

**IN THE MATTER OF**

the Resource Management Act  
1991

**AND**

**IN THE MATTER OF**

applications by Central Plains Water  
Trust to:

Canterbury Regional Council for  
resource consents to take and use  
water from the Waimakariri and  
Rakaia Rivers and for all associated  
consents required for the  
construction and operation of the  
Central Plains Water Enhancement  
Scheme

Selwyn District Council for resource  
consents to construct and operate  
the Central Plains Water  
Enhancement Scheme

**AND**

**IN THE MATTER OF**

a notice of requirement by Central  
Plains Water Limited to:

Selwyn District Council for the  
designation of land for works  
associated with the construction and  
operation of the Central Plains  
Water Enhancement Scheme

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**BRIEF OF EVIDENCE OF GORDON JOHN GLOVA**

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## Qualifications and experience

1. My full name is Gordon John Glova
2. My academic qualifications consist of the following: BA (Arts) from the University of Alberta, Edmonton; BSc Honours (Zoology) from the University of Alberta, Edmonton; MSc (Biology) from the University of Victoria, Victoria, British Columbia; and PhD (Zoology) from The University of British Columbia, Vancouver, Canada.
3. As regards professional societies, I am a member of the Editorial Board of the *Ecology of Freshwater Fish*, an appointment I have held since 1992 to the present. This is an international journal that publishes scientific articles on all aspects of freshwater fish, and for which I am frequently called upon to review articles submitted to the Editors of the Journal for consideration for publication.
4. I have some 35 years of experience in freshwater fisheries with approximately 65% of that time spent as a fisheries scientist in New Zealand, first with the Ministry of Agriculture and Fisheries, Freshwater Section (1979-1992) and subsequently with *N/VA* (1992-2003). During my employment in New Zealand, collaboratively with colleagues, I conducted a wide range of field and laboratory research on salmonid and native fish populations from various catchments, with an emphasis on braided rivers on the east coast of the South Island. From my extensive involvement in research studies on the Rakaia River over a period of several years, I have acquired a very good understanding of the likely effects of reduced flows on fish habitat dynamics and passage, and fishability of the river. I was a key expert witness on fisheries issues in the various Rakaia River hearings held in Christchurch in the early to mid 1980s. My involvement in studies on the Waimakariri River over the years has dealt mainly with that of adult salmon passage and migration and fishability of the river in relation to low flows. Currently, I am employed as a Senior Fisheries Biologist with LGL Limited, environmental research and associates, in Sidney, British Columbia, at which I share a major responsibility with colleagues in proposal writing, project management, data analysis, report writing and presentation of results to clients, regulatory agencies and others on various projects

dealing mainly with habitat, fish populations and fisheries in large riverine/lake systems and estuaries in western North America.

5. I have read the code of conduct for expert witnesses set out in the Environment Court practice note, and confirm that I have complied with the code in the preparation of my evidence.

## **Scope of Evidence**

6. In my evidence I will provide an assessment of the potential effects of the Central Plains Water Enhancement Scheme (CPWES) takes from the Waimakariri and Rakaia Rivers on downstream habitats and passage for salmon and trout, and salmon fishability, as well as fish screening issues at the proposed intake sites. In addition, I will provide an assessment of the potential effects of the scheme on salmonids in lowland streams and Lake Ellesmere in relation to changes in water quantity and quality of these environments.
7. In preparing my evidence, I have drawn primarily on my many years of experience with the flows, habitats and fish populations of these rivers, as well as information available in scientific journals and client reports, with particular emphasis on the report by Glova et al. (2001) which provides an in-depth assessment of potential environmental effects of the CPWES initially proposed in the early 2000s. For recent information on flows, habitats and fish stocks of relevance to my evidence I have relied mainly on information supplied to me by URS Ltd and from the evidence of various expert witnesses appearing for the applicant.

## ***Some Relevant Background Information***

### **Salmon and Trout Populations**

8. Chinook (quinnat) salmon *Oncorhynchus tshawytscha* and brown trout *Salmo trutta* (both sea-run and freshwater resident) - introduced to New Zealand approximately a century ago for sport fishing - are present in the Waimakariri and Rakaia Rivers and constitute valuable recreational fisheries. Both species spawn in the autumn primarily in springfed headwater tributaries located some 100 km upstream from the sea, although some spawning also occurs in the mainstem of these rivers and in streams tributary to the lower Waimakariri River. Juveniles of both species are most abundant in mainstem habitats during the spring to

autumn period. Juvenile salmon migrate to the ocean, where they feed and grow mainly in coastal areas (within 50 km from shore (Unwin and James 1998), whereas trout (both juveniles and adults after spawning (kelts)) move down to the estuary, and possibly to nearshore areas to feed and grow. Generally, salmon return to fresh water between two and four years of age from November through May and migrate upstream to spawn and then die, whereas trout upon reaching maturity at three or more years of age may spawn several times in a life time, involving migrating upstream to spawn and then back down again as kelts to feed in the lower reaches and possibly in nearshore areas. Runs of up to 20,000 salmon returning to spawn have been recorded, although in the last decade the runs have declined with no more than a few thousand fish returning to either the Waimakariri or Rakaia since 2001 (Deans et al. 2004); this declining trend is consistent with that noted for other major salmon rivers in the country and appears to be related primarily to factors affecting food resources in the ocean (G. James, fisheries scientist, NIWA, Christchurch, pers. comm.). Annual angler harvest of salmon runs in the Rakaia and Waimakariri between 1993 and 2003 has been estimated at approximately 41% and 49%, respectively (Deans et al. 2004); there are no comparable data for the proportion of trout stocks harvested annually by anglers in these rivers. There is general consensus amongst the local angling fraternity that the abundance of brown trout in lowland streams has declined in recent years, attributable mainly to habitat degradation (water abstraction, stream enrichment, pollution, riparian losses).

