IN THE MATTER	of the Resource Management Act 1991
A N D	
IN THE MATTER	of the hearing of submissions on Proposed Plan Change 5 (Nutrient Management and Waitaki Sub-region) to the Canterbury Land and Water Regional Plan
BY	**BELLFIELD LAND CO LIMITED**
AND	**GLENTANNER STATION LIMITED**
AND	**HALDON STATION LIMITED**
AND	**MACKENZIE IRRIGATION COMPANY LIMTED**
AND	**KILLERMONT STATION 2012 LIMITED**
AND	**OMARAMA STREAM WATER USERS GROUP**
AND	**TWINBURN LIMITED**
	Submitters
TO	**CANTERBURY REGIONAL COUNCIL**
	Local authority

STATEMENT OF EVIDENCE OF GREGORY IAN RYDER

Introduction

1. My full name is Gregory Ian Ryder.

2. I hold BSc. (First Class Honours) (1984) and PhD. (1989) degrees in Zoology from the University of Otago. For both my honours dissertation and PhD. thesis I studied stream ecology with particular emphasis on sediment and benthic invertebrates.

3. I am a member of the following professional societies:

   (a) New Zealand Freshwater Society;

   (b) New Zealand Water and Wastes Association;

   (c) Royal Society of New Zealand;

   (d) Society for Freshwater Science (North America).

4. I am an Environmental Scientist at Ryder Consulting Limited, a company I established over 20

years ago. Prior to this, I held positions at the Otago Regional Council and the University of Otago. I work largely in the field of water quality and aquatic ecology. I have undertaken or been associated with a large number of investigations that have assessed the effects of discharges of nutrients and other contaminants on surface water ecosystems, including land use activities that produce point source and non-point source discharges. A large number of these investigations have assessed ecological responses including effects on algae and plants, benthic invertebrates and fish.

5. My work covers the whole of New Zealand, but primarily in the South Island. Private industries, utility companies, local and regional councils and government departments engage me to provide advice on a wide range of issues affecting surface waters. I have previously provided advice relating to existing and proposed irrigation schemes.

6. I presented evidence at Environment Canterbury's proposed Land and Water Regional Plan hearing and the hearings on Variation 1 (Selwyn/Te Waihora), Variation 2 (Hinds/Hekeao Plains) and Variation 3 (South Canterbury Coast Sub-regional area) to that plan.

7. Although this is a Council hearing, I have read the Expert Witness Code of Conduct set out in the Environment Court's Practice Note 2014. I have complied with the Code of Conduct in preparing this evidence and I agree to comply with it while giving oral evidence before the hearing committee. Except where I state that I am relying on the evidence of another person, this written evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this evidence.

Scope of evidence

8. This evidence is presented on behalf of a group of upper Waitaki catchment farmers who have sought my advice on the relationships between:

   (a) the freshwater outcomes specified in tables 15B(a) for upper Waitaki rivers and 15B(b) for upper Waitaki lakes;

   (b) the water quality limits specified for in tables 15B(c) for upper Waitaki rivers and 15B(d) for upper Waitaki lakes;

   (c) the existing water quality status of upper Waitaki rivers and lakes with respect to the above PC5 tables; and

   (d) river and lake water quality triggers specified in conditions on existing resource consents for irrigation held by upper Waitaki farmers.

   (e) the appropriateness of the limits/targets in Table 15(c) for surface water and the linkage between these and water quality outcomes;

9. In preparing this evidence, I have assessed water quality monitoring collected by both Environment Canterbury and on behalf of the farmers who are required to collect this information as a part of their resource consent conditions. I comment on this process further on in my evidence.

10. In preparing my evidence I have read sections of proposed Plan Change 5 (PC5) to the Land and Water Regional Plan (**LWRP**) and the submissions of various parties. I have also reviewed technical information relating to PC5, including Environment Canterbury's technical overview

(Shaw & Palmer 2015[1]) report. I have also viewed a number of Environment Canterbury documents relating to the upper Waitaki Zone Committee and PC5.

11. I have also read relevant parts of the Officers section 42A report prepared by Christensen *et al*. (2016).

General comments on freshwater outcomes and water quality limits in PC5

15B.6 Freshwater Outcomes

12. As for all rivers in Canterbury (Table 15B(a)), rivers in the Upper Waitaki catchment have been classified into freshwater management units; Alpine-upland, Hill-fed upland, Hill-fed lower, Lake-fed, Spring-fed upland and Natural state. Each classification is assigned various freshwater outcomes that include a range of ecological, water quality and cultural 'attributes', most of which are based on various guidelines that are generally well recognized and accepted, although there is some degree of subjectiveness associated with how these are apportioned between the various classifications.

13. Similarly for lakes (Table 15B(b)), these have been classified into lake 'types' and each type has been assigned various ecological, water quality and cultural attribute states. Again, there is some degree of subjectiveness associated with how attributes have been assigned to the various lake types. It is my understanding that these have been derived through recommendations from Environment Canterbury staff and advisors along with processes associated with the Zone Implementation Committee.

14. The farmers I am presenting this evidence on behalf of have irrigation consents for land that drains into either the Ahuriri Arm of Lake Benmore or the Haldon Arm of lake Benmore. These two arms of the lake are separated out in Table 15B(b) with respect to the 'TLI' which is a lake water quality indicator of the degree of eutrophication. I will comment on this index later in my evidence as it relates to irrigation consent conditions. Tables 15B(a) and 15B(b) largely mirror Table 1a of the LWRP and those found in various sub-sections of the plan relating to regional zones. The freshwater outcomes are to be maintained where the outcomes are already met, or achieved by 2030 where they are not currently met. Where existing water quality is better than the outcome, the outcome is to maintain that water quality.

