 24 days of shortfall and 40 days in the last 9 seasons. By month, there were 5 days of shortfall in September, 16 in October, 4 in November, 20 in December, 9 in January, 3 in February, 4 in March, 3 in April and 0 in May. On average over the 16 seasons, there would be about 4 days per year when, if the shortfall was not made up, flows would have fallen below 100 cumecs but **only** in the 16 km reach downstream of the last intake down to the sea. However if the inflow between the Dam and Black point is taken into account, on average there would be less than 2 days per year over the 16 seasons. Over the remaining 54 km of the Lower Waitaki River upstream of Bells Pond, flows would be in excess or well in excess of the 100 cumec minimum flow.

Making up the shortfall

51. MEL controls the daily mean flow in the Lower Waitaki River . The volumes required to make up the shortfalls are minimal when compared to the overall flows in the Waitaki. As is the frequency such adjustments would be required.

52. From **Table 5** (pre-HDI) the maximum average daily flow required would have been an extra 7 cumecs for 1 day with the other two days of shortfall in 16 years requiring less over the day and one of them having only a 1 cumec shortfall which is unlikely to be measureable.

53. From **Table 6** (post HDI**)**, the maximum average daily flow required would have been 27 cumecs on 28 October 2007. This low flow was caused by MEL dropping the flows so the water level recorder immediately downstream of the dam could have some essential maintenance done on it on both the 27th and 28th October 2007. The total number of days over the 16 years was 29 once actual and median inflows between the Dam and Black Point were taken into account with 19 of them requiring less than an extra 10 cumecs over the 24 hour period.

54. Given these shortfalls are likely to be mainly operational procedures for MEL, some minor changes to its operation generally at times of otherwise plentiful water would provide 100% reliability to current and subsequent irrigation up to the Plan's maximum of 90 cumecs if the minimum flow is over 24 hours. In return irrigators could consider off-setting demand during periods of less than 190 cumecs over 24 hours by notifying MEL of their demand for water when significant changes to potential demand were happening. For example, if a good rainfall of 50-100mm should occur in the Waitaki valley, then irrigation is unlikely to be necessary for at least 2 weeks and that information would need to be passed onto MEL so that it can generate without any requirement to meet any irrigation demand.

Will flows fall below 100 cumecs at the mouth?

55. Using mean flows means there is a possibility that flows could briefly fall below the 100 cumec minimum in the 16 km reach below Bells Pond. In the case of the 24 hour mean flow, given dampening of the flow extremes released from the Waitaki Dam, this excursion is unlikely to occur and if it does, it is likely to be very brief. An example of this is the set of data in Table 3 of this evidence. Figures 3 and 4 show the hourly and 24 hour average flows as measured at the

Dam. Figure 3 shows the flows released without any abstraction. Figure 4 shows the flows **at the dam** with the calculated total abstraction some 54 km downstream. The extent of dampening of the drop in flows with distance downstream is not available for this report but such information may be required to be collected if it has not already been done to assess whether or not flows in this instance would briefly fall below the minimum. In addition there is the calculated inflow from URS on 17th, 18th, and 19th January 2004 of 10, 11, and 22 cumecs respectively in the reach Dam to Black Point that would need to be taken into account. These inflows would, along with the dampening of the flow fluctuations with distance downstream, help to offset any potential falls below 100 cumecs downstream of the HDI intake.

56. The longer the mean flow being used the more likely that flows will fall below the 100 cumec minimum when abstraction is occurring. Indications are that flows could be below the minimum flow for at least 36 hours on occasions if managed under a 72 hour mean flow scenario but probably less for the 48 hour mean flow.

57. Figures 3 & 4 illustrate the difference between managing around a mean when compared to a rolling average. Under the rolling averages the frequency of changes to abstraction rates would be very difficult if not impossible to manage whereas with the mean flow there is no requirement to change abstraction at all.