### **Downstream Habitats**

9. The habitats in braided mainstem channels of the Waimakariri and Rakaia Rivers between the gorge and the sea are similar between rivers, comprising minor, intermediate and dominant channels. In my evidence, for both rivers I use the channel criteria developed for the Rakaia River by Glova and Duncan (1985), with minor channels being those with flow less than 1 m<sup>3</sup>/s, dominant channels being those with the largest flow, and intermediate channels being those between the above two categories. The beds of all channels are composed mainly of gravels and cobbles, with the presence of fines (e.g., sand, silt, clay) usually being greater in minor channels.

10. Habitat types in the intermediate and dominant channels consist of extensive shallow riffle areas with turbulent flow, moderately deep and narrow fast-flowing pools, and long sections of uniform runs of relatively deep fast water. Minor channels typically consist of riffle-pool-run sequences of varying lengths. Other habitat types such as backwaters, side pools, isolated pools and seepage channels constitute a small proportion (not >3%) of the total wetted area in these rivers. Riffles are the main food-producing areas consisting of diverse and abundant communities of periphyton and benthic invertebrates during periods of moderately stable flows. Juvenile salmon and trout occupy riffles, marginal areas of runs, large backwaters and side pools, and debris clusters of riparian origin scattered primarily along the margins of channels. Adult salmon and trout occur mainly in pools and runs more than 1 m in depth with cobble/boulder beds and adequate cover (e.g., areas with broken water surfaces, undercut banks and root wads, overhanging boughs, large debris clusters).

### **Minimum Flows**

11. Takes from the Rakaia River are restricted by the variable monthly minimum flows set by the National Water Conservation Order (NWCO). From 1 September through 30 April (herein referred to as summer period), the monthly minimum flows stipulated by the NWCO as measured at the Rakaia gorge range between 90.3 and 138.7 m<sup>3</sup>/s; above these minimum flows a maximum bulk allocation of 70 m<sup>3</sup>/s is allowed but with one-to-one sharing between instream and out-of-stream users. Currently, 34.3 m<sup>3</sup>/s of the maximum allowable 70 m<sup>3</sup>/s has been allocated to other users, so only a maximum take of 35.7 m<sup>3</sup>/s is available during summer, but only when river flows exceed the NWCO minimum flows by 68.6 m<sup>3</sup>/s because of priority rights to other users and 1:1 sharing of these takes. It is my understanding from Mr Tipler's evidence that the available take of 35.7 m<sup>3</sup>/s during summer would be shared between CPWES and the Ashburton Community Water Trust (ACWT), under their current agreement, on a virtually equal priority basis (18:17.7) and that during winter the full 40 m<sup>3</sup>/s would be available to CPWES and ACWT.
12. The minimum flows for the Waimakariri River at the gorge as specified by the Waimakariri River Regional Plan (WRRP) is 41 m<sup>3</sup>/s for "A" permit water and 63 m<sup>3</sup>/s for "B" permit water. From Mr Tipler's evidence it is my

understanding that the current existing takes from the river amount to 23.24 m<sup>3</sup>/s, which constitute the total allocation limit of 22 m<sup>3</sup>/s for “A” permit water and the first 1.24 m<sup>3</sup>/s of “B” permit water. As 1.24 m<sup>3</sup>/s of “B” permit water is already allocated, the minimum flow for CPWES “B” permit water is 64.24 m<sup>3</sup>/s. The take of Class “B” water does not have a flow sharing requirement, and according to Mr Tipler’s evidence I understand that up to 40 m<sup>3</sup>/s can be taken by CPWES, if available. I have been informed by Mr Tipler that the base case scenario for CPWES involves a take of up to 25 m<sup>3</sup>/s at the upper intake site. The application is such that 40 m<sup>3</sup>/s would be taken at this intake if it is shown that on balance the environmental impacts of a higher peak rate of take are less than those of the base case. I have therefore also considered the potential impacts of a peak rate of take of 40 m<sup>3</sup>/s.

## ***Assessment of potential effects of CPWES***

### **Fish Passage**

13. During low flows, the broad and shallow riffles in braided rivers are critical areas for upstream passage of adult salmonids. At maturity, salmon are deep-bodied fish requiring sufficient depth of water for safe upstream passage. It is widely accepted that minimum water depths of 0.25 to 0.28 m are required for passage of adult Chinook salmon. This depth range is considered more than adequate for adult brown trout as they generally are of smaller body size than salmon. Mosley (1982a) estimated that a minimum flow of 68 m<sup>3</sup>/s at the Rakaia River gorge is required to provide a depth of 0.25 m along the line of greatest depth (thalweg) in the dominant channel. In my opinion, the NWCO monthly minimum flows for the Rakaia River adequately provide for passage of adult salmon and trout. Since the take for CPWES from the Rakaia River will be governed by the rules of the NWCO, the scheme in all likelihood will not present passage problems for adult salmonids.
14. CPWES cannot abstract below 64.24 m<sup>3</sup>/s from the Waimakariri River. Thus, from my experience with the river, it is unlikely that the Scheme’s take would result in passage problems for adult salmon and large trout, even in the most extensively braided sections during the late summer period of low flows. However, the Scheme’s take will worsen the flow situation for adult salmon through lowering the flows and harvesting small

freshes, which are an important stimulus for salmon upstream movement. From radio-tracking of adult salmon in the Waimakariri River in the late 1980s, Glova and Docherty (1986) found that salmon upstream migration was adversely affected (migration was delayed; some fish died) by naturally occurring prolonged low flows ( $<60 \text{ m}^3/\text{s}$ ) in February and March. In my view, the occurrence of critically low flows will likely increase with Class B and Class A takes acting in concert, with the CPWES take drawing the river down to  $64.24 \text{ m}^3/\text{s}$  and Class A takes further depressing the river to  $41 \text{ m}^3/\text{s}$ . This continuing decline of flow down to  $41 \text{ m}^3/\text{s}$ , and possibly lower by natural means in extremely dry summers, will be very stressful on adult salmon, particularly as water temperatures are more likely to be in the range ( $>18^\circ\text{C}$ ) that will impose additional stress on them.