15B.7 Water Quality Limits

15. Table 15B(c) relates to water quality limits for rivers, while Table 15B(d) relates to water quality limits for lakes. The table for rivers list concentration limits for dissolved reactive phosphorus (DRP), nitrate-nitrogen (NO_3-N) and ammoniacal nitrogen (NH_3-N). All three nutrients have a concentration limit based on an annual median, while NO_3-N also has a 95th percentile limit and NH_3-N also has an annual maximum limit.

16. Like Table 15B(a), rivers in Table 15B(c) are grouped into freshwater management units, however specific measurement locations are identified for particular streams and rivers. Also, streams and rivers that fall within the same freshwater management unit may have different water quality limits for the three water quality variables. Not all rivers and streams in the catchment are identified in this table and it is my understanding that only streams in which Environment Canterbury conduct monitoring are included.

[1] Shaw, H. and Palmer, K. 2015. Waitaki Limit Setting Process: Technical Overview. Report No. R15/99.

17. Table 15B(d) for lakes list concentration limits for total phosphorus (TP), total nitrogen (TN), ammoniacal nitrogen, chlorophyll *a* (an indicator of phytoplankton biomass) and a TLI limit as an indicator of eutrophication state. TN, TP and NO_3-N have a concentration limit based on the annual median, while NH_3-N also has an annual maximum limit. Chlorophyll *a* also has annual median and annual maximum limits, while the TLI limit is an maximum annual average.

18. I also note that for Lake Benmore, three measurement locations are specified: Ahuriri Arm (map reference[2] NZMG 2280270 5626670), Haldon Arm (map reference NZMG 2288092 5636130) and Lake Benmore at Dam (map reference NZMG 2287977 5623571).

19. My understanding of the relationship between tables 15B(a), 15B(b), 15B(c) and 15B(d), and PC5 policies and rules, is presented below.

15B.4 Policies - Upper Waitaki Freshwater Management Unit

20. Under **Tangata Whenua**, Policy 15B.4.1 states: "*Freshwater quality in the Waitaki Sub-region is managed to support the exercise of customary uses and to achieve the tangata whenua freshwater outcomes described in Tables 15B(a) and 15B(b)*".

21. Under **Fresh Water Management Units**, Policy 15B.4.5 states: "*Management of freshwater quality in the Waitaki Sub-region is achieved through the establishment of four Freshwater Management Units and the setting of water quality limits for each of those areas*".

22. Under **Nutrient Management** and **Consenting Considerations**, Policy 15B.4.16 states: "*Within the Waitaki Sub-region, resource consents granted for the use of land for farming activities and the associated discharge of nutrients are restricted to a term of no more than 15 years and include conditions that enable a review of the resource consent under section 128(1)(a) of the RMA where an exceedance of the limits in Tables 15B(c), 15B(d) and 15B(e) is identified*".

23. Policy 15B.4.20 states: "*Freshwater quality is maintained in the Upper Waitaki Freshwater Management Unit by:*

24. *(d) applying to any resource consent granted for the use of land for a farming activity, or any permit granted for a discharge associated with an aquaculture operation or community wastewater activity, adaptive management conditions in accordance with the water quality limits set out in Tables 15B(c),15B(d) and 15B(e).*"

15B.5 Rules - Upper Waitaki Freshwater Management Unit

25. Clause 15B.5.10 states: "*The use of land for a farming activity on a property that forms part of a Nutrient User Group is a discretionary activity, provided the following conditions are met:*

3. The nitrogen loss calculation for the Nutrient User Group does not cause the relevant limits set out in Tables 15B(c), 15B(d), 15B(e) and 15B(f) to be exceeded"

26. Thus, it appears from my reading of this text is that the concentration and biomass levels specified in Table 15B(c) are clearly being treated as limits.

[2] Note that while map coordinates are specified in Table 15B(c) and Table 15B(d) the actual map coordinate system is missing (e.g., NZTM vs NZMG).

Farm Irrigation consents and water quality limits and triggers

27. The farmers I am presenting evidence on behalf of all have resource consents that contain conditions relating to water quality triggers for local streams and rivers, and also for Lake Benmore.

28. These conditions generally comprise of:

    (a) A condition requiring the consent holder to monitor stream water quality upstream and downstream of irrigated land. This condition typically specifies monitoring locations, water quality parameters to be assessed and the frequency of monitoring, among other requirements.

    (b) A trigger condition that specifies concentration limits in local streams that, once exceeded, trigger a requirement to investigate the cause of the exceedance and, potentially, a requirement to undertake measures to reduce nutrient discharges from the farm in order to become compliant with the trigger. In all instances, the triggers relating to stream nutrient concentrations and chlorophyll *a* biomass are based on an average monthly concentration over the period December to April in any given year. The nutrients specified are DRP and DIN (i.e., dissolved inorganic nitrogen which is the sum of nitrate-nitrogen and ammoniacal nitrogen).

    (c) A condition requiring the consent holder to monitor Lake Benmore water quality for nutrients and chlorophyll *a*. Depending on which catchment the farm is located in, The monitoring will be either in Ahuriri Arm and at the Benmore Dam site, or the Haldon Arm and the Benmore Dam site.

