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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EVIDENCE IN REPLY OF GREGORY PETER BURRELL

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INTRODUCTION

1. My name is Gregory Peter Burrell. My qualifications and experience, and the basis on which I prepared this brief, are set out in my main brief of evidence prepared for this hearing (dated January 2008).

2. This evidence in reply focuses on the following key issues raised in evidence by submitters, Council Officers, and the Commissioners:

   (a) Effects of different water abstraction scenarios on the duration of low flows in the Waimakariri River.

   (b) Effects of CPW on nuisance growths in the Waimakariri River.

   (c) The relative importance of floods and habitat availability for biota in the Waimakariri River.

   (d) Didymo.

   (e) Benefits of increased flow to lowland streams (in response to Dr Larned's evidence).

FLOW SCENARIOS BEING COMPARED

3. A number of different potential water abstraction scenarios have been presented to date by CPW and submitters. The six flow scenarios provided by URS that I have been asked by CPW to comment on are as follows::

   A. **Scenario 1 – "Unmodified".** River flow with no abstraction. This is the flow series that was computed by Mr de Joux, and is the measured river flow with known water takes added in.

   B. **Scenario 2 – "Existing".** The above "Unmodified" flow series with known water takes removed. It may also be thought of as the "pre CPW" river flow.

   C. **Scenario 3 – "Base Case".** This is the 20-40-230 CPW take scenario referred to in Mr Tipler's main brief of evidence and is the CPW "base case" scenario, as it involves no specific mitigation of potential effects of the take.

D. **Scenario 4 – "Flow Share".** This is the 20-40-243 CPW take scenario that involves CPW taking the first 8.76 m^3/s of Class B water, then 1:1 sharing for higher flows. It is one of the options discussed by Mr Tipler.

E. **Scenario 5 – "80 m^3/s Minimum".** This is the 20-40-279 water take scenario that has a minimum flow of 80 m^3/s for Class B water. It is another option discussed by Mr Tipler.

F. **Scenario 6 – "100 m^3/s Minimum".** This is the regime proposed by Mr de Joux and Fish and Game, and involves a minimum flow of 100 m^3/s for Class B water.

EFFECTS OF DIFFERENT FLOW SCENARIOS ON ACCRUAL LENGTHS

4. A key concern voiced by various submitters and ECan is the effect of different CPW water take scenarios on the duration of low flows in the Waimakariri River. Information has been presented on this matter in Mr Tipler's July 2008 supplementary evidence. To further assist the commissioners and submitters in this area, I have calculated the effect of the six different flow scenarios on mean annual accrual periods (the average period between floods).

5. As stated in my evidence in chief, there is a variety of research suggesting that floods between around 120-200 m^3/s are "ecologically significant", in that they remove periphyton and "reset" biological communities in the Waimakariri River. Lower flood flows (e.g., twice the preceding base flow) may also provide similar, although not as substantial, ecological benefit if they follow long periods of stable low flow.

6. I have used three different flood flow statistics to cover the range of flood flows of potential ecological interest:

   (a) **MIN3 – 123 m^3/s**. This is three times the minimum flow of 41 m^3/s. It is the lower bound of flood flows of ecological interest.

   (b) **MIN5 – 205 m^3/s**. This is five times the minimum flow. It is the upper bound of flood flows of ecological interest.

   (c) **FRE3 – 284 m^3/s.** This is three times the "unmodified" median flow of 94.6 m^3/s. It is included to allow comparison with other studies using this statistic.

7. The attached plots (Figures 1-7) show the effect of the six flow scenarios on annual mean accrual lengths, for all data and for summer-only data (December-March). Figure 1 shows that the biggest increase in mean accrual length occurs between Scenarios 1 to 3, which shows the effect of existing abstractions (Scenario 1 versus 2) and the CPW take (Scenario 2 versus 3). The increase in mean accrual period between Scenario 2 and 3 is more pronounced in the summer period and is greatest for the MIN5 flood statistic, where there is a mean increase of 11 days. The mean increase in summer accrual period for the MIN3 flood statistic is only 3 days when comparing Scenario 2 and 3.

8. The key point here is that if the ecologically-relevant flood flows occur between MIN3 and MIN5, then the effect of the CPW take is to increase mean summer accrual length somewhere between 3 and 11 days. The effect is most pronounced in summer, as flows are generally lower and removing 40 m^3/s therefore has the greatest effect.

9. Another key point is that there is no significant difference in mean accrual length (all data) between CPW abstraction Scenarios 3-6 for the ecologically relevant MIN3 and MIN5 floods (Figure 1). Also of interest, but not necessarily ecological significant, is that the mean annual FRE3 accrual period shows a steady increase from Scenario 1 to 6. The hydrological basis for differences between the different flow scenarios are discussed in Mr Tipler's evidence.

10. The additional plots in Figures 2-7 show mean accrual length for each of the years of the modelled flow record. The plots show that the average time between floods varies considerably year to year and they therefore provide a useful indication of the relative increase in accrual period caused by the CPW take compared to natural variations year to year.

11. Overall, the data I have presented suggests that in terms of mitigating effects of accrual periods, there is little difference between abstraction Scenarios 4-6 relative to the base case (Scenario 3). Therefore, I consider that the conclusions I arrived at in my evidence in chief concerning ecological effects remain unchanged. Thus, the CPW take is predicted to increase inter-flood accrual periods, and this will likely result in greater periphyton biomass, but not to the extent of causing nuisance growths, as the river will remain flood-disturbed and the increase in accrual length is not large.

12. I also note that the modelled flow scenarios do not include additional mitigation measures described in Mr Tipler's evidence in reply. Briefly, the key mitigation proposed is to cease abstracting to let small freshes pass down the river following low flows of 21 days or more. As discussed in Mr Tipler's evidence, it is proposed that in such a situation, abstraction will cease for two days or until flows exceed 130 m^3/s. In my opinion, this is a useful mitigation measure from an ecological perspective as it will increase the likelihood of periphyton and sediment being moved regularly.

POTENTIAL FOR NUISANCE GROWTHS IN THE WAIMAKARIRI RIVER

13. In his supplementary S42A evidence and presentation, Dr Meredith suggested that nuisance algal growth issues in the Waimakariri River may be associated with blue-green algal mats, and not filamentous growths. However, I have reviewed the same National River Water Quality Network (NRWQN) data as Dr Meredith and think his interpretation of the data is somewhat misleading. Attached Figures 8 and 9 are plots of mean periphyton cover (average of 10 samples) as mats and filaments at the two Waimakariri River sites. The data show that streambed coverage with both mats and filaments is typically very low in the Waimakariri River. The Waimakariri River Regional Plan (WRRP) standard of <25% cover with filamentous algae or mats has seldom been exceeded, and the less stringent MfE (Biggs 2000) periphyton guidelines (<30% cover with filaments and <60% cover with mats) are exceeded even less frequently.

14. I gather that the point of Dr Meredith's evidence was to highlight that mats of nuisance blue-green algae such as *Phormidium* do sometimes occur in the Waimakariri River and that the CPW scheme could increase the extent and frequency of these occurrences. Although I consider this is a valid concern, having reviewed the different flow scenarios and hydrological statistics, I maintain my assertion that nuisance growths are unlikely to result from the CPW water take.