15. In response to concerns regarding 'flat-lining' of river flows by Class B and Class A takes acting in a sense as a continuum of takes down to  $41 \text{ m}^3/\text{s}$ , Mr Tipler has included in his evidence an analysis of the February to March Waimakariri River flow data for the period 1970 to the present. His analysis shows that over this time period for these two months the average rate of take is  $9.7 \text{ m}^3/\text{s}$  and the median take is  $3.2 \text{ m}^3/\text{s}$ . Mr Tipler has pointed out that the median flow in the Waimakariri River during those years over February and March would have been  $44.5 \text{ m}^3/\text{s}$  and  $41.0 \text{ m}^3/\text{s}$  without and with the CPWES take, respectively. Clearly, the take in these months in critically dry years would be fairly small, but nonetheless it will add to the already stressful conditions imposed on adult salmon returning from the sea to migrate upriver to the headwaters to spawn.
16. Mr Tipler has further shown that in exceedingly dry years (1970, 71, 72, 73, 78 and 2001) in February alone, the reservoir would be empty, with the average and median takes being  $0.5 \text{ m}^3/\text{s}$  and  $0 \text{ m}^3/\text{s}$ , respectively, with nothing taken 75% of the time. To minimize the 'flat-lining' effect on low flows in such years, Mr Tipler has proposed that when the flow in the Waimakariri River is  $\leq 41 \text{ m}^3/\text{s}$  for a continuous period of 14 days, that CPWES will not take water until the river flow is  $\geq 41 \text{ m}^3/\text{s}$  for a period of two days, or until the flow is  $\geq 100 \text{ m}^3/\text{s}$ , which ever comes first. It is my understanding that under Mr Tipler's proposed condition that if a small fresh should arise and the river's flow relatively rapidly exceeded  $100 \text{ m}^3/\text{s}$ , then fairly quickly by way of combined Class B and Class A takes

the river could be drawn down to 41 m<sup>3</sup>/s in the lower part of the river where the impacts of all takes are felt, and this may still leave insufficient time for salmon to complete travel upriver to a point where flows are sufficient for upstream passage without the risk of stress. . On a fresh, salmon in the Rakaia River are known to move upriver at an average rate of about 8 km/d, with some extremely fast migrators travelling approximately 21 km/d (Glova 1987). There are no comparable data for salmon migrating upstream in the Waimakariri River, but in my opinion, their rate of upstream movement is probably similar to that in the Rakaia River. Thus, for salmon holding in the lower river awaiting a fresh, they will require about five days to get past the upper intake site. Mr Tipler's proposed condition of abstraction during summer in critically low flow years should provide sufficient time for salmon to get past the intensively braided section at Crossbank, which is desirable, but, depending where the significant takes of water occur on the river, may mean that the effects of the takes have returned the river to relatively low levels before the salmon have reached a point in the river where flows are appreciably above the minimum flow.

17. In his evidence, Mr Tipler indicated that in extremely dry years the CPWES take would extend the duration of low flows by up to 30 days. While the Waimakariri River has had low flow events that have lasted for up to 133 days in the past (refer to Mr Tipler's evidence), in my opinion, an extension of up to 30 days of exacerbating critically low flows is considerable, and may adversely affect the run size of that particular year class of salmon for several future generations. However, as pointed out by Mr Tipler, such an extreme event would be a very rare occurrence, and in my opinion if and when it occurs and the effects on salmon runs are significant, they could be compensated for by releases of hatchery-reared salmon to offset the possible prolonged persistence of depressed salmon year classes.

## **Downstream Habitats**

### ***Waimakariri River***

18. It is my understanding, as outlined in Mr Tipler's evidence, that the CPWES base take from the upper intake site near the Kowai River mouth will be 25 m<sup>3</sup>/s with nothing taken from the gorge intake, but that

potentially the full 40 m<sup>3</sup>/s would be taken from the upper intake at any time of year when the CPWES' full quota of Class B water is available, particularly after the summer draw-down period to fill the reservoir as quickly as possible and thus lessen the impact on winter low flows. My assessment of potential downstream effects on habitat and salmonid fish populations will deal primarily with the 25 m<sup>3</sup>/s base take during the irrigation season, but, in addition, I will comment on the significance of the 40 m<sup>3</sup>/s take.

19. The greatest effect of the CPWES take on river flows will occur during the late summer period (February-March) when the river is naturally low and irrigation demand is high. River flows that will be most affected by the CPWES take will be those that lie between 65 and 150 m<sup>3</sup>/s, which will include small freshes. Dr Mabin has pointed out that the 40 m<sup>3</sup>/s take will not significantly affect flood frequency or the duration of the larger floods and freshes. Thus, it follows that a take of 40 m<sup>3</sup>/s will not significantly alter channel morphology and vegetation clearance and instream habitat.
20. In his evidence, Mr Tipler provided a comparison of the percentages of time that four different rates of take from the Waimakariri River would not be exceeded. This comparison has important implications for salmon, which shows that as the peak rate of take is increased, the length of time that the river is affected decreases. For example, the trade-off between the 25 m<sup>3</sup>/s and 40 m<sup>3</sup>/s scenarios would be as follows. For the peak rates of take of 25 m<sup>3</sup>/s and 40 m<sup>3</sup>/s, respectively, for 60% of the time the take will be <8.5 and <2.5 m<sup>3</sup>/s, respectively. These differences in the takes are considerable and I do therefore fully support the option of the higher peak take during winter, but not during summer. My reason being is that during summer, adult salmon are in the river and the allowable take needs to be minimised to lessen the stressful effects of critically low flows on their well-being and migration upriver. In my opinion, to increase the take to reduce the time that the river would be affected by abstraction is not a suitable option while adult salmon are in the reach between the upper intake and the river mouth (November-April).