    (d) A trigger condition that specifies a lake TLI limit that, once exceeded at either of the two lake monitoring sites, triggers a requirement to undertake measures to reduce nutrient discharges from the farm in order to become compliant with the TLI trigger. In all instances, the trigger relating to the TLI is based on average of monthly readings over the period December to April in any given year.

29. From what I have been able to determine from the consents I have viewed, and the map references in tables 15B(c) and 15B(d) of PC5, the PC5 lake monitoring sites generally coincide with those specified on the resource consents (except in for Grays Hill Station and Haldon Station in the Haldon Arm catchment, which both differ by about 1 km from the PC5 specified site for the Haldon Arm). However, the stream monitoring sites specified in consent conditions can differ from the stream monitoring sites in Table 15B(c) of PC5. This is not unexpected given the consents are site specific with respect to stream water quality. However, it does raise issues with respect to inconsistencies between the proposed water quality limits of PC5 and water quality triggers (which are effectively limits) specified under individual resource consents, which I address below.

Inconsistencies between water quality triggers on consents, PC5 freshwater outcomes, and PC5 water quality limits

30. Table 1 (at the back of my evidence) of my evidence attempts to summarise key aspects of resource consent conditions relating to water quality conditions and compares these with numerical freshwater outcomes and water quality limits in PC5.

31. The table identifies several inconsistencies which in my opinion will make life difficult for both the consent holders and Environment Canterbury with respect to interpreting consent compliance and meeting plan policies and outcomes.

32. Firstly, for the consents I have viewed, triggers for nutrient concentrations in streams and rivers are based on an average concentration of monthly sampling between December and April (i.e., over a typical summer period of 5 months). Water quality limits for comparable streams in Table 15B(c) of PC5 are based on median concentrations over a 12-month period and, in the case of NO_3-N and NH_3-N, also include a 95th percentile value and an annual maximum value respectively.

33. Secondly, the consents include a trigger condition for DIN (NO_3-N + NH_3-N), but not for NO_3-N or NH_3-N individually. So, in theory, it may be possible to be complying with the DIN trigger specified on a consent but the stream may not be meeting the water quality limits in PC5 with respect to NO_3-N and/or NH_3-N.

34. Thirdly, the DRP trigger on some consents is much higher than the DRP water quality limit for the relevant stream identified in Table 15B(c) of PC5. For example, Quail Burn consents have a DRP trigger of 0.007 mg/L, but Table 15B(c) has a DRP limit of 0.003 mg/L. The Mary Burn consent in my Table 1 has a DRP trigger of 0.007 mg/L while Table 15B(c) has a DRP limit for the Mary Burn of 0.002 mg/L or 0.003 mg/L depending on what section of the river is at issue. There are similar, but less frequent discrepancies for stream chlorophyll *a* and, although direct comparisons with consent DIN triggers and Table 15B(c) limits for NO_3-N and NH_3-N are not possible, simple maths suggests a number of discrepancies are also likely.

35. Fourthly, all consents I have viewed have lake TLI triggers of >2.75 for both the Ahuriri and Haldon arms of Lake Benmore, and the Benmore Dam site. This trigger is higher than the TLI limit of 2.7 for the Haldon Arm and Benmore Dam sites in Table 15B(d) of PC5 (both 2.7), and less than the limit for the Ahuriri Arm (2.9). I note, however, that there is consistency between the TLI values for freshwater outcomes and water quality limits in tables 15B(b) and 15B(d) respectively.

Table 15B(a) - Freshwater Outcomes for Waitaki Rivers to be achieved by 2030

36. I am in general agreement with the basis for Table 15B(a). It does not differ greatly from Table 1a of the LWRP (Freshwater Outcomes for Canterbury Rivers), which I have previously presented evidence on largely in support of its general approach. Previously at other hearings, I have expressed some concerns about the wording of some of the attributes within this table, and have recommend some changes be made. Not all of these appear to have been adopted in Table 15B(a), so at the risk of sounding like a stuck record, I have repeated some of these concerns below.

37. For 'Human Health for Recreation Attributes' in Table 15B(a), under the sub-heading row relating to cyanobacteria cover, 'Cyanobacteria mat cover' should be accompanied by a minimum level of mat thickness or height to bring the outcome in line with wording used in the Ministry for the Environment's New Zealand periphyton guidelines (Biggs 2000[3]), and as has already been used for the filamentous algae cover attribute in Table 15B(a). As it is currently worded, there is no clarification of what thickness of cyanobacteria mat the outcome refers to and, consequently, the presence of between 20 and 50% cover (depending on the river management unit) of even a very thin cyanobacteria mat (e.g. < 1mm) could be taken to mean the outcome has not been meet. I find this approach to be overly restrictive.

38. I note that the joint MfE and MoH guidelines document "New Zealand Guidelines for

[3] Biggs, B.J.F. 2000. *New Zealand periphyton guideline: detecting, monitoring and managing enrichment of streams.* Ministry for the Environment, Wellington, New Zealand.

Cyanobacteria in Recreational Fresh Waters" (Wood *et al*. 2009[4]) states that cover should only be recorded if mats are greater than 1 mm thick. I recommend, therefore, that the sub-heading should read "Cyanobacteria mat >1mm (%)", to be consistent with these guidelines and standard monitoring procedures. There is also a lack of clarification regarding the percentage of samples that are required to meet the cyanobacteria outcome.