15. To provide some further assurance regarding effects on mat-forming nuisance growths, I have analysed periphyton data from the Opuha River Skipton Bridge site. Data from the foothills-fed Opuha River provides a useful comparison to the Waimakariri River data, as the Opuha Dam was completed in 1989 and since then flow variability has drastically reduced. Figure 10 attached shows

that prior to 1989, periphyton mats were relatively sparse, but filamentous growths were common compared to the Waimakariri River. However, since 1989, bed coverage with mats has increased markedly, and *Phormidium* has become one of the common mat-forming species in the Opuha. I understand from talking with local fishermen that the proliferation of *Phormidium* in the Opuha River has created a nuisance, with its chemical compounds tainting water and fish flesh.

16. Analysis of the hydrograph for the Opuha River shows it was a naturally highly flood disturbed river prior to completion of the dam in 1998 (Figure 11 attached). Up until 1998, the mean summer FRE3 accrual length was 45 days, which is very similar to that of the unmodified Waimakariri River flow (Figure 1). Unfortunately, ECan have not kept an accurate low flow rating curve since mid-1999 (Tony Gray, ECan hydrologist, pers. Comm.). However, inspection of the hydrograph in Figure 11 shows that for at least the year following dam completion and filling, there were no floods down the Opuha River. This extremely long period of stable flows was associated with a large increase in the growth and extent of mat-forming nuisance growths in the Opuha River (Figure 10).

17. These data illustrate the fact that nuisance mat-forming algae do occur in Canterbury rivers, and that river regulation by dams can lead to increased proliferations. However, the evidence presented to date by Mr Tipler, Mr Duncan and by me show that the CPW scheme will not appreciably reduce flood frequency in the Waimakariri River. My data also shows that the increase in accrual length will be small (3-10 days) compared to that of the Opuha River, whose flows have been regulated by a dam upstream, and where accrual periods increased in length by the order of months. Overall, in my opinion there is no compelling evidence that the CPW scheme will lead to an increase in nuisance growths of algal taxa such as *Phormidium*.

FACTORS LIMITING BIOTA IN THE WAIMAKARIRI RIVER

18. In my evidence in chief and supplementary evidence, I stated my opinion that increased productivity caused by lengthened accrual periods would offset the effect of the CPW take on reduced habitat availability in the Waimakariri River. I also opined that floods, rather than habitat, limit biological communities in braided rivers such as the Waimakariri. However, Dr Hayes (expert acting for

Fish and Game) questioned the degree to which increased productivity would offset habitat losses. Similarly, Dr Olsen (for Fish and Game) and Dr Hayes stated that there was insufficient data presented to support my claim that biological communities were limited by floods rather than habitat.

19. Subsequent to Drs Hayes and Olsen evidence presentation, Mr Duncan has presented extensive supplementary evidence, including information on productivity offsets and habitat losses. In summary, Mr Duncan found (paragraph 72 of his supplementary evidence): *"The index of productivity for the take regimes is no more than 2.5 % different from the unmodified flow regime and so the effect on* Deleatidium *productivity could be said to be less than minor.* " Although Mr Duncan's modelling approach has numerous assumptions, it does represent the state of the art in this area of hydro-ecology. I therefore consider that Mr Duncan's modelling results provide reassurance that the potential loss of productive invertebrate habitat caused by the CPW take will be offset by increased productivity, due to increased colonisation time and periphyton productivity.

20. To provide further evidence that habitat is not limiting invertebrate communities in the Waimakariri River, I have compared the IFIM results from the Waimakariri River to those of the "100 rivers project", where Jowett (1992) analysed trout abundance data for 89 sites in 82 rivers. In summary, Jowett (1992) reported the following statistics for the Habitat Suitability Index (HSI, also known as percent weighted usable area):

– Adult brown trout: Median = 15%; range = 3-44%; interquartile range = 8-18%.

– Food producing (%): Median = 34%, range = 11-51%; interquartile range: 26-40%.

21. As noted in my evidence in chief, HSI for food producing is between 40-50% in the Waimakariri River, irrespective of flow. This is high relative to studies carried out throughout New Zealand, indicating it is in the top 25% of sites studied. Thus, confirming that there is indeed a large amount of potential habitat for food production in the Waimakariri River.

22. Jowett (1990) found HSI, calculated at median flow using the preference criteria described by Waters (1976) for "food production", was an important

discriminating variable amongst groups of sites with higher versus lower trout biomass. Sites with higher food production HSI values at median flow support greater invertebrate productivity and more trout biomass.

23. Thus, the “100 rivers” studies show that the HSI food production measure is positively related to trout biomass and that trout biomass is greatest in rivers with lower flow variability (e.g., lake outlets). Hence, the “100 rivers” research provides further defensible data on which to say that some reduction in flow variability in a flood-disturbed river should be associated with increased invertebrate productivity and food for fish.

DIDYMO

24. Some concerns have been raised by submitters and the commissioners concerning the effect of the CPW take on the invasive alga *Didymosphenia geminata* (Didymo). One issue of concern is whether reduced flows in the Waimakariri River, caused by the CPW take, would exacerbate the spread of Didymo in the river, if it does indeed arrive.

25. I have reviewed the recent reports published on the Biosecurity New Zealand website. Research by Kilroy et al (2006) and Larned et al (2007) indicates that Didymo occupies a wide depth and velocity range, suggesting that general increases or decreases in water depth or velocity will not greatly affect Didymo. However, both studies found a substantial reduction in Didymo biomass following moderate to large floods (>3 x preceding baseflow).

26. Concerning nutrient effects, Larned et al (2007) found that, *“…on average, benthic algae accrual under ambient conditions is ≤60% of the potential, nutrient-enriched rate. Therefore, increased nutrient loading to affected rivers is likely to be followed by increased growth of D. geminata.”*

27. These recent studies indicate that reduced velocities and depths in the Waimakariri River, caused by the CPW take, are unlikely to hasten the spread of Didymo. Similarly, adverse effects caused by reduced flood frequency will be avoided, because larger flood flows will be relatively unaffected by the scheme. However, the finding that Didymo may be limited by nitrogen or phosphorus in many instances puts a greater imperative on the need for CPW shareholders to employ best farm practices to minimise nutrient runoff.

BENEFITS OF INCREASED FLOW TO LOWLAND STREAMS

28. In his evidence, Dr Larned (for Fish and Game and DoC) undertook a very detailed critique of CPW evidence relating to lowland streams and Lake Ellesmere. One of his criticisms was a lack of quality data in general, and in particular insufficient information proving that increased flows in lowland streams would be beneficial to aquatic ecosystems. I have therefore collated some additional information in this area.

29. A useful source of information for the area is a series of unpublished draft ECan reports produced as part of a review of minimum flows for streams in the Lake Ellesmere/Te Waihora catchment (see Table 1 attached). The review used an Expert Panel with expertise in the areas of trout, native fish, general aquatic habitat, general amenity, indigenous vegetation, and cultural Maori values. The Expert Panel visited streams in low flow conditions in summer 2003 and 2005, and ranked each waterway according to the values it supported. Each panellist then used their professional judgement to recommend the minimum flow required to sustain a given instream value.

30. The ECan Expert Panel draft minimum flow reports provide perhaps the most extensive assessment of instream values for Lake Ellesmere tributary streams and it is worthwhile briefly summarising these values here. Table 1 attached provides a summary of the Expert Panel average rankings for instream values at the different sites visited.

31. Overall, indigenous vegetation values were regarded as low to moderate at all sites, with no high value sites recognised out of the 25 assessed (Table 1 attached). This reflects the general lack of intact riparian vegetation and long history of farming in the area. Similarly, natural character and general amenity values were mostly moderate to low, with Harts Creek, Birdlings Brook and the Lee River notable exceptions.