Figure 3. Flows in the Waitaki River at the Dam Before Abstraction

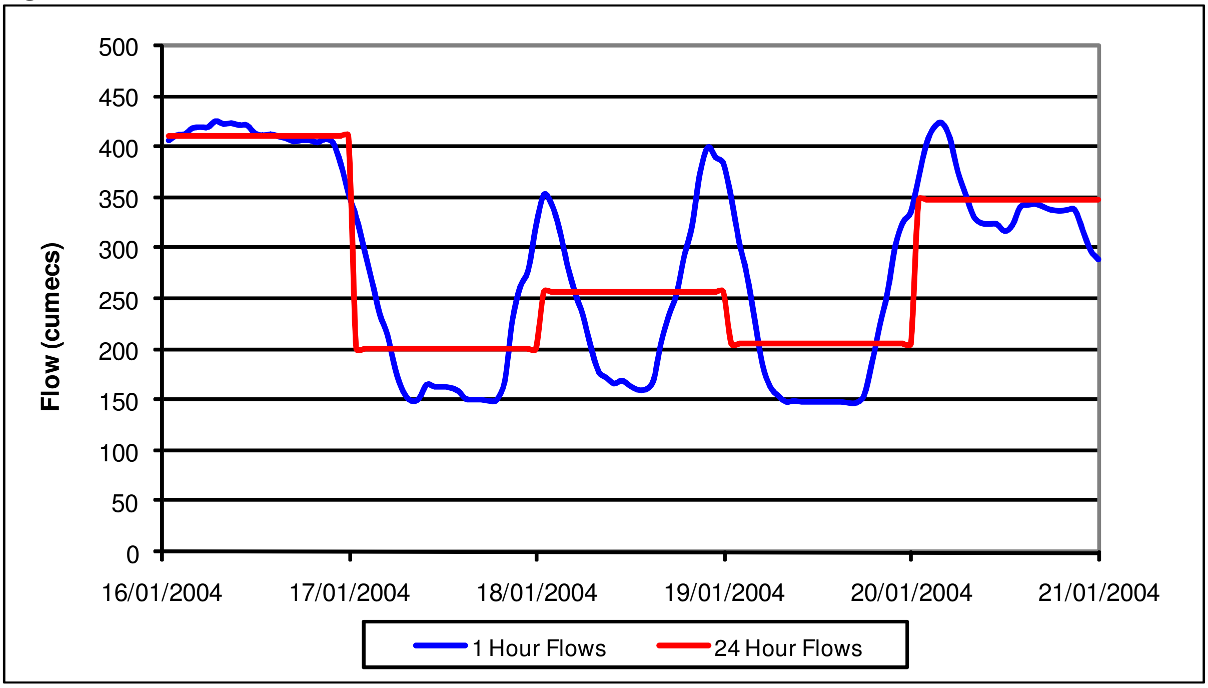
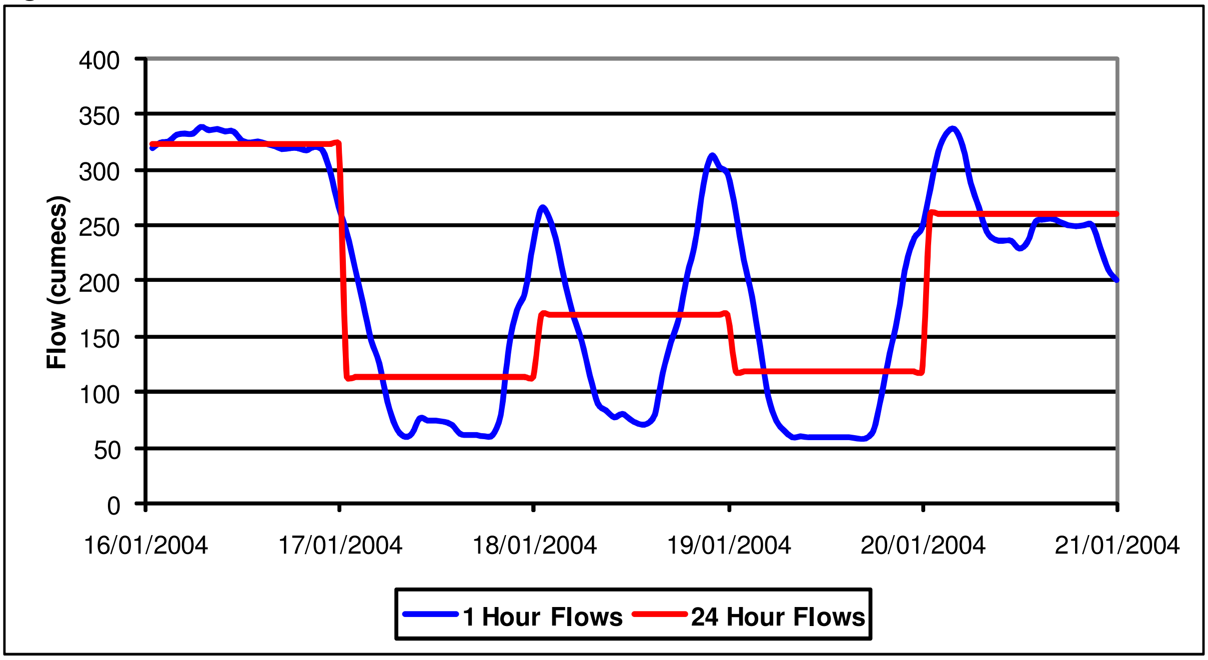