*Upper Intake*

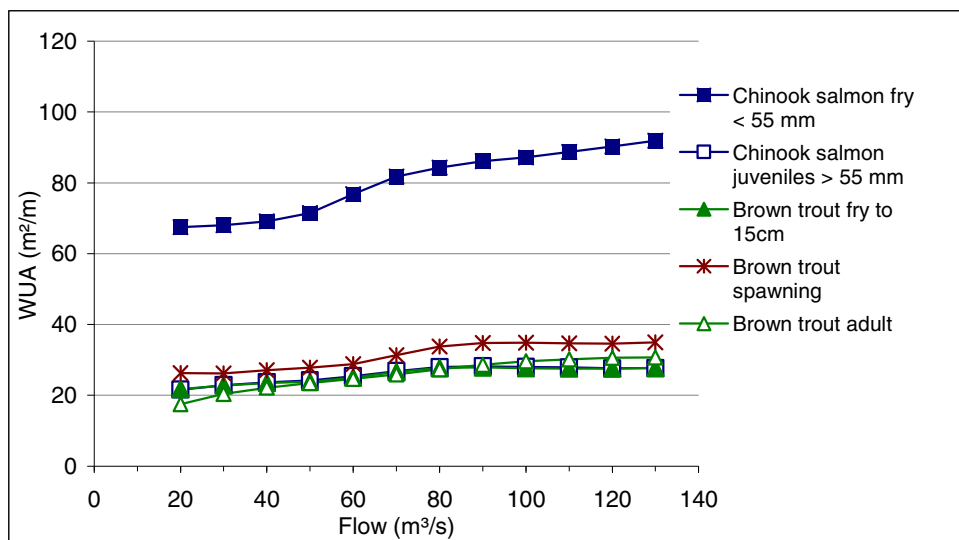
21. The river reach between the upper intake and lower intake is not extensively braided and water losses to groundwater and subsurface flow

are not major for this reach (North Canterbury Catchment Board 1986; also refer to evidence by Dr Bright and Mr Weir). From my experience with the river, I do not regard the reach between the upper and lower intake sites as an area of critical habitat for salmonid spawning and rearing. This reach is primarily of importance for passage of salmonids between lower and upper sections of the river, for which in my view minimum flows of 64.24 m<sup>3</sup>/s and 41 m<sup>3</sup>/s at which CPWES would cease taking its summer Class A water and winter Class B water, respectively, would be adequate. A flow of 41 m<sup>3</sup>/s would suffice for fish passage during winter as there are no adult salmon present in the river at that time of the year, so adequate flows for passage are only required for adult trout and juvenile salmonids and native fish species.

#### *Lower Intake*

22. The reach from the upper intake to the mouth of the river provides important habitat for rearing and holding of salmonids. However, it is extensively braided in some sections (e.g., at Crossbank) and therefore susceptible to creating passage problems for adult salmon during periods of low flows. As I pointed out in Paragraph 14, sustained flows <60 m<sup>3</sup>/s were a problem for adult salmon migrating up river.
  
23. Insofar as rearing of salmonids is concerned, I am of the opinion that neither a 25 m<sup>3</sup>/s take nor a 40 m<sup>3</sup>/s take will significantly alter the availability of habitat for rearing of salmonids in the lower Waimakariri River. For the significantly braided river section at Crossbank, Duncan (2001) has shown that water depths and velocities (as preferred by juvenile salmonids) and wetted areas in the channels were not appreciably lowered with a reduction in flow from 85-41 m<sup>3</sup>/s. Thus, in light of these findings, I am of the opinion that the base take of 25 m<sup>3</sup>/s down to the allowable CPWES minimum of 64.24 m<sup>3</sup>/s during summer, and the 40 m<sup>3</sup>/s take down to as low as the minimum flow of 41 m<sup>3</sup>/s, if available, will not significantly impact rearing and holding habitat for salmonids, irrespective of whether the take that results in the river dropping to 41 m<sup>3</sup>/s is 25 m<sup>3</sup>/s or 40 m<sup>3</sup>/s. The end result is that the river would be at 41 m<sup>3</sup>/s, and in my opinion the difference in the dynamics in it getting there would have a negligible effect on habitats downstream.

24. Mr Ian Jowett of NIWA has provided weighted useable area plots in relation to river flows showing that the potential habitat available for both juvenile salmon and brown trout in the lower Waimakariri River increases considerably as flows increase to about 80 m<sup>3</sup>/s (Figure 1); this may be due largely to increased habitat in minor side braids at the slightly higher flows. Moreover, Mr Jowett used a finer resolution model of 4 m<sup>2</sup> cells rather than 8 m<sup>2</sup> cells as was formerly used by Duncan (2001) which may have attributed to the increased response in available habitat with flow. However, on the basis of the findings from the study by Duncan (2001) which showed very little change in weighted useable area in the extensively braided river reach at Crossbank with a reduction in flow from 85-41 m<sup>3</sup>/s, I conclude that the decrease in available habitat from 80 m<sup>3</sup>/s down to 64.24 m<sup>3</sup>/s, and even down to 41 m<sup>3</sup>/s, for juvenile salmon and brown trout in the lower Waimakariri River would be minor. At either of these minimum flows, in my opinion, there will be adequate rearing habitat available for juvenile salmonids.