39. The heading row in relation to QMCI (under 'Ecological Health Attributes') states 'min score', but does not specify over what period of time or frequency of monitoring this relates to. The equivalent table in PC3 included the sub-heading "min. 80% of samples in 5 year period". This wording is consistent with that found in Variation 1 and I recommend it be included in table 15B(a).

Appropriateness of the Table 15B(c) water quality limits for Waitaki rivers

40. As already discussed, Table 15B(c) contains nutrient concentration 'limits' for a number of specified streams. The Upper Waitaki freshwater management unit is divided into three river types (Alpine upland, Hill-fed upland, Lake-fed, and Spring-fed upland).

41. It is my understanding from reviewing Environment Canterbury supporting technical documents (Shaw & Palmer 2015), that the intent of the limits for phosphorus, ammonia and nitrate-nitrogen is to control the growth of plants and algae in streams in order to meet outcomes relating to stream health, as identified in Table 15B(a). In my opinion, some of these limits, particularly DRP, are very restrictive and unlikely to be met regardless of current or future farming practices permitted under PC5. Further, these limits are arguably unnecessary to met the outcomes identified in Table 15B(a), and some farm monitoring data appears to support this argument.

42. For example, Quailburn Downs has four monitoring sites associated with its irrigation consent: two on the Quailburn and two on the Henburn. Farm monitoring data spans the period December 2010 to April 2016. Data for recent years is collected monthly over the summer months (December to April but sometimes November also) and coincides with the commencement of quantitative chlorophyll *a* monitoring.

43. Table 15B(c) has a DRP limit of 0.003 mg/L (calculated as an annual median) for Quailburn and 0.004 mg/L for the Henburn. Figure 1 below indicates that DRP concentrations at all fours sites exceed both DRP limits. DRP annual median concentrations at the Henburn upstream monitoring site range between 0.004 and 0.008 mg/L. The overall median concentration over the monitoring period is 0.0065 mg/L. At the downstream site, the annual median concentrations also vary between this range, with an overall median of 0.006 mg/L.

[4] Ministry for the Environment and Ministry of Health. 2009. *New Zealand Guidelines for Managing Cyanobacteria in Recreational Fresh Waters – Interim guidelines*. Prepared for the Ministry for the Environment and the Ministry of Health by S.A. Wood, D.P. Hamilton, W.J. Paul, K.A. Safi, W.M. Williamson. Wellington: Ministry for the Environment. 89 p.

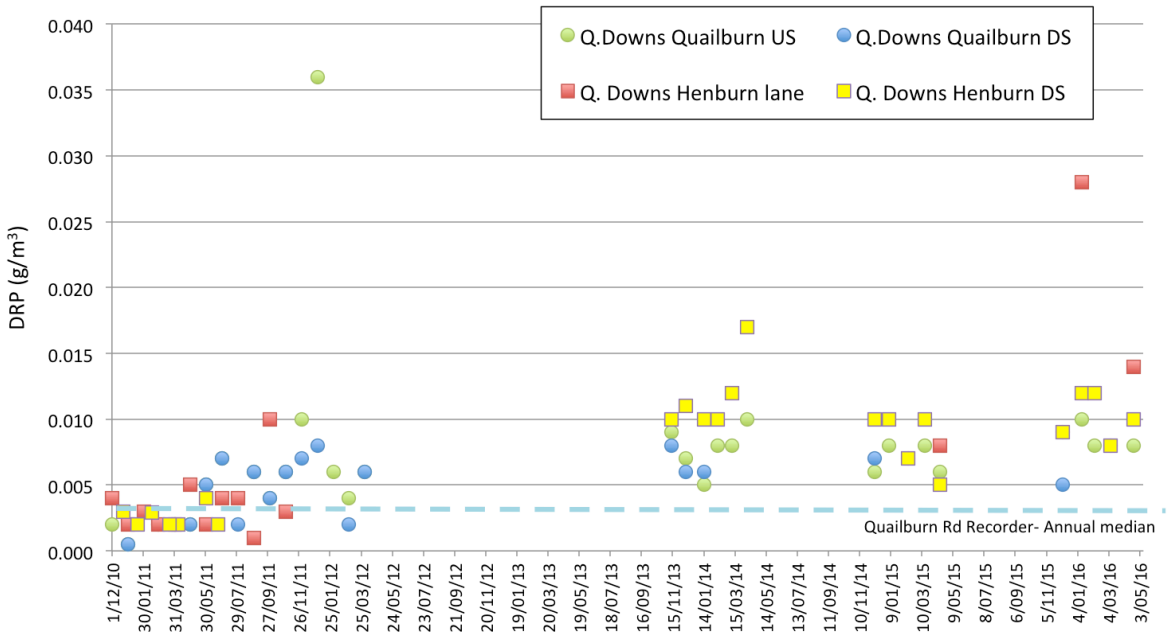

Figure 1. Quailburn and Henburn farm monitoring data for DRP concentration (data supplied by Irricon).

44. Table 15B(c) has a NO_3-N limit of 0.044 mg/L (calculated as an annual median) and a 95th percentile of 0.231 mg/L for the Quailburn. NO_3-N annual median concentrations at the upstream monitoring site have been consistently at 0.005 mg/L. The overall median concentration over the monitoring period is 0.005 mg/L. At the downstream site, the annual median concentrations have also been consistently at 0.005 mg/L although one reading of 0.011 mg/L was recorded in December 2015. So water quality limits for NO_3-N are being met.