Figure 4. Flows at the Dam Less Total Abstractions 54 km Downstream



GST/Chapman Tripp draft agreement

58. In the draft agreement between MEL and the irrigators, the parties contemplated that a block of water would be provided for irrigators between 1 September to 30 April and without regard to actual demand that usually occurs in the shoulders of each season. MEL would ensure reliability of supply of combined takes up to 80 cumecs. Supply was guaranteed in all years except those years where there were low inflows into the Waitaki catchment. The frequency of occurrence of low inflow was predicted to be 1 in 20 years. In those years MEL proposed that a group of consent holders (also defined) restricted their take by 50% for a period of time.

Managing Around Demand and Supply

59. Putting an actual demand curve onto supply (i.e. the releases from the Dam) frees up water in the shoulder season which allows MEL to do as it wishes within the confines of its water permits without impacting on the extensive irrigation requirements in the Lower Waitaki. **Figures 5 and 6** show stylised diagrams of what was in the draft agreements (burgundy colour) and what is now proposed (blue) with a 70 cumec abstraction. **Figures 7 and 8** show the same but for a 90 cumec abstraction. Table 7 shows the values used in the Figures. In each case whether it is expressed as a volume or a percentage of total release, it is less than the supply (180 cumecs) under the GST/Chapman Tripp draft agreement.

Table 7. Values Plotted in Figures 5 to 8

Month	180 cumec Allocated Block of Water (Draft Agreement) (%)	Likely Actual Usage as Percent of Allowable (70 cumecs) (%)	Likely Actual Usage as Percent of Allowable (90 cumecs) (%)	180 cumec Allocated Block of Water (Draft Agreement) (m^3/s)	Likely Actual Usage 70 cumec Analysis (m^3/s)	Potential Average Freed-Up Water 70 cumecs (m^3/s)	Likely Actual Usage 90 cumec Analysis (m^3/s)	Potential Average Freed-Up Water 90 cumecs (m^3/s)
Sep	100	49	49	180	134	46	144	36
Oct	100	70	70	180	149	31	163	17
Nov	100	77	77	180	154	26	169	11
Dec	100	80	80	180	156	24	172	8
Jan	100	82	82	180	157	23	174	6
Feb	100	80	80	180	156	24	172	8
Mar	100	82	82	180	157	23	174	6
Apr	100	60	60	180	142	38	154	26
May	100	29	29	180	120	60	126	54

60. Fitting demand to supply in **Figure 5** shows the likely freed-up water (this is the difference between the blue and the burgundy). The values in this diagram are the usage as a percentage of total allocation. The blue section represents the average monthly water usage based on the future 70 cumec allocation derived from the schemes water usage pattern over the 16 seasons for which usage data were available. Note that the entire take is assumed to be used for irrigation. In practise that is not the case as the Plan sets aside surface water allocation for all activities, including irrigation. Basing demand curves assuming use is for irrigation purposes only means that it is likely to be a worst case scenario. According to Table 5 of the Plan, irrigation in the Lower Waitaki will make up 86% of total allocation. Of the other 14%, town and community supplies tend to peak at the same time as irrigation demand and the other activities are more spasmodic.