32. Native fish and trout values were greatest in the Lee, LII and Halswell Rivers, Harts and Taumutu Creeks. Native fish values were also ranked highly in Knights Stream (a tributary of the Halswell), Birdlings Brook, Waikekewai Creek and Jollies Brook.

33. Fish values in general and trout values in particular are closely related to stream size, as illustrated in Figure 12 attached. The lower, mainstem reaches

of the LII and Halswell Rivers are deep and broad, and provide good instream habitat for adult trout and native fish, particularly large eels. Fish diversity naturally declines with distance upstream from the sea due to increased distance for migratory species to travel, the dominance of migratory species in the area, and also reduced habitat availability for larger fish species or life stages.

34. Most sites were given high scores (5 out of 5) for mahinga kai values. This reflects the fact that many of the tributary streams support good numbers of eels, which support a highly valued fishery.

35. A number of sites, including the lower reaches of Silverstream and the Selwyn River at Coes Ford were ranked highly in terms of mauri. Wahi tapu and wahi taonga are present at numerous locations in the Lake Ellesmere/Te Waihora tributaries. Although the exact nature of these values were not always elucidated by the relevant panellist, recurring themes are values associated with historic food gathering areas, intrinsic value of clear spring waters, and proximity to historic settlements.

36. In addition to the generalised habitat modelling presented in earlier technical assessment reports for CPW, the positive relationship between stream flow and fish habitat in Lake Ellesmere tributary streams was highlighted in a qualitative sense by the Expert Panel. Thus, Figure 12 attached shows a clear positive relationship between the site ranking in terms of trout habitat values and the minimum flow recommendation.

37. This habitat-flow relationship was quantified more recently in a study by Eric Graynoth from NIWA, where longfin eel biomass was correlated with stream flow for a number of streams, and eel habitat availability versus flow relationships were modelled for small Lake Ellesmere tributary streams (Graynoth 2007). The review found that eel habitat availability and biomass declines below flows of 100 L/s in small rivers such as the Selwyn, and that flows of 100 to 300 L/s would be adequate to maintain stocks. Habitat availability declined rapidly at flows less than 50 L/s. It was therefore suggested by Dr Graynoth that minimum flows for eels should be in the order of 100-300 L/s for the larger streams, and 50 L/s for smaller drains and tributaries. What is noteworthy is that the rate of increase of eel biomass and habitat availability was much less at flows greater than 100-300 L/s, indicating that

greater flows were not necessarily beneficial to maintaining healthy eel populations.

38. The key point to take from these two different studies is that increased flows in some lowland waterways will increase the amount of habitat available for aquatic biota and will therefore beneficial to the aquatic community. Overall, the benefits of increased flow will be greatest for the smaller streams, where low flow currently restricts the amount of habitat available to the biota.

GP Burrell, 8 September 2008

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Kilroy C.; Biggs B.; Blair N.; Lambert P.; Jarvie B.; Dey K.; Robinson K.; Smale D. 2006: Ecological studies on Didymosphenia geminata. NIWA Client Report CHC2005, prepared for Biosecurity New Zealand, September 2005.

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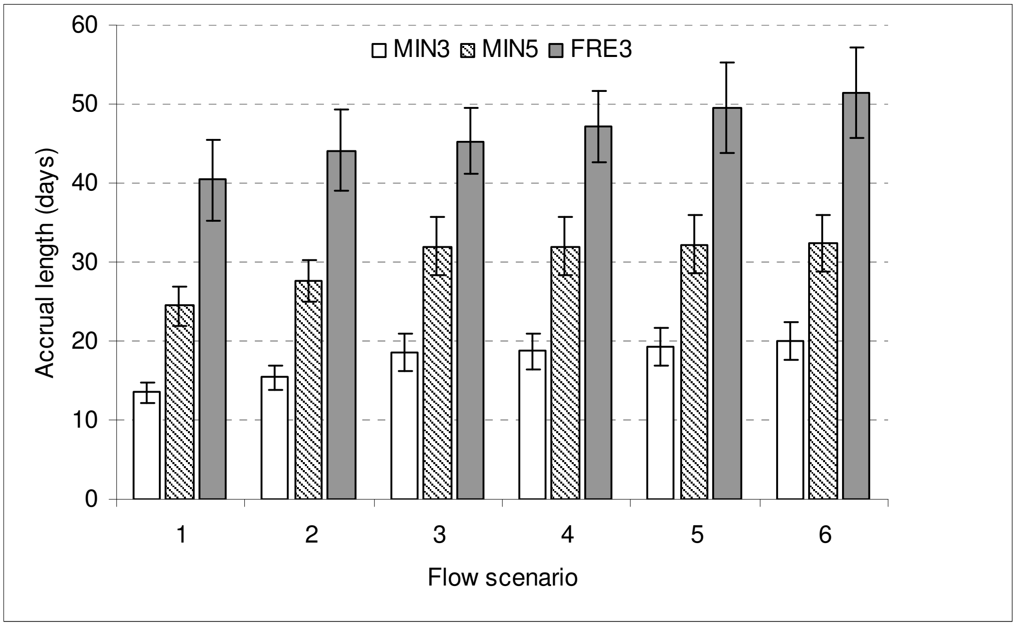
Waters B. F. 1976: A methodology for evaluating the effects of different streamflows on salmonid habitat. In: Orsborn J. F.; Allman C. H. eds. Proceedings of the symposium and speciality conference on instream flow needs II. American Fisheries Society, Bethesda, Maryland.