45. Table 15B(c) has an NH_3-N limit of 0.005 mg/L (calculated as an annual median) and an annual maximum of 0.017 mg/L for the Quailburn. Ammonia-N annual median concentrations at the Quailburn upstream monitoring site have ranged between 0.005 and 0.017 mg/L. The overall median concentration over the monitoring period is 0.005 mg/L. At the downstream site, the annual median concentrations have ranged between 0.001 and 0.003 mg/L. The highest concentration recorded was 0.059 mg/L in May 2011. So it appears that water quality limits for NH_3-N are being met on some but not all occasions.

46. In summary, the DRP concentration limit in Table 15B(c) is not currently being met at Quailburn and Henburn monitoring sites, nor the Environment Canterbury Quailburn monitoring site. The nitrate-nitrogen limit appears to be met as does the annual concentration limit for ammonia-nitrogen, but the 95 percentile limit is possibly not being met. The NH_3-N annual concentration limit appears to be met but the 95th percentile limit is possibly not being met.

47. Another example is the Omarama Stream catchment, which has multiple consent holders and multiple monitoring sites. Table 15B(c) has an annual median DRP limit of 0.006 mg/L for Omarama Stream (at SH8). The DRP and DIN trigger levels on resource consents are 0.005 and 0.08 mg/L respectively (calculated as average values over the 5 month period December-April). Figure 2 below shows that DRP concentrations at all monitoring sites frequently exceed the Table 15B(c) DRP limit (0.006) and the consent trigger value (0.005). Of concern is that the two monitoring sites upstream of all irrigation (including one in DOC hill country) are

already at or just above the DRP trigger, and so it may be almost impossible to meet consent and plan limits further downstream. Despite this situation, and in spite of much higher DRP concentrations downstream on occasions, it appears from my reading of the monitoring data that downstream periphyton biomass (measured as chlorophyll *a*) is typically well below the consent trigger value of 50 mg/m^2 which is also the freshwater outcome attribute for this stream under Table 15B(a). This suggests to me that the water quality limits may be inappropriate for the specified freshwater outcomes.

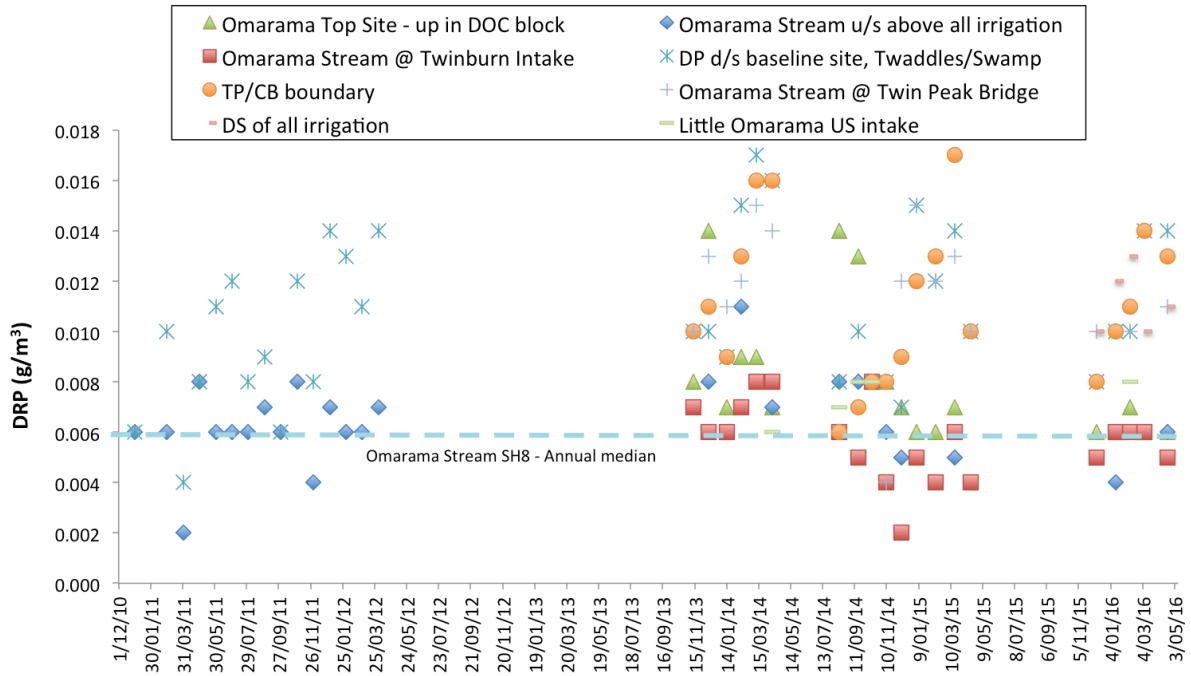

Figure 2. Omarama catchment monitoring data for DRP concentration (data supplied by Irricon).

48. As a general comment, the ammonia concentration limits in Table 15B(c) have nothing to do with ammonia toxicity and as stated in the supporting documents, are based on existing state. It is my opinion that the current ammonia limits are meaningless in terms of ecosystem protection. Specifying ammonia limits is in my opinion only relevant if ammonia toxicity limits are desired. While it is my experience that the risk of toxicity effects resulting from the types of farming practices permitted under PC5 is highly unlikely, if ammonia toxicity limits are necessary, then the commonly accepted guidelines indicate that the limits required for ecosystem protection are orders of magnitude higher than the concentrations specified in Table 15B(c).