61. Similarly **Figure 6** shows the likely freed-up water (the difference between the blue and the burgundy) this time with all values in cumecs for the 70 cumec demand. Note this is modelled using the assumptions contained in the GST/Chapman Tripp agreement that except in a 1 in 20 low flow year, MEL would provide reliable supply for 180 cumecs.

62. **Figure 7** is the same as **Figure 5** because the percentages stay the same whatever the total demand The demand curve starts out as a percentage of total demand and we simply apply a different total demand either 70 or 90 cumecs.

63. **Figure 8** shows the likely freed-up water (the difference between the blue and the burgundy) this time with all values in cumecs but for a 90 cumec demand. Similarly to **Figure 6**, this is modelled using the assumptions contained in the GST/Chapman Tripp agreement that except in a 1 in 20 low flow year, MEL would provide reliable supply for 180 cumecs. It can be seen by

comparing **Figures 6 and 8** that as expected the amount of freed up water is significantly less for the 90 cumec abstraction than for the 70 cumec abstraction. **Table 7** quantifies the differences in freed up water.

Figure 5. Comparison of Draft Agreement and Actual Lower Waitaki Irrigation Demand (70 cumecs Abstraction)(%)

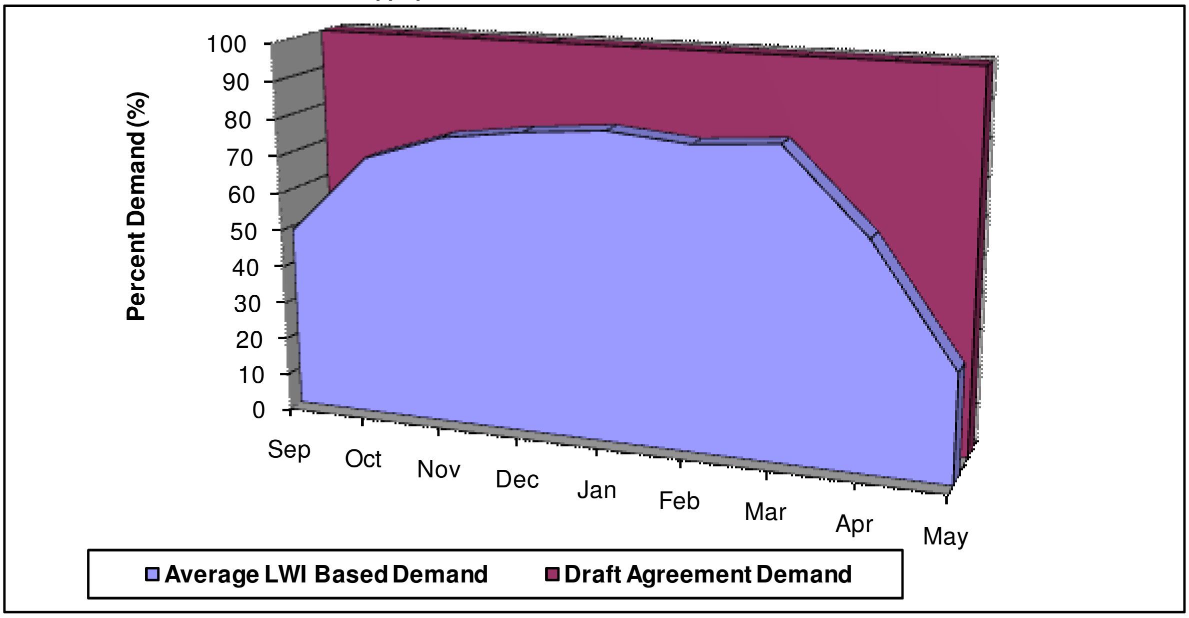


Figure 6. Comparison of Draft Agreement and Actual Lower Waitaki Irrigation Demand (70 cumecs) (cumecs)