All data



Summer data – December to March inclusive

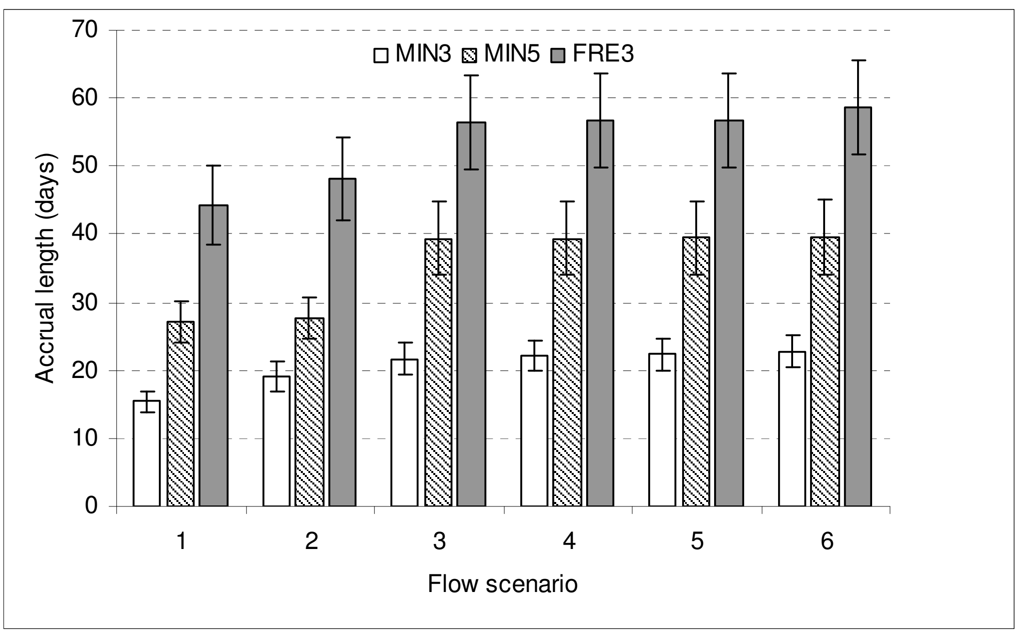
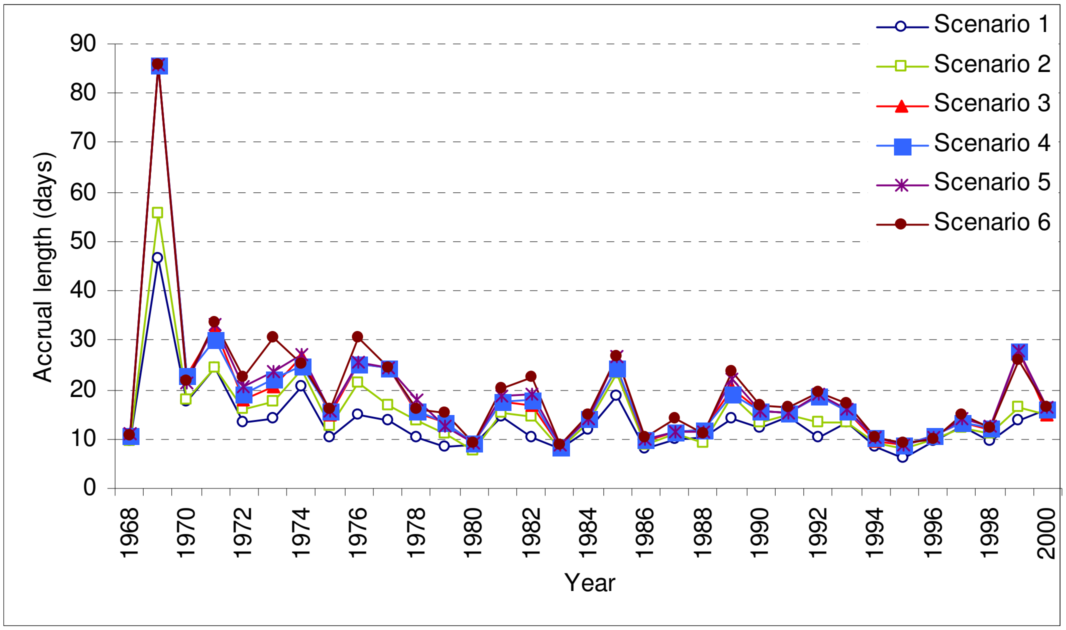


Figure 1: Effect of different flow scenarios on mean (±1 SE) accrual length for all data and summer data only (December-March), based on MIN3, MIN5 and FRE3 floods. See text for details of flood and flow scenarios.



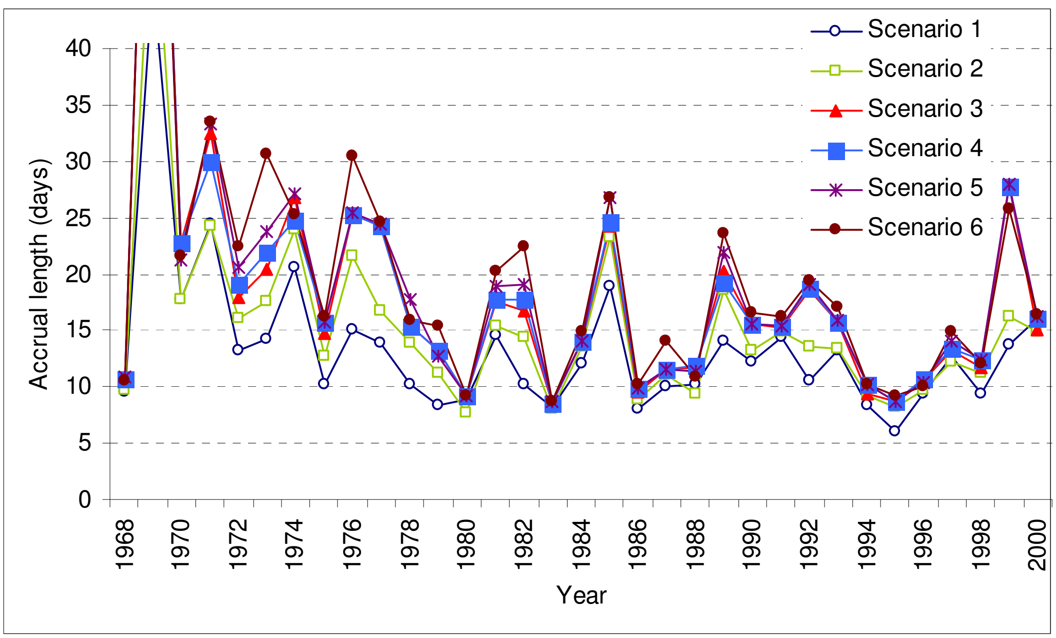


Figure 2: Effect of different flow scenarios on annual mean accrual length for all data, based on MIN3 floods (>123 m^3/s). Both plots include the same data, but the lower plot has a shortened y-axis to exclude the very long accrual period in 1969.

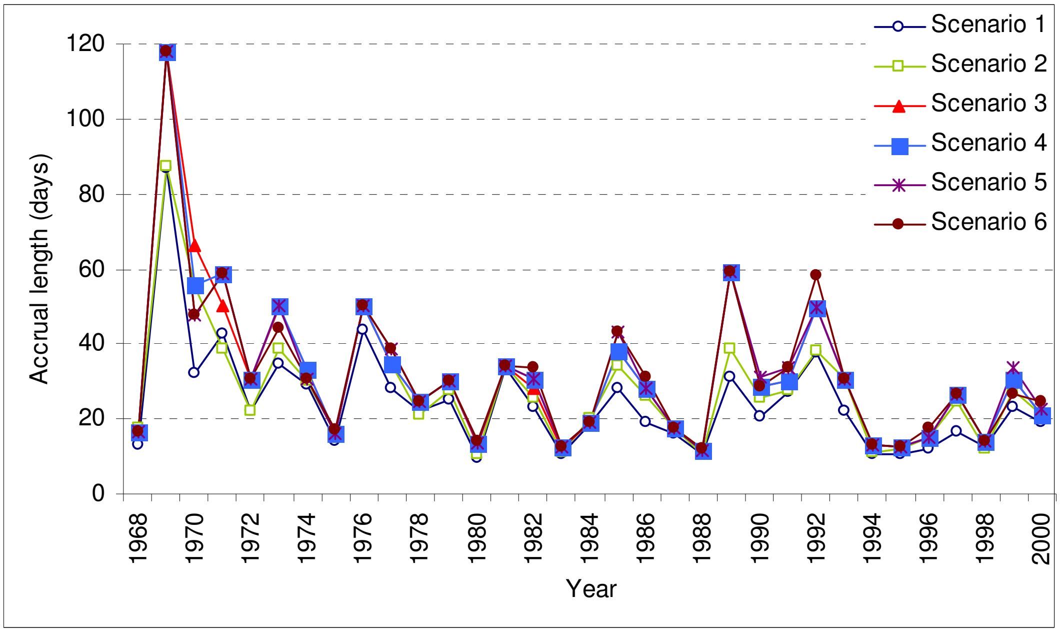


Figure 3: **Effect of different flow scenarios on annual mean accrual length for all data, based on MIN5 floods (>205 m^3/s).**

