

**Before the Commissioners appointed by Canterbury  
Regional Council**

**IN THE MATTER OF** The Resource Management Act  
1991

**AND**

**IN THE MATTER OF** 60 resource consent applications  
to take and use water for  
agricultural and horticultural  
activities

**Section 42A Officer's Report**

**Date of Hearing: 21 September 2009**

**Report of ADRIAN SELWYN MEREDITH**

**INTRODUCTION**

**Background**

1. This report forms part of Environment Canterbury's audit of the assessment of environmental effects (AEE) provided by the applicants in support of resource consent applications to take and use water in the upper Waitaki catchment for agricultural and horticultural activities.
2. This report will provide the decision-maker with information and advice related to the actual and potential cumulative effects of the proposed activities on water quality. I undertook this audit as an employee of *the Canterbury Regional Council (Environment Canterbury)*, whose role is to audit these applications in relation to cumulative water quality effects.

**Qualifications**

3. I hold the degrees of Bachelor of Science (First Class Honours) in animal physiology (1981) and Doctor of Philosophy in Zoology from the University of Canterbury (1985). I have been employed by the Canterbury Regional Council for over twelve years, firstly as the southern area water quality scientist in Timaru for two years, and more recently as a Christchurch based principal water quality scientist. My areas of responsibility include monitoring, investigations, and technical advice on water quality and ecology of rivers and lakes of the Canterbury Region.
4. Prior to this I was employed for ten years as an environmental scientist in the areas of ecology, fisheries, coastal ecology and water quality by the Waikato Regional Council and its preceding authorities, and for two years as a freshwater fisheries scientist with the Fisheries Research Division of the Ministry of Agriculture and Fisheries. I am a member of the New Zealand Freshwater Sciences Society (formerly the NZ Limnological Society), and the American Fisheries Society.

5. I am familiar with most of Canterbury's rivers and streams having designed, conducted and reported on monitoring and investigation programmes on individual rivers, generically on river types, and on regional trends. I am familiar with the rivers, streams and lakes of the upper Waitaki catchment and Mackenzie Basin, having visited the area on a large number of occasions. I have subsequently scoped, designed, conducted and supervised monitoring programmes throughout the upper Waitaki catchment to establish baseline information on lakes and rivers for a range of council functions. Data from these programmes have also been used by the consultants for the applicants in the applications.
6. I confirm that I have read the Environment Court consolidated practice note dated 31 July 2006 on code of conduct of expert witnesses and have complied with it in the preparation of this evidence. I confirm that this evidence is within my area of expertise and that I have not omitted any material or facts known to me.

### **Scope of Report**

7. This report is prepared under the provisions of section 42A of the Resource Management Act 1991 (RMA). This section allows a Council officer or Council-appointed consultant to provide a report to the decision-makers on a resource consent application made to the Council, and allows the decision-makers to consider the report at the hearing. Section 41(4) of the RMA allows the decision-makers to request and receive from any person who makes a report under section 42A "any information or advice that is relevant and reasonably necessary to determine the application".
8. This report forms part of a suite of section 42A reports prepared by Environment Canterbury for the above consent applications. All reports should be read together to gain a complete understanding of the audit of the resource consent applications. Full details of the consent applications are provided in Report 1.
9. The scope of this report is to cover the following:
  - (a) Consideration of the state, values and effects on rivers and streams, and their entry points into lakes
    - (i) Surface water quality targets and considerations with relation to cumulative effects of all developments, and where necessary consideration of individual application effects.
10. To carry out this audit I have read and considered the following information and reports both received from the applicants, and available and sourced from elsewhere:
  - (a) Cumulative Water Quality Effects of Nutrient from Agricultural Intensification in the Upper Waitaki Catchment – Summary report and appendices. Report prepared on behalf of applications in the upper Waitaki via Mackenzie Water Research Limited (GHD, August 2009).
  - (b) Cumulative Water Quality Effects of Nutrient from Agricultural Intensification in the Upper Waitaki Catchment – Groundwater report. Report prepared on behalf of applications in the upper Waitaki via Mackenzie Water Research Limited (GHD, August 2009).