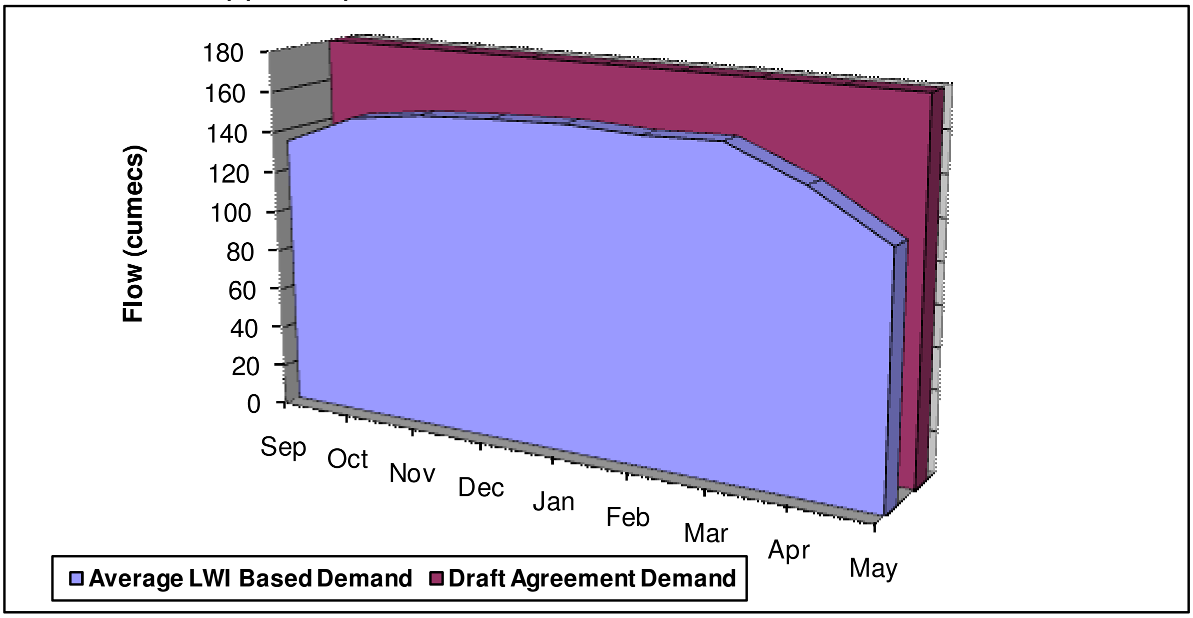


Figure 7. Comparison of Draft Agreement and Actual Lower Waitaki Irrigation Demand (90 cumecs) (%)