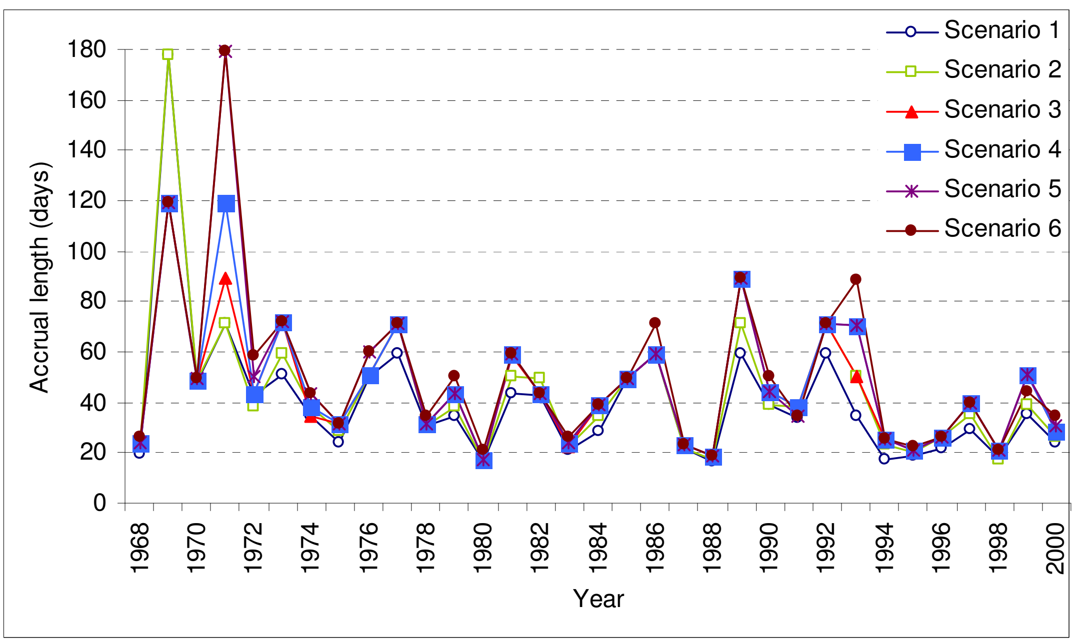


Figure 4: **Effect of different flow scenarios on annual mean accrual length for all data, based on FRE3 floods (>284 m^3/s).**

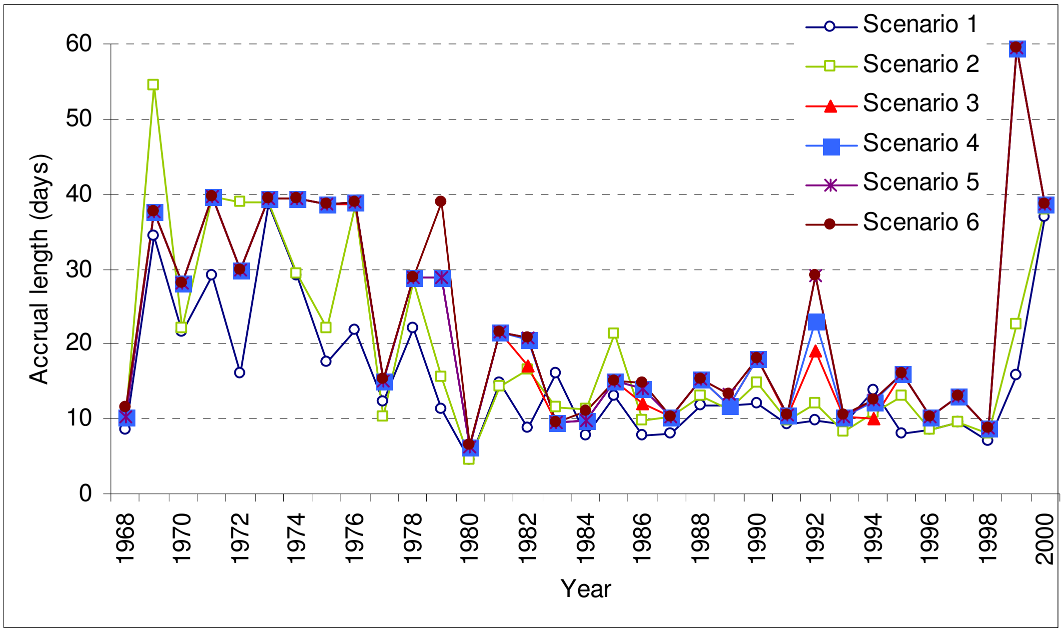


Figure 5: Effect of different flow scenarios on annual mean accrual length for summer periods (December-March), based on MIN3 floods (>123 m^3/s).

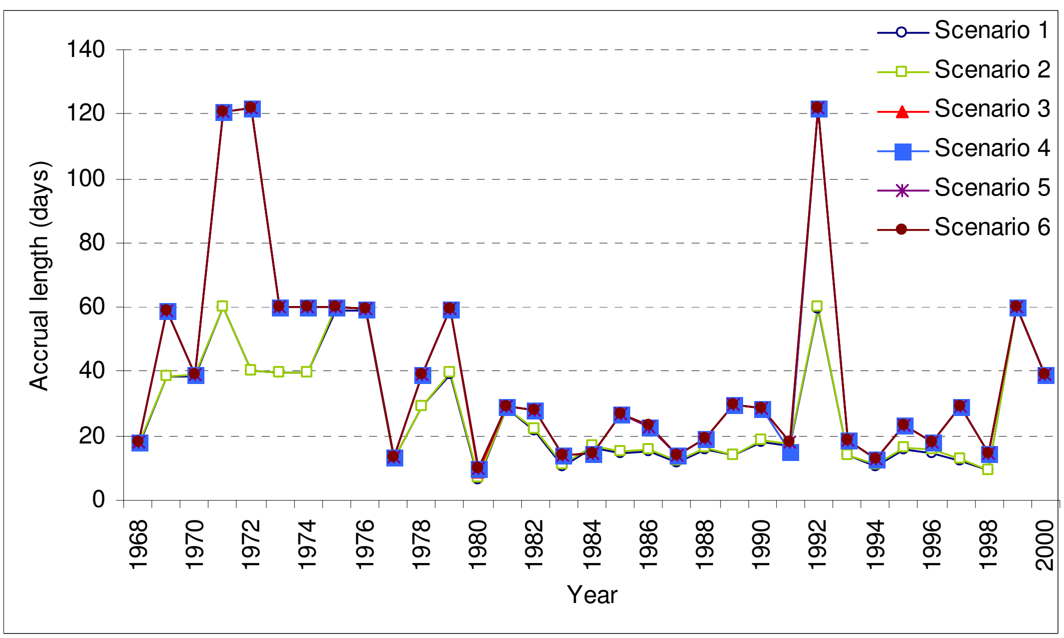


Figure 6: Effect of different flow scenarios on annual mean accrual length for summer periods (December-March), based on MIN5 floods (>205 m^3/s).