**Figure 1: Weighted useable area for juvenile salmonids and adult brown trout in relation to river flow in the braided reach at Crossbank, Waimakiriri River. Taken from I. Jowett, NIWA.**

### ***Rakaia River –***

25. Dr Mabin states in his evidence that the CPWES take from the Rakaia River will not appreciably alter the river's flood flows that determine channel morphology and will not result in a significant build up of sediments in habitats downstream. From his assessment and given that we know that there is relatively little change in quantity of potential habitat downstream with changes in flow above base flow levels in braided rivers (Mosley 1982b; Glova and Duncan 1985), I am of the opinion that the CPWES take will not appreciably reduce the amount of useable habitat available for salmonid fishes downstream of the intake. From the detailed study by Glova and Duncan (1985) on habitat dynamics in relation to low flows in two extensively braided reaches in the lower Rakaia River, there was no appreciable change in the amount of useable habitat for juvenile salmon and trout for flows ranging from approximately 70 to 150 m<sup>3</sup>/s. From the results of this study, I am convinced that the CPWES take to a maximum of 40 m<sup>3</sup>/s with the river drawn down to the NWCO minimum flow of 68.6 m<sup>3</sup>/s, because of priority rights to other users and 1:1 sharing, will not significantly impact the availability of habitat for juvenile salmon and trout. Moreover, the take conditions proposed by Mr Tipler for exceedingly dry years will in my opinion help abate 'flat-lining' of flows over prolonged periods and minimize effects on habitat quality downstream.

### ***Flushing of Stilling Basins***

26. I have assumed that the sediment trapping efficiency of the stilling basins on the Rakaia and Waimakariri Rivers would be similar to that of the Rangitata Diversion Race scheme (RDR) on the Rangitata River. The RDR has a trapping efficiency of 84-92% in retaining sand-sized particles, but those of the finer silt and clay fraction largely pass through (Waugh 1983). Flushing of sediments from the stilling basins of the CPWES will have less impact on downstream habitats if done during floods when the river has the capacity to handle additional sediment load. The Rakaia River NWCO and the Waimakariri River Regional Plan both stipulate that any discharges into the river shall not conspicuously alter the river's natural water quality conditions. Mr Lewthwaite stated in his evidence that minimum river flows for flushing of sediments at the intakes would be 100

m<sup>3</sup>/s for the Waimakariri River, and 300 m<sup>3</sup>/s for the Rakaia River, which he indicated are flows for which the additional sediment during sluicing will not have any noticeable effect on water quality as the water in the river will be reasonably fast flowing and discoloured naturally.

27. In general, I am of the opinion that the flushing of sediments from the stilling basins would not have any major prolonged effect on habitats downstream in both these rivers. Dr Mabin has indicated (pers. comm.) that a large proportion of the sediments would settle out within about five km downstream of the stilling basin and be swept out with the next flood of sufficient magnitude (ie, at least three times the median flow of the river). In my assessment of potential impacts downstream, I am of the opinion that a 5-km distance downstream for settling of the majority of the fines is not extensive and the interval between bed-moving floods in both of these rivers, with the exception of February through March, is generally not protracted, so any adverse effect on habitat quality and the biota downstream will be relatively short-term.

## **Fishability**

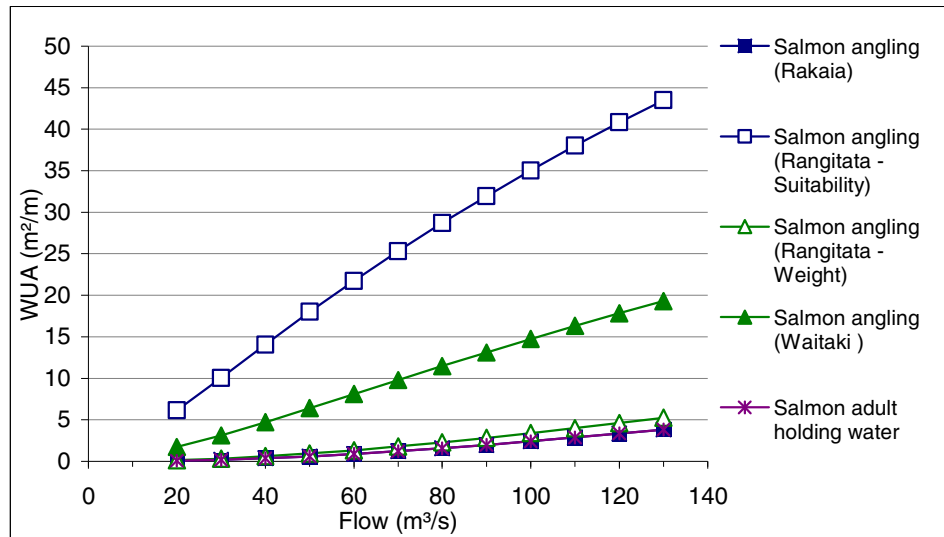
### ***Waimakariri River***

28. The Waimakariri River is one of the two most heavily fished rivers in the country, the other being the Mataura River (Deans et al. 2004). Fishing for salmon occurs mostly in the lower reaches, particularly at the mouth and in deep water holding areas, where the fish are more concentrated and in prime condition 'fresh' from the sea. The flows naturally are quite low during late summer, which will be further depressed by Class A takes for irrigation to as low as 41 m<sup>3</sup>/s. From my experience with the river, I consider the 41 m<sup>3</sup>/s minimum flow specified in the Waimakariri River Regional Plan to be well below that required for salmon fishing. A more meaningful minimum flow for salmon fishing would be 60 m<sup>3</sup>/s, and possibly higher. Although the flows required for salmon fishing in the Waimakariri River are not well documented, there are data available from other braided rivers in Canterbury to gain an understanding of fishability in relation to flow in braided rivers. From studies on the Rakaia (Glova 1987, 1988) and Rangitata (Davis et al. 1987) Rivers, it is known that quite specific flows and water clarity are required for salmon fishing. The same

criteria almost certainly apply to fishing in the Waimakariri River, but to date this has not been adequately documented by appropriate field investigations of the river's fishability in relation to river flows, followed by hydraulic modelling to identify the range of flow suitable for salmon fishing.