49. While I understand that the nutrient concentration limits for rivers in Table 15B(c) are to control the growth of plants and algae in streams in order to meet outcomes relating to stream health, they do not appear to be related to any particular relationships between nutrient levels and plant biomass such as found in the New Zealand periphyton guidelines.

50. I recommend that ammonia be combined with nitrate and nitrite to become one limit (DIN), which would be used as a check for protection against nuisance algae and plant growth. I also recommend that DIN limits be applied as per the approach outlined in the New Zealand periphyton guidelines, which consider both nutrient concentrations and accrual period for biomass. The approach should also consider the concentrations required to meet the

freshwater outcome attributes for periphyton identified in Table 15B(a).

Appropriateness of the Table 15B(d) water quality limits for lakes in the Upper Waitaki Freshwater Management Unit

51. As I have already indicated, there is a discrepancy between lake TLI triggers on all resource consent that I have viewed and the TLI limits specified in Table 15B(d). While the differences appear to be relatively minor, in my opinion it is important that it be considered and addressed so as to avoid uncertainty in terms of consent compliance.

52. Lake Benmore water quality has been monitored regularly by Environment Canterbury since about 2006. Particular interest has centred around nutrient and chlorophyll concentrations and turbidity. Significant increases in the nutrient concentration of lake waters will usually result in increased growth of phytoplankton (algae that suspends in the water column), which affects both ecological and recreational values.

53. Lake water quality is commonly classified by their trophic (degree of enrichment) status[5]. The trophic characteristics of most New Zealand lake types are summarized in Table 2. The trophic status of lakes in Canterbury and elsewhere in NZ is measured by the Trophic Level Index (or TLI for short). The TLI uses equations that use the annual average values of four key water quality variables (Chlorophyll *a* which is an indicator for the concentration of phytoplankton in the water column, water clarity as determined by the Secchi depth method, Total Phosphorus concentration and Total Nitrogen concentration). TLIs can range between 0.0 and 7.0 (Table 3).

Table 2. *Trophic Characteristics of Lake types proposed by Burns* et. al *(1999)*[6].

Parameter	Trophic Status of Lakes			
	Microtrophic	**Oligotrophic**	**Mesotrophic**	**Eutrophic**
Water clarity	Clear Visually appealing	Clear Visually appealing	Clear tending green (variable appeal	Turbid green visually unappealing
Visual phytoplankton	No risk of green colour	Very low risk of green colour	Moderate risk	High risk of sustained phytoplankton blooms
Periphyton on bed & margins	Low moderate	Low moderate	Moderate	Low moderate
Macrophyte beds	Healthy	Healthy	Increased Stress. Potential shift to phytoplankton dominated system	High risk of collapse. Likely phytoplankton dominated system
Toxic algal blooms	No risk	No risk	Some risk	High risk
Invertebrate & fish communities	Healthy	Healthy	Increased productivity	Shifts in composition
Biodiversity value	High	High	Good	Compromised
Contact recreation value	Very High	High	Good	Poor
Amenity value	Very High	High	Good	Poor
Nuisance growths to hydro-generation	Very low risk	Low risk	Moderate risk	High risk

[5] Lakes are classified according to their trophic state. "Trophic" means nutrition or growth. A eutrophic ("well-nourished") lake has high nutrients and high plant growth. An oligotrophic lake has low nutrient concentrations and low plant growth which is typically a desirable water quality state. Mesotrophic lakes fall somewhere in between eutrophic and oligotrophic lakes.

[6] Burns, N. M., Rutherford, J. C., Clayton, J. S., 1999. A monitoring and classification system for New Zealand lakes and reservoirs. Journal of Lakes Research & Management 15(4): 255-271.

Table 3. *Indicators of lake trophic level using the TLI method (Burns* et al.*, 1999).*

Lake type	Trophic level (TLI)	Chlorophyll *a* (mg/m^3)	Secchi depth (m)	Total Phosphorus (mg/m^3)	Total Nitrogen (mg/m^3)
Microtrophic	< 2.0	< 0.82	> 15	< 4.1	< 73
Oligotrophic	2.0 – 3.0	0.82 – 2.0	15 – 7.0	4.1 – 9.0	73 – 157
Mesotrophic	3.0 – 4.0	2.0 – 5.0	7.0 – 2.8	9.0 – 20	157-357
Eutrophic	4.0 – 5.0	5.0 – 12	2.8 -1.1	20 – 43	337-725
Supertrophic	5.0 – 6.0	12 – 31	1.1 – 0.4	43 – 96	725 – 1558
Hypertrophic	6.0 – 7.0	> 31	< 0.4	> 96	>1558

54. Environment Canterbury monitoring shows that TLI values of the northern arm of Lake Benmore vary both in space and in time, but have typically remained below the lower boundary of the Oligotrophic range (Figure 1). I note that, at the 2009-2011 Environment Canterbury hearings on upper Waitaki irrigation consent applications, all parties to the hearing agreed that the TLI threshold (if there was to be a threshold) for Lake Benmore (both Haldon and Ahuriri arms) should be set below the oligotrophic-mesotrophic boundary. Currently, this threshold appears to be easily met for the Haldon Arm and at Benmore Dam, and also in the Ahuriri Arm for the past three years.