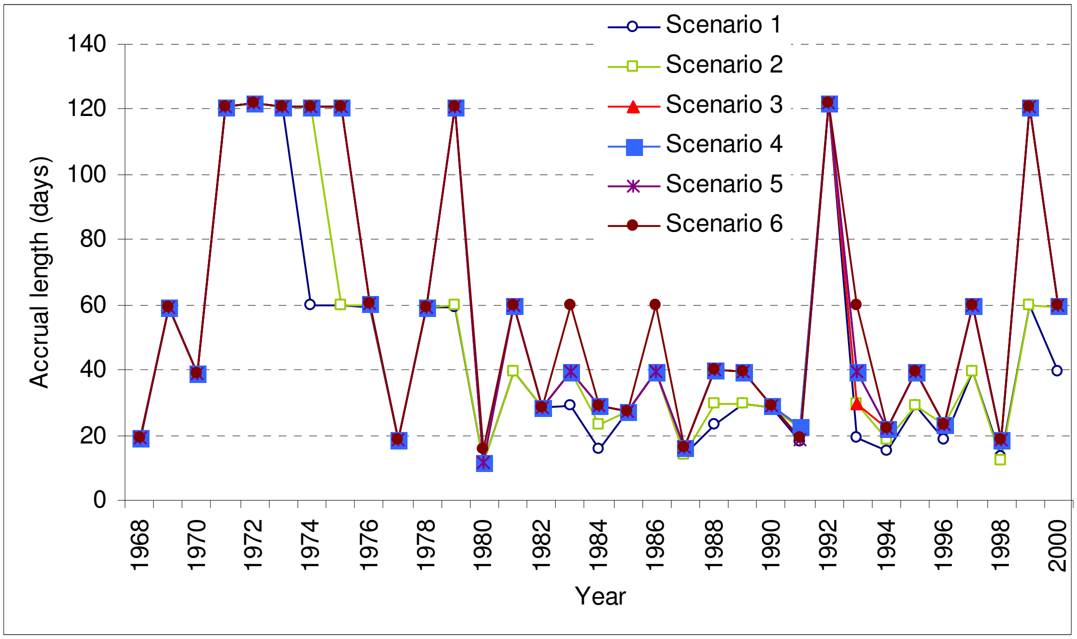
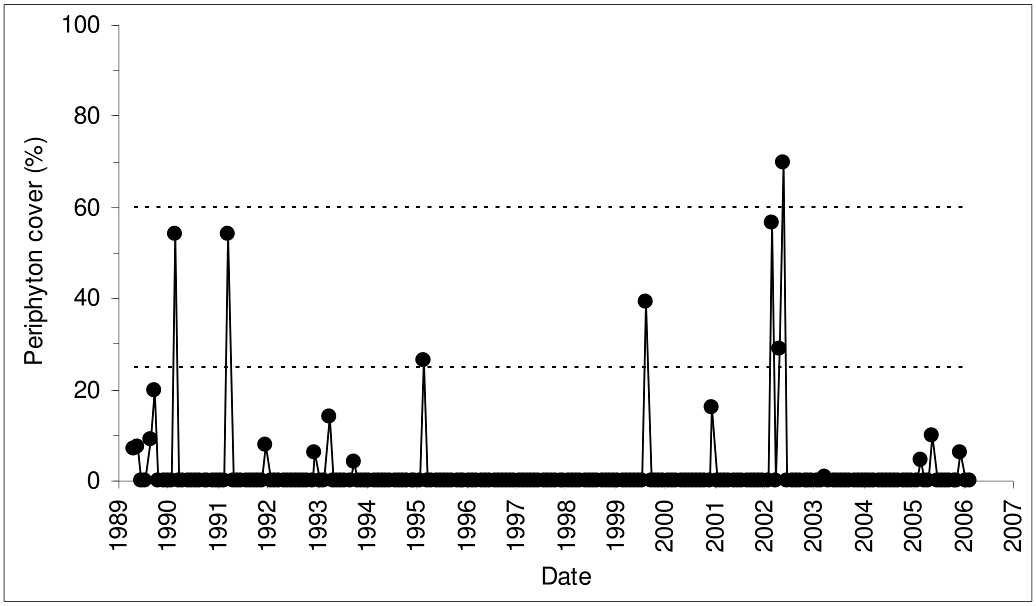


Figure 7: **Effect of different flow scenarios on annual mean accrual length for summer periods (December-March), based on FRE3 floods (>284 m^3/s).**



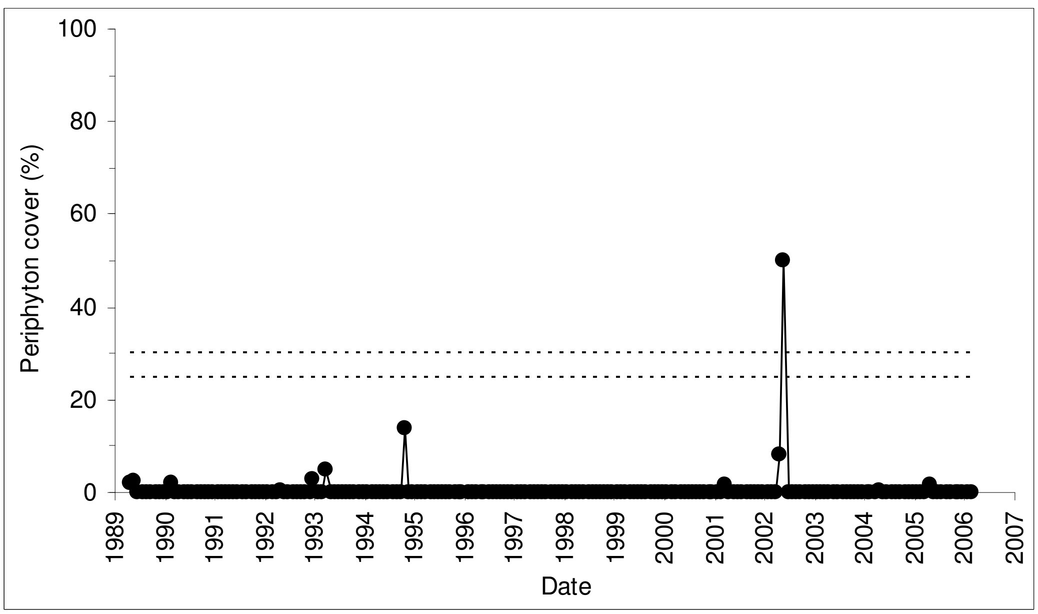
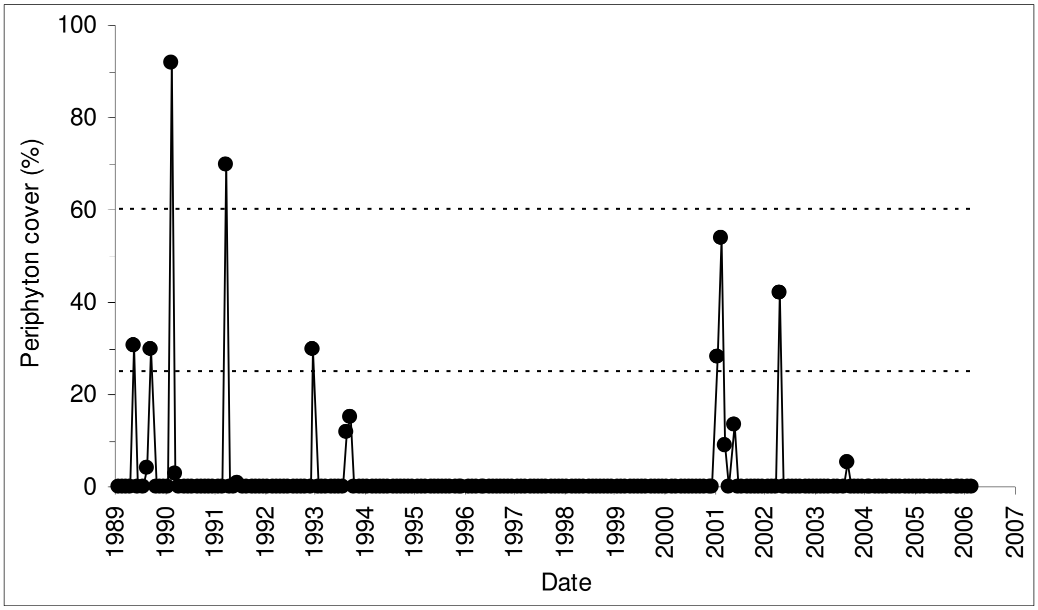


Figure 8: Mean bed coverage with mats (upper) and filamentous algae (lower) at the Waimakariri River Gorge site. Data are courtesy of Graham Bryers at NIWA. Upper and lower dashed lines relate to the MfE periphyton guidelines and WRRP standards, respectively.