29. In addition to the two-dimensional modelling work by Duncan (2001) for the braided reach at Crossbank on the Waimakariri River, which shows that there is little change in available habitat for salmonids with flows ranging between 41 and 85 m<sup>3</sup>/s, some further modelling with these data has recently been conducted by Golder Kingett Mitchell (2007). These authors applied Duncan's data to assess the relationship between flows and habitat for a wider range of instream uses, and made some comparison with other salmon rivers in Canterbury. They, too, found that there is little change in mean water depths and velocities and weighted useable areas for juvenile and adult salmonids for the above mentioned range of baseflows. Their results parallel those reported by Glova and Duncan (1985) for baseflows in the Rakaia River. Water clarity (measured as distance of underwater visibility) suitable for salmon fishing following a fresh or flood in the Rakaia River has been found to be in the range of 0.5 to 1.0 m (Glova 1988). Similar water clarity levels in the Waimakariri River occur on average at flows from around 50 to 85 m<sup>3</sup>/s (Kingett Mitchell 2006), which agrees with that reported by Mr Kennedy in his evidence.
30. The justification for a higher minimum flow for salmon angling in the Waimakariri River is clearly supported by WUA plots in relation to river flows recently made available by Mr Ian Jowett of NIWA. In this simulation modelling exercise, Mr Jowett used a finer resolution model of 4 m<sup>2</sup> cells rather than 8 m<sup>2</sup> cells as was formerly used by Duncan (2001) and Golder Kingett Mitchell (2007). For these plots, I maintain that the Habitat Suitability Index (HSI) for salmon angling used by Mr Jowett for the Rakaia River is more representative of hydraulic conditions in the Waimakariri River than that of other large braided rivers in Canterbury, since river gradient and substrate size of the Waimakariri River is more similar to that of the Rakaia than those of the Rangitata and Waitaki Rivers. Mr Jowett's plot (Figure 2) shows that there is very little fishable water available in the braided reach at Crossbank at flows below 60 m<sup>3</sup>/s, but that the amount of fishable water increases slightly with increasing

flow between 60 and 130 m<sup>3</sup>/s. From this plot it cannot be ascertained if the amount of fishable water actually decreases at flows greater than 130 m<sup>3</sup>/s as higher flows were not presented by Jowett. On the other hand, the available habitat for adult brown trout holding would be optimal at a flow of approximately 80 m<sup>3</sup>/s.



**Figure 2: Weighted useable area for salmon angling and adult salmon holding in relation to river flow for the braided reach at Crossbank, Waimakariri River. Taken from plots by I. Jowett, NIWA.**

31. Mr Tipler indicated in his evidence that the base take of 25 m<sup>3</sup>/s will occur for approximately 23% of the time and that the take will give rise to the greatest decrease (12.6 to 13.9%) in mean monthly flows between February and May, typically the period when river flows are lowest, water temperatures are highest, and the instream conditions are stressful for salmonids and other fishes. The take, however, as pointed out by Mr Tipler, will have a negligible effect (1.14% change) on the mean annual 7-day low flow as a result of lower priority access to water by CPWES restricting the take to a higher minimum flow (63 m<sup>3</sup>/s).
  
32. The time that flows in the Waimakariri River would be suitable for salmon fishing will be less with the CPWES take, particularly in dry years. Plots of flow duration curves for the Waimakariri River at the State Highway 1 bridge with and without the CPWES takes for several low flow years (1972/73, 1973/74, 1977/78, 1984/85, 1989/90 and 1991/92) all show that

the percentage of time that the flow of the river would exceed 60 m<sup>3</sup>/s would decrease by approximately 15-20% (Glova et al. 2001). The effects of the take on high flow years was not modelled, although it is accepted that the take may improve conditions for salmon fishing at flows above the range (80-130 m<sup>3</sup>/s ) considered to be optimal for fishing.

### ***Rakaia River***

33. Chinook salmon and brown trout constitute valuable recreational fisheries in the Rakaia River, with the river rated as the sixth most heavily fished river in the country (Deans et al. 2004). Optimal flows for salmon fishing have been identified to occur between 160 and 180 m<sup>3</sup>/s (Glova 1988). These flows are considerably greater than the minimum flows adopted by the NWCO to protect the main period of salmon fishing, which are 105.3 and 107.9 m<sup>3</sup>/s for February and March, respectively. Because of priority rights to existing users (total take to them is 34.3 m<sup>3</sup>/s) and 1:1 sharing between instream and out-of-stream users, the maximum take of 35.7 m<sup>3</sup>/s by CPWES would only occur when river flows exceed the NWCO monthly minima by 68.6 m<sup>3</sup>/s. In effect, the take would shift the band of flows that is considered optimal for salmon fishing (ie, 160 to 180 m<sup>3</sup>/s) to occur earlier on the hydrograph. From an analysis of flow data for the Rakaia River for 10 low-flow years that occurred between 1973 and 1994, Glova et al. (2001) estimated that the CPWES take would result on average in a 29% reduction in time that the flows would be optimal for salmon fishing during dry years, as compared with the flow in the river including the existing takes of 28.5 m<sup>3</sup>/s already allocated by year 2001 and 1:1 sharing rule limiting the CPWES take to when river flows exceed the NWCO monthly minima by 57 m<sup>3</sup>/s. This estimate by Glova et al (2001) does not truly represent the present position, as the takes allocated to other users is now slightly greater (34.3 m<sup>3</sup>/s) and the minimum flow that CPWES has to comply with is accordingly higher (68.6 m<sup>3</sup>/s), but it does provide an indication of the likely magnitude of effects on flows for salmon fishing. . However, in some years the available fishable days may increase with the CPWES take, as was found to occur for the 1986/87 flows in the analysis conducted by Glova et al. (2001) and in the Feasibility Report of 2002 which indicated a 2.4% increase in fishable days.