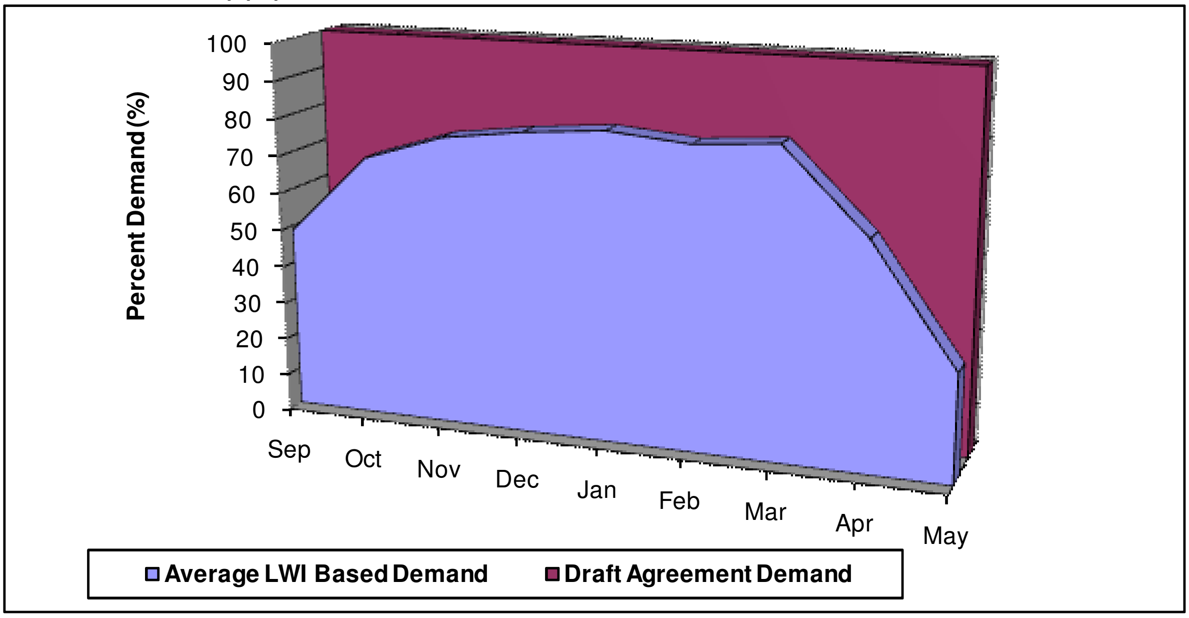
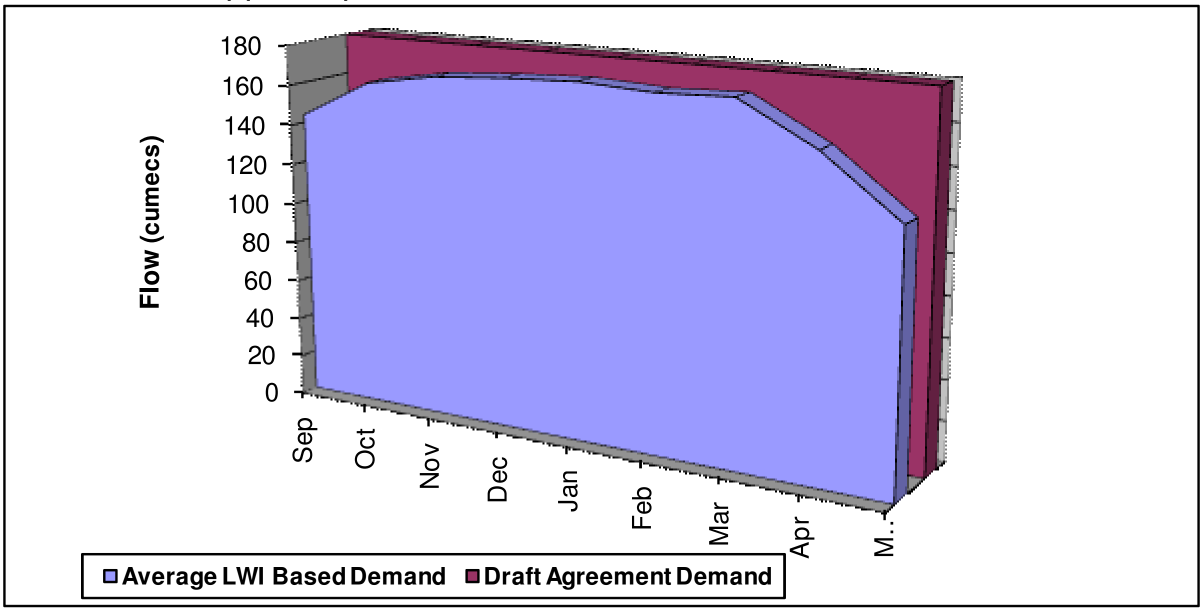


Figure 8. Comparison of Draft Agreement and Actual Lower Waitaki Irrigation Demand (90 cumecs) (cumecs)



Summary

64. Unlike the Rakaia, Rangitata and Waimakariri Rivers which have natural flow regimes and a degree of predictability about their flows, the Lower Waitaki River does not have a natural flow regime and there is no predictability about its likely flows in forthcoming days. Its flow regime is controlled entirely by demand for hydro electricity, it has no naturalness about in any of its flows and the only authority that can predict its future flows is MEL.

65. Large irrigation schemes such as those using the Rangitata Diversion Race can operate well on natural rivers due to the predictable day to day nature of low flows and potential restrictions but on the Lower Waitaki River flows can fluctuate from mean to low and back to mean flows within 24 hours. It is not possible to operate large irrigation schemes on such unpredictable flows on an hourly basis as is currently being contemplated in the Lower Waitaki River.

66. In my opinion the minimum flow requirement in the Waitaki Catchment Water Allocation Regional Plan (the Plan) does not restrict the minimum flow to be administered on an hourly basis. Alternatives to this should be given serious consideration by the commissioners.