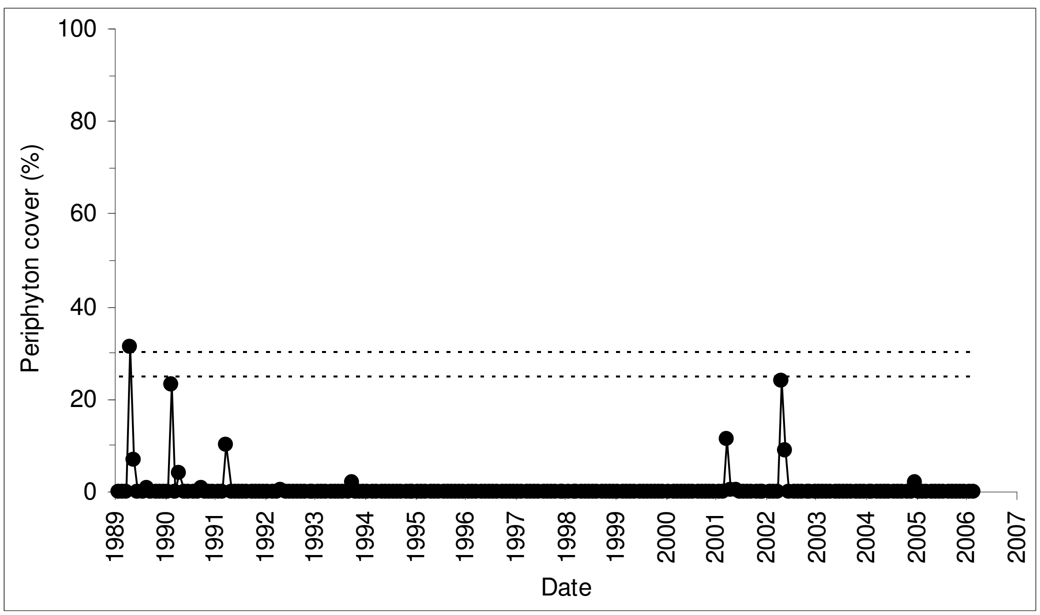
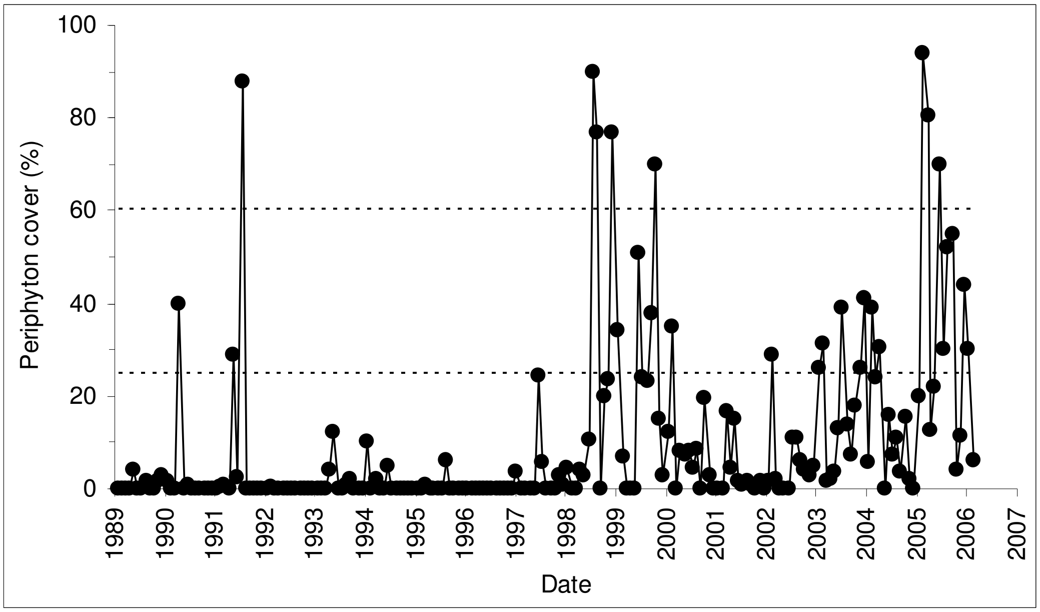


Figure 9: Mean bed coverage with mats (upper) and filamentous algae (lower) at the Waimakariri River Old Highway Bridge site. Data are courtesy of Graham Bryers at NIWA. Upper and lower dashed lines relate to the MfE periphyton guidelines and WRRP standards, respectively.



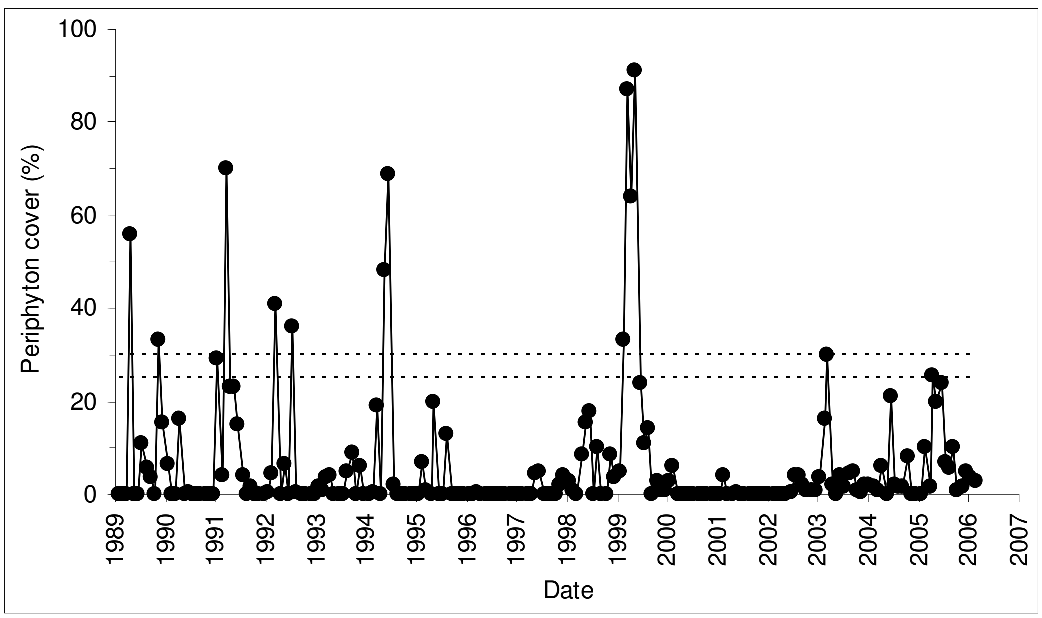


Figure 10: Mean bed coverage with mats (upper) and filamentous algae (lower) at the Opuha River Skipton Bridge site. Completion of the Opuha Dam in 1998 has caused an increase in nuisance growths of mat-forming blue-green algae. Data are courtesy of Graham Bryers at NIWA. Upper and lower dashed lines relate to the MfE periphyton guidelines and WRRP standards, respectively.