## ***Both Rivers***

34. An issue of concern for both the Waimakariri and Rakaia Rivers will be the effect of flushing of sediments from the stilling basins during the salmon fishing season, which occurs from November through April. As emphasised previously salmon fishing in large braided rivers requires specific flows and water clarity, which, in most instances, will be adversely affected by flushing of sediments from the stilling basins for variable distances downstream. An exception would be during periods of lower flows and higher water clarity that salmon fishing is likely to improve briefly with sediment flushing, due to increased turbidity and increased salmon movement upstream with conditions that may simulate the onset of a fresh for fish. On at least two occasions during periods of prolonged low flows in February/March, I observed that discolouration of the water by instream bulldozer activity during the day at the Silverstream Hatchery on the Kaiapoi River resulted in a significant number of salmon caught in the salmon trap at the hatchery on the following morning, whereas prior to these events no salmon had been recorded at the trap for several weeks, with the fish continuing to hold in deep pools of the lower Kaiapoi due to persisting low flows.
35. While it is possible that flushing may have some beneficial effects for salmon fishing during low flows, at most times it will be an inconvenience to anglers to organise their fishing around flushing events. However, I would expect the impact of sediment flushing on salmon fishing in the Waimakariri and Rakaia Rivers to be relatively short-lived. Moreover, the impact would probably be less for the Waimakariri than the Rakaia, because most fishing in the Waimakariri occurs in the deep pools in the lower reach (e.g, McIntosh's Rock, 'Banana' hole) and near the river mouth, which are considerable distances downstream from the proposed sediment flushing sites. In contrast, fishing on the Rakaia is widespread along the length of the river, with several good fishing sites likely to exist downstream of the proposed stilling basin. Some of the recommendations made by Waugh (1983) to reduce impact of sediment flushing from the RDR scheme on salmon fishing in the Rangitata River,

which in my opinion are still current thinking, may be incorporated into operation of the CPWES.

### **Lowland streams**

36. Most of the lowland streams located between the Waimakariri and Rakaia Rivers contain fishable populations of brown trout, which cumulatively contribute to a significant amount of fishing mainly for local anglers. These waterways are important spring-fed, low-gradient nursery areas for trout in Canterbury, but have increasingly suffered from habitat degradation attributable mainly to increased silts and nutrients and pollutants from agricultural, industrial/commercial and residential developments. Dr Bright in his evidence indicated that operation of the CPWES will result in greater groundwater inputs to these streams, which in my opinion will increase the quantity of habitat available for trout at the time of year when flows are likely to be limiting their populations.
37. However, increased groundwater intrusion to these streams may result in increased nutrient loading (mainly  $\text{NO}_3\text{-N}$ ), which in my view would tend to cancel out the ecological benefits associated with increased water quantity. Most of these waterways are already in an enriched state, and further enrichment will lead to increased algal and macrophyte growth and further reduction in habitat quality for trout and fishing. However, on the basis of Mr Tipler's conclusions regarding nutrient loading to these waterways, the net effect may be that the water quality in them would not be altered appreciably by operation of the CPWES. According to Mr Tipler, the water quality of these streams is determined primarily by the water quality in the upper aquifer, which if it does not change appreciably, then neither would the water quality in the lowland streams. If this is the likely outcome, then, in my opinion, the increased flow in these streams as a result of operation of the CPWES will improve the habitat available for trout and fishing.
38. Buffer strips of sufficient width and adequate fencing along lowland streams will help minimize the inflow of nutrients and silts and prevent stock from trampling bank side vegetation and adversely affecting water quality and streambeds. The terrain of these lowland catchments is gentle and stream banks are not erosion prone; in my opinion, buffer strips 5 m wide would be adequate to protect these waterways in most places.

## **Lake Ellesmere**

39. This large, shallow, turbid lake is a major feeding ground for several species of diadromous (fish that migrate between fresh and salt water), wholly freshwater resident, and estuarine-marine fishes (Glova and Sagar 2000). Foods that are abundant in the lake for various carnivorous fishes include several species of small crustaceans, snails, and midge larvae, and similarly the lake has an abundance of phytoplankton and periphyton for herbivorous fishes. The lake supports valuable commercial and customary fisheries for eels, flounders and mullet, as well as recreational fisheries for brown trout and inanga. Historically, brown trout were very abundant in the lake. However, following the extensive loss of the *Ruppia* beds (which were important habitat for trout) during the Wahine storm in 1968, and cumulative loss of rearing and spawning habitats and fish passage problems in the Selwyn River attributable mainly to draining of wetlands and water abstraction, the Lake Ellesmere trout stock has declined significantly over time. Since the early 1980s, there have been no more than a few hundred spawners annually moving from the lake up the Selwyn River to spawn.
40. According to Dr Mabin's evidence, the CPWES takes will result in slightly increased lake water levels and frequency of lake mouth openings mainly due to increased inflows from the tributary streams. From a fisheries' perspective, a greater number of mouth openings will benefit the fish populations as it will increase the opportunity for fish to enter and exit, many of which are migratory and require access to and from the sea to complete their life cycles. Mr Kennedy indicated in his evidence that the increased lake mouth openings will not appreciably increase the salinity of the lake and that the slight increases in salinity will be diluted by increased inflows from the tributaries. Hence, in my opinion, the possible adverse effects of rising salinity levels on food organisms and trout rearing in the lake and lower reaches of the tributaries are likely to be negligible.

## **Fish Screening**

41. It is my understanding that at this stage, CPWES is seeking approval for a process from which to develop performance specifications for fish

screens, rather than details of design for screens that would be appropriate for the quantities of flow, river conditions and fish species requiring screening. In considering fish screening for the CPWES, I have reviewed the technical report recently completed by NIWA (October 2007) on good practice guidelines for fish screening in Canterbury rivers and various overseas publications. The guidelines given in NIWA's report are intended for takes up to 10 m<sup>3</sup>/s and the report explicitly indicates that for larger takes extra design considerations are required. The information contained in the report is therefore largely a review of existing fish screen designs for takes up to 10 m<sup>3</sup>/s and life histories and life stages of fish species likely to be encountered in Canterbury rivers. The report and other publications have been referred to in developing a performance specification for fish screening considerations for the CPWES.