67. There is no reason why the minimum flow could not be administered as an average flow over 24 hours. Analyses of water usage in this river controlled using a 24 hour mean flow along with a minimum flow of 100 cumecs and some minor operational changes by MEL show that:

    (a) Of the total 70 km reach from the Dam to the sea, the reach most at risk of flows falling below 100 cumecs is the 16 km reach from the proposed Hunter Downs Irrigation (HDI) scheme intake to the sea.

    (b) The total allocation of 90 cumecs proposed in the Plan could achieve 100% reliability by using 24 hour mean flows as an operational tool.

    (c) Irrigators will notify their requirements over the coming days to MEL. This will enable MEL more freedom to operate, similar to what they have done for the past 28 years.

    (d) MEL will meet any shortfall in flows.

    (e) The combination of (b) to (d) above should ensure that the river flow does not fall below 100 cumecs at any time **in** the reach from the HDI intake to the sea.

Suggested Minimum flow conditions for the Lower Waitaki River

A. The minimum flow from Dam to Sea is 100 cumecs

This condition would only apply if agreement with holder of the Waitaki Dam consent is reached to the effect that the Dam consent holder will ensure that the following condition is not activated.

Minimum Flow Condition

If the holder of the Waitaki Dam consents provides notice to the Canterbury Regional Council that the mean flow in the Waitaki River as measured at the Kurow Recorder in the next 24 hour period is estimated to be less than 170 cumecs or actual demand (and taking of water has not commenced under the HDI consents) or 190 cumecs or actual demand (and taking of water has commenced under the HDI consent) the taking of water under this permit shall cease at the start of that period.

For the purpose of this condition:

i. *Actual demand means the peak rate of taking required and notified to the consent holder of the Waitaki Dam at least 14 days in advance.*

ii. *Flows shall be estimated at the Kurow Recorder (Kurow Recorder flow map ref: 140:079-088) by the Canterbury Regional Council and expressed in cubic metres per second.*

iii. *Each 24 hour period shall start 12.00am and finish 11.59pm.*

iv. *The flow in the Waitaki River at the Kurow Recorder shall include any flow taken from the Waitaki catchment upstream of the Kurow Gauge and returned downstream of the Kurow Recorder but upstream of the Hunter Downs Irrigation Scheme point of take.*

This condition incorporates by reference an agreement between the holder of the Waitaki Dam consents [CRC references], the signatories to the 1990 Access Agreement and MRNAG dated (date).

The minimum flow condition shall not apply upon commissioning of the North Bank Tunnel Concept [CRC references] and the diversion of flows through the tunnel.

B. The minimum flow in the River is the NBTC variable minimum flow between the Dam and Black Point

Minimum Flow Condition

Whenever the mean flow in the Waitaki River in the preceding 72 hour period falls below the minimum flow rates in Table 1 the taking of water from the Waitaki River shall cease.

Table 1

Month of Year	***Jan***	***Feb***	***Mar***	***Apr***	***May***	***June***	***July***	***Aug***	***Sep***	***Oct***	***Nov***	***Dec***
Minimum River Flow m^3/s	*140*	*150*	*145*	*125*	*120*	*110*	*110*	*110*	*120*	*125*	*130*	*140*

This condition shall not apply if the consent holder of the Waitaki Dam consents provides notice to the Canterbury Regional Council that the mean flow in the Waitaki River in the next 24 hour period is estimated to be equal to or exceed the flows in Table 1.

For the purpose of this condition:

i. *Flows shall be estimated at the Kurow Recorder (Kurow Recorder flow map ref: 140:079-088) by the Canterbury Regional Council and expressed in cubic metres per second.*

ii. *Each 24 hour period shall start 12.00am and finish 11.59pm.*

iii. *The flow in the Waitaki River at the Kurow Recorder shall include any flow taken from the Waitaki catchment upstream of the Kurow recorder and returned downstream of the Kurow Recorder but upstream of the Hunter Downs Irrigation Scheme point of take.*

The minimum flow condition shall not apply upon commissioning of the North Bank Tunnel Concept [CRC references] and the diversion of flows through the tunnel.