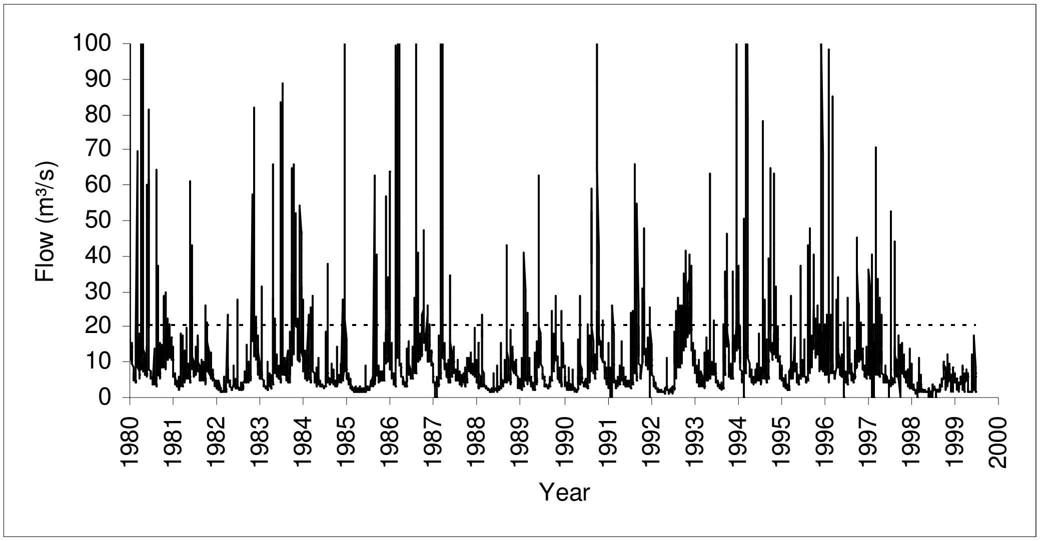


Figure 11: Opuha River flow measured at Skipton Bridge. The dashed horizontal line is 3 x median flow (20.4 m^3/s). Raw data are courtesy of ECan.

Table 1: Summary of ECan Expert Panel instream value scores and draft minimum flow recommendations.

Minimum Flow Site	Trout	Native fish	Indigenous vegetation	Natural character	General amenity	Mahinga kai	Mauri	Wāhi tapu & wāhi taonga	Aquatic habitats	Average score	Median score	Gauged Flow (L/s)	7DMALF (L/s)	Recom. Min. Flow (L/s)
Knights Stream	3	5	3	1	3	3	3	Present	3	3.0	3	142	220	150
Halswell R @ Leadleys	3	3	3	3	3	5	3	Present upstream	3	3.3	3	348	487	320
Halswell R @ Branthwaites	1	3	1	1	2	5	3	Present upstream	3	2.3	2	388	483	
Halswell R @ Ryans	4	5	1	3	4	5		Present locally	4	3.7	4	329	515	350
Halswell @ Tobecks	4	5	2	1	1	5	3	-	4	3.0	3	488	631	450
Halswell R @ Neills	3	3	1	1	1	5		-	3	2.3	2	516	636	510
LII River @ Moirs	2	1	1	2	3	5	1	-	1	2.1	2		200	200
LII River @ Pannetts	5	5	1	3	3	5	3	Absent	5	3.6	3	897	1824	1000
Bailey's Ck @ Lincoln-Leeston Rd	1	3	1	1	1		3	1		1.7	1	3	14	40
McGraths Ck @ Lincoln-Leeston Rd	1	2	1	1	1	3	4	Not ranked	4	1.9	1	13	46	40
Snakes Ck @ Lincoln-Leeston Rd	1	2		1	1			Present	1	1.3	1	36	55	55
Silverstream Ck @ Lincoln-Leeston Rd	2	1	1	3	3	5	3	Present	1	2.6	3	26	90	90
Silverstream @ Selwyn R Confl.	2	3	1	3	3	5	5	Present	1	3.1	3	38	150	150
Selwyn R@Coes Ford	4	4	1	4	3	5	5	Present	4	3.7	4	177	749	700
Miles Dr @ Pannetts Rd	1	3	1	1	1	1	1	Not ranked	1	1.3	1	1	37	30
Kaituna River	1	3	2	4	1	5	5	Not present	2	3.0	3	34	32	60
Prices Stream	1	3	2	3	3	5	1	Present	1	2.6	3	19	22	40
Birdlings Brook @ Locheads Rd	3	5	2	4	4	3	5	1		3.7	4	171	345	200
Harts Creek @ Timberyard Road	5	5	3	4	5	5	5	Present		4.6	5	1120	1282	1000
Parkin Drain @ Taumutu Rd	1	2	1	1	1	5	3	Present downstream		2.0	1	19	45	
Waikekewai Creek @ Marae	1	5	3	3	4	5	5	Present upstream		3.7	4	37	89	
Taumutu Creek @ Beach	5	5	3	3	3	5	5	Present upstream		4.1	5	95	109	
Lee River @ Brooklands	5	5	4	5	4	5	5	Present upstream		4.7	5	2151	2061	1700
Tentburn @ Beachcroft	3	3	3	3	2	3	3	1		2.9	3	218	324	250
Jollies Brook @ Bullocks Rd	3	5	2	2	3	5	3	Present downstream		3.3	3	295	464	360
All Sites														
Mean	3	4	2	2	3	4	4		3	3	3	315	436	366
Median	3	3	2	3	3	5	3		3	3	3	157	220	200

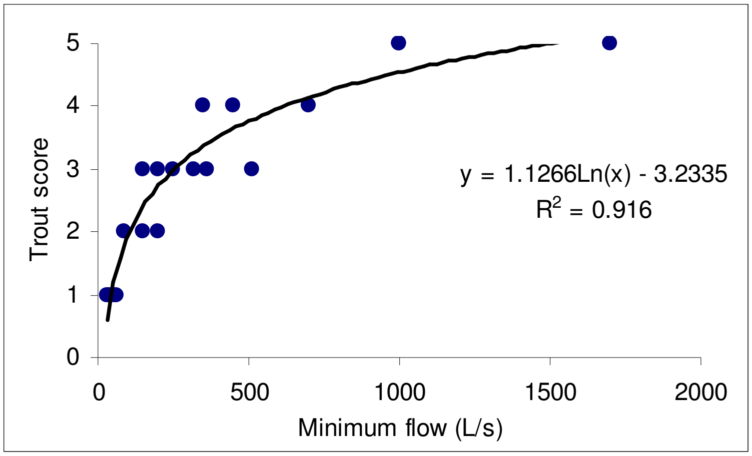


Figure 12: The relationship between Expert Panel trout value scores and recommended minimum flows for lowland streams around Lake Ellesmere.