42. Regarding fish screening specifications, it is my understanding that the CPWES will endeavour to provide the following:
- Locate the intake sites at locations which will minimise fish exposure to the screen structures.
  - Mesh size small enough to exclude salmonid fry (5 mm aperture; a smaller aperture is impractical for the quantity of flow that would be taken by CPWES).
  - Approach velocities that are slow enough that will be negotiable by salmonid fry.
  - Sweep velocities across the screen will be sufficient to sweep all fish past the screen efficiently without damage to them.
  - Suitable bypasses with adequate flows will be provided to convey fish from the intake back to the source channel which will connect to an actively flowing main braid in the river.
43. As I have stated in previous sections, the Waimakariri and Rakaia Rivers are important rearing areas and corridors for salmonids moving to and from the sea at almost all times of the year. The intakes of the CPWES need to be adequately screened to keep salmonid fry and older life stages out of the intakes. Possible options for screening include rotary screens , flat screens, and sonic barriers. Rotary screens are more suited for

smaller takes (<10 m<sup>3</sup>/s), whereas flat screens are better suited for adaptation to larger takes. Whatever screen design(s) would ultimately be proposed for the CPWES, it will be important to consider having the screens installed at a maximum 45° to the flow to facilitate moving fish past the screens to the bypass channel, as well as debris.

44. I consider that a minimum flow of 5 m<sup>3</sup>/s should be provided in all bypass channels to ensure safe passage for fish back to a major channel in the river. Underwater sonic barriers, as a means of keeping fish out from being entrained into the intakes, is a relatively recent innovation and is still in the process of being further tested for use in the United Kingdom, with quite promising results. The effectiveness of sonic barriers, and others, has not been tested in large rivers with high sediment loads as occur in the Waimakariri and Rakaia Rivers. Thus, it is unlikely that underwater sonic barriers will be an option for consideration for the CPWES.
45. For the takes of up to 40 m<sup>3</sup>/s at the upper and lower intakes on the Waimakariri River, as well that on the Rakaia River, the flat-screen version in a labyrinth design as proposed for Project Aqua on the lower Waitaki River (Glova and Boubée 2002) to reduce the spatial extent of the required area of screening, would be a likely option. For flows of up to 10 m<sup>3</sup>/s, a rotary screen is a likely option as indicated by NIWA, for which Mr Lewthwaite has experience with the design for some existing facilities in Canterbury rivers. For screening juvenile salmonids, mesh size and approach velocity would be 5 mm and 0.12 m/s, respectively, as recommended by Clay (1995). Alternatively, a 'boat-design' intake, unscreened, as exists at Brown's Rock operated by Waimakariri Irrigation Ltd, for which juvenile salmon entrainment has been estimated to range from 1-4% depending on river flows (Unwin and Taylor 2007), may be an appropriate option for flows <10 m<sup>3</sup>/s.

### **Conclusions**

46. Chinook salmon and brown trout constitute valuable recreational fisheries in the Waimakariri and Rakaia Rivers, with fishing for salmon in the Waimakariri occurring mostly in the lower reaches and at the mouth, whereas fishing for salmon in the Rakaia is widespread along the length of the river as well as at the mouth. Fishing for trout occurs mostly in the lower reach and at the mouth in both rivers, particularly in spring when

they are feeding on incoming small native fishes (bullies, white bait, smelt) from the sea.

47. These rivers consist of unstable, braided channels whose fish-food organisms and fish populations and fishing conditions require adequate minimum flows.
48. Passage for adult salmon and trout is not likely to be adversely affected by the CPWES take in the Rakaia River as the monthly minimum flows of the NWCO adequately provide for safe upstream passage of these fish. Similarly, passage for adult salmon and trout in the Waimakariri River is not likely to be adversely affected by the CPWES take as it will be mainly limited to Class B water during the irrigation season for which the minimum flow as it applies to CPWES will be 64.24 m<sup>3</sup>/s.
49. The take of up to 40 m<sup>3</sup>/s at both the upper and lower intakes on the Waimakariri River is not likely to have any significant negative effect on habitat and salmonid fish populations downstream.
50. The take of up to 40 m<sup>3</sup>/s from the Rakaia River is not likely to adversely affect the availability of potential habitat for salmonids as the river is adequately protected by the minimum flows of the NWCO.
51. Flushing of sediments from the stilling basins is not likely to have any major lasting effects on habitats downstream in either river.
52. Salmon fishing will likely be affected by the CPWES takes in the Waimakariri River, with the percentage of time that the flow will be considered optimal for salmon fishing in dry years will be reduced by 15-20% but with possible positive effects in high flow years.
53. Fishing for salmon in the Rakaia River will be affected by the take, with varying effects on the amount of time that flows are likely to be considered optimal for salmon fishing. These will range from quite distinct reductions during dry years to small increases in other years
54. Salmon fishing in both rivers will in most instances be affected by the flushing of sediments from the stilling basins for variable distances downstream. During periods of low flows and high water clarity, salmon fishing may improve slightly with sediment flushing.

55. The habitat available for trout in the lowland streams will improve slightly as a result of increased flows. Should nutrient loading to these stream increase as a result of increased groundwater inflows, which may become enriched in the upper aquifer, then the benefits that would accrue for trout and fishing due to increased flows, would likely be cancelled out.
56. The slight increases in water levels and mouth openings of Lake Ellesmere as a result of the CPWES are not likely to significantly affect the lake's existing water quality and ecological balance of the floral and fauna, nor the status quo of the brown trout fishery.
57. As the takes involved are large, at this stage CPWES is seeking approval for a process from which to develop a performance specification for effectively screening fry and older life stages of salmonids, as well as various species and life stages of native fish. There are viable options for screening a water take of this size and the NIWA guidelines are relevant although there may be additional considerations, as I have discussed, for a take of this size.

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