55. The difference between the TLI trigger of 2.75 specified of resource consents for irrigation and the 2.7 specified for the Haldon Arm in Table 15B(d) is within the margin of error associated with TLI calculations and in my opinion does not represent a meaningful change in the water quality status of the lake. Further, Environment Canterbury data indicates that monthly variations in the TLI of Lake Benmore can vary by considerably more than the difference between 2.75 and 2.9.

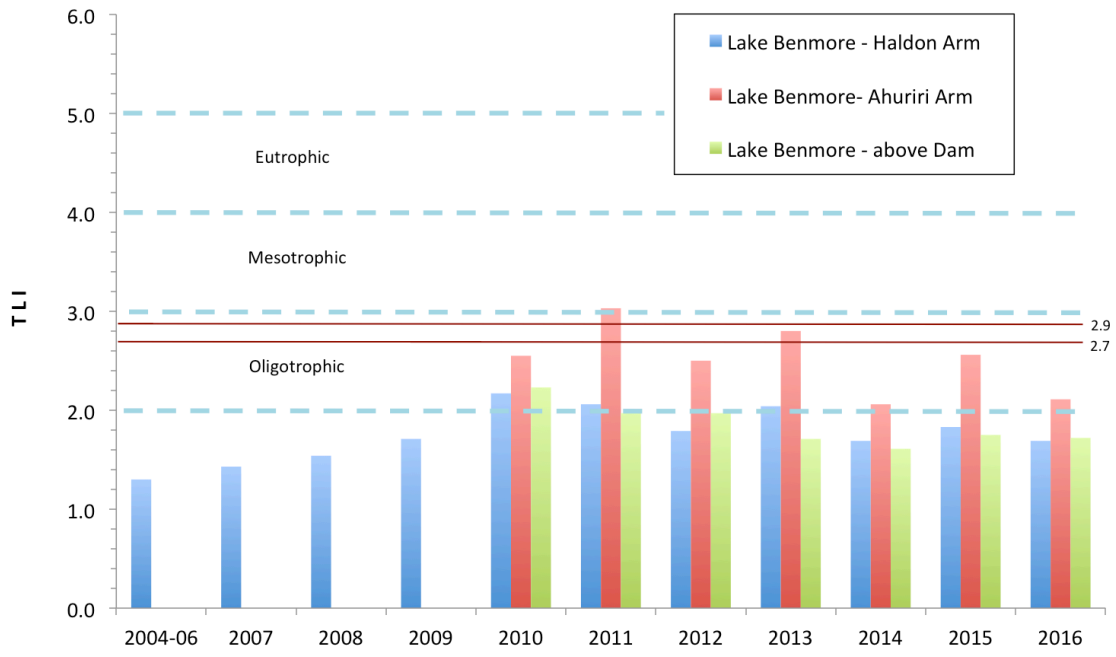

Figure 2. *Summary of annual average TLI values for Lake Benmore at three Environment Canterbury monitoring sites based on calculations using TN, TP and chlorophyll a monitoring data. The two black horizontal lines indicate TLI values in Table 15B(d) for Ahuriri and Haldon arms (monitoring data courtesy of Environment Canterbury).*

Conclusion

56. I recommend the following changes to sections 15B.6 and 15B.7 of PC5:

(a) Amendments to Table 15B(a) as per my comments in paragraphs 37 and 38 (cyanobacteria mat cover) and paragraph 39 (invertebrate QMCI scores).

(b) Remove the ammoniacal-nitrogen and nitrate-nitrogen limits in Table 15B(c) and replace these with a dissolved inorganic nitrogen limit. This at least would provide some consistency between the plan water quality limits and water quality triggers specified in resource consents.

(c) The DRP limits in Table 15B(c) for streams and rivers are in some cases extremely conservative and unlikely to be met currently or in the future, given background levels. They are also in many instances inconsistent with DRP trigger values specified on resource consents, creating uncertainty in interpreting compliance and in determing what is the appropriate nutrient limit for individual streams and rivers. I suggest that some provision be made that acknowledges these inconsistencies and enables the higher limit or trigger to apply for existing consent holders.

(d) Increase the TLI limits in Table 15B(d) for the Lake Benmore Haldon Arm and Lake Benmore at Dam sites from 2.7 to 2.75 to keep these in line with triggers on existing resource consents.

Gregory Ian Ryder

22 July 2016

Table 1. Comparison of triggers values on Upper Waitaki resource consents with freshwater outcome attributes values in tables 15B(a) and 15B(b) and water quality limits in tables 15B(c) and 15B(d) of PC5.

CONSENT CONDITIONS											PC5 – FRESHWATER OUTCOME VALUES AND WATER QUALITY LIMITS					
						Stream Triggers				Lake Triggers	Freshwater Outcomes		Water Quality Limits			
Catchment	**Consent holder/Site**	**Stream/River**	**River type**	**Consent No.**	**Commence Date**	**Trigger criteria For DRP, DIN and Chloro *a***	**DIN trigger** (mg/L)	**DRP trigger** (mg/L)	**Chloro *a* trigger** mg/m^2	**TLI** Monthly Dec-Apr Average summer TLI 1-10m depth integrated in **either Ahuriri Arm or Lower Lake Benmore** is greater than (but does not exceed)	**Table 15B(a)** **Stream Chloro *a*** (mg/m^2)	**Table 15B(b)** **Lake TLI (max. annual average)**	**Table 15B(d)** **Lake TLI (max. annual average)**	**Table 15B(c)** **Stream DRP (annual median)** (mg/L)	**Table 15B(c)** **Stream NO_3-N (annual median, 95th percentile)** (mg/L)	**Table 15B(c)** **Stream NH_3-N (annual median, annual maximum)** (mg/L)
Ahuriri Arm	Bellfield Land Company Limited Map reference: the Quailburn Stream inflowing water upstream of the confluence with the Ahuriri River (downstream of the irrigation area)	Quail Burn	Spring-fed upland	CRC132204	20 Jul 2015	Average sample over Dec-Apr period at D/S site is greater than (but does not exceed)	> 0.10 (0.18)	> 0.007 (0.007)	> 50 (90)	> 2.75 (3.0)	50	2.9 (Ahuriri) 2.7 (Lake Benmore at Dam)	2.9 (Ahuriri) 2.7 (Lake Benmore at Dam)	0.003	0.044 (0.231)	0.005 (0.017)
Ahuriri Arm	Bellfield Land Company Limited Map reference: NZMS 260 H39: 626-337 downstream of the discharge	Hen Burn	Spring-fed upland	CRC071649	11 May 2015	Average sample over Dec-Apr period at D/S site is greater than (but does not exceed)	> 0.10 (0.18)	> 0.007 (0.007)	> 50 (90)	> 2.75 (3.0)	50	2.9 (Ahuriri) 2.7 (Lake Benmore at Dam)	2.9 (Ahuriri) 2.7 (Lake Benmore at Dam)	0.004	0.244 (0.428)	0.010 (0.023)
Ahuriri Arm	Dannie William McAughtrie Map reference: NZMS 260 H39:691-343 downstream of the discharge Willowburn Stream at Quailburn Road Bridge.	Willow Burn	Spring-fed upland	CRC011940	27 Nov 2014	Average sample over Dec-Apr period at D/S site is greater than (but does not exceed)	> 0.14 (0.18)	> 0.006 (0.007)	> 90 (120)	> 2.75 (3.0)	50	2.9 (Ahuriri) 2.7 (Lake Benmore at Dam)	2.9 (Ahuriri) 2.7 (Lake Benmore at Dam)	0.01	0.648 (1.047)	0.016 (0.037)
Ahuriri Arm	Twinburn Station Map reference: NZMS 260 H40614-193 and H39: 606-246 downstream of the discharge.	Omarama Stream	Spring-fed upland (?)	CRC167125	5 May 2016	Average sample over Dec-Apr period at either of the 2 D/S sites is greater than (but does not exceed)	> 0.08 (0.18)	> 0.005 (0.007)	> 50 (90)	> 2.75 (3.0)	200	2.9 (Ahuriri) 2.7 (Lake Benmore at Dam)	2.9 (Ahuriri) 2.7 (Lake Benmore at Dam)	0.006	0.195 (0.532)	0.005 (0.021)
Haldon Arm	Classic Properties Limited At or about Map reference: NZMS 260 I38:969-644 downstream of the irrigation area on the Irishman Creek, before the confluence with Maryburn Stream as identified on the attached Plan CRC063106C; and	Irishman Creek	Spring-fed upland	CRC168521	25 June 2016	Average sample over Dec-Apr period at D/S site is greater than	> 0.21	> 0.006	> 50	> 2.75 (3.0)	50	2.7 (Haldon) 2.7 (Lake Benmore at Dam)	2.7 (Haldon) 2.7 (Lake Benmore at Dam)	0.002	0.013 (0.059)	0.005 (0.016)

	At or about Map reference: NZMS 260 I38: 98910-69515 at the Canterbury Regional Council bore I38/0086 as identified on the attached Plan CRC063106C.															
Haldon Arm	Classic Properties Limited Map reference: NZMS 260 H39:968-623 downstream of irrigation on Maryburn Station	Mary Burn	Spring-fed upland	CRC070406	14 May 2012	Average sample over Dec-Apr period at D/S site is greater than	> 0.10	> 0.007	> 50	> 2.75 (3.0)	50	2.7 (Haldon) 2.7 (Lake Benmore at Dam)	2.7 (Haldon) 2.7 (Lake Benmore at Dam)	0.002	0.022 (0.108)	0.007 (0.049)
Haldon Arm	Grays Hills Station Limited Map reference: NZMS 260 I38:033-602 downstream of the discharge	Grays River	Hill-fed upland	CRC042661	8 Dec 2014	Average sample over Dec-Apr period at D/S site is greater than	> 0.21	> 0.006	> 50	> 2.75 (3.0)	50	2.7 (Haldon) 2.7 (Lake Benmore at Dam)	2.7 (Haldon) 2.7 (Lake Benmore at Dam)	0.005	0.079 (0.230)	0.010 (0.055)
Haldon Arm	Haldon Station Limited Map reference: I39:9090-4510 downstream of the discharge at the Hinch Bend minimum flow monitoring site.	Stony River	Hill-fed upland	CRC144880	26 March 2014	Average sample over Dec-Apr period at D/S site is greater than	> 0.21	> 0.006	> 50	> 2.75 (3.0)	50	2.7 (Haldon) 2.7 (Lake Benmore at Dam)	2.7 (Haldon) 2.7 (Lake Benmore at Dam)	-	-	-