- (c) Cumulative Water Quality Effects of Nutrient from Agricultural Intensification in the Upper Waitaki Catchment – Rivers and Lakes report. Report prepared on behalf of applications in the upper Waitaki via Mackenzie Water Research Limited (GHD, August 2009).
  - (d) Upper Waitaki Basin – Accumulated Effects of Nutrient Runoff: Selected Stream Survey, April 2008. Report prepared for GHD Ltd on behalf of applicants by Brian T Coffey and Associates Ltd (May 2008).
  - (e) Upper Waitaki Basin – Follow up Stream Surveys to Assess the Effects of Irrigation on Nutrient Runoff: to Waterways, Dated April 2009. Report prepared for GHD Ltd on behalf of applicants by Brian T Coffey and Associates Ltd (Received August 2009).
  - (f) Lake Benmore Water Quality: a modelling method to assist with assessments of nutrient loadings. NIWA, August 2009.
  - (g) Periphyton growth and nutrient limitation in the upper Waitaki catchment. Draft Environment Canterbury Technical Report prepared by Taryn Wilks and Ned Norton.
  - (h) New Zealand Periphyton Guideline: Detecting, Monitoring and Managing Enrichment of Streams. Report prepared for Ministry for the Environment Wellington, by B.J.F. Biggs (NIWA), Christchurch.
  - (i) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000. Report prepared for the Australian and New Zealand Environment and Conservation Council.
11. It should be emphasised that any conclusions reached or recommendations made in this report are not binding on the decision-makers. It should not be assumed that the decision-makers will reach the same conclusion having considered all the evidence to be brought before them at the hearing by the applicant and submitters.
12. In this report I audited four reports or bodies of work received on behalf of the applicants, notably,:
- (a) A GHD Summary Report dated August 2009
  - (b) Appendices to the summary report including raw data (undated)
  - (c) A GHD Lakes and Rivers Report (dated April 2009) and a cursory look at an updated report dated August 2009.
  - (d) Two stream survey reports by Brian T Coffey and Associates dated April 2008 and April 2009 (but received and referenced as May 2008 and July 2009 respectively).

I audited these primarily from the summary report (a), with reference to the accompanying reports where necessary.

I then provide concluding statements of the overall approach proposed by the applicants to managing the cumulative effects on rivers, streams, and their entry into the receiving lakes.

## AUDIT OF GHD SUMMARY REPORT

13. The GHD summary report identifies that mitigation of nutrient losses is the primary (or only) issue that needs to be addressed as a result of the effects of the additional area of irrigation proposed in the upper Waitaki catchment. This philosophy fails to identify the wide range of other water quality issues identified in planning documents and water quality guidelines and that are required to be managed or addressed. Subsequent audit is therefore focused on assessment of the nutrient loss assessment and management approaches. However, I do not agree with or condone this narrow effects approach. Other issues that should be considered both cumulatively and for individual applications are:
- (a) water quality and habitat effects of sediment loss and addition to streams (effects on water clarity and stream bed sedimentation).
  - (b) Effects of accompanying loss of pesticides, herbicides and novel contaminants (estrogenic compounds, pharmaceutical and therapeutic compounds such as metals (Zinc, Copper, Magnesium, etc), detergents, and animal remedies that are novel to the minimally disturbed upper Waitaki environment
  - (c) Water borne effluent components of human health significance such as virus's and bacteria as indicated by common indicator bacteria (i.e. *E. coli*) that affect uses and values of water.
  - (d) Possibility of increased leaching of soil carbon components and consequent water 'colour' consequences, as well as stream function consequences of increased soluble carbon and soluble micro-nutrients (i.e. iron, etc.).
  - (e) Habitat effects from loss of riparian margin vegetation and function.

Without consideration of these the full effects of the applications on rivers and streams are not complete.

14. **River and Stream Nutrient Thresholds:** The Summary Report states that ANZECC 2000 guidelines are recognised as New Zealand's only adopted guidelines for toxicants. I would agree with this statement with regard to 'toxicants', but the nutrient 'trigger values' (Table 3.3.10 of ANZECC (2000)) are:
- (a) NOT toxicant guidelines, and
  - (b) NOT the only nationally applied guidelines,
  - (c) Are not guidelines, but a table of 'trigger values'.
15. The ANZECC 2000 Table 3.3.10 of 'default trigger values', states that "...*these values are derived from data for unmodified or slightly modified ecosystems*". It further states that "...*these values were not based on any objective biological criteria [cf. effects based criteria]. This lack of specificity may have resulted in inclusion of reference systems of varying quality and further emphasises that the default trigger values should only be used until site or ecosystem specific values can be generated*".

16. There is little guidance in ANZECC 2000 as to how these trigger values should be used or considered. As it is these 'default trigger values' are a statistical (80%ile) summary of data from a subset of the NIWA National Rivers Water Quality Network of 77 (medium to large sized river) sites throughout New Zealand. Small inland alpine streams are poorly or not represented in this national data set, and so the 'default trigger values' bear little in common with the streams and small river types modelled in this study.
17. The water quality data assembled for the summary report clearly show that water quality for streams in the upper Waitaki catchment are very different from those summarised in ANZECC 2000 Table 3.3.10. For this reason alone, it is inappropriate to set the ANZECC trigger values as guidelines, as they would allow for significant degradation from the current state.
18. This is also inconsistent with the proposed objectives and standards in the ECan proposed NRRP that covers this area. Proposed objectives range from "no conspicuous growths" (proposed in 2004) through to maximum biomass consistent with the MfE Periphyton guideline (Biggs 2000) currently proposed in Proposed NRRP officer reports (2009). Corresponding nutrient standards are also considerably lower than ANZECC (2000) and are more consistent with those in Biggs (2000).
19. The Ahuriri part of the catchment is also subject to the operative National Water Conservation (Ahuriri) Order (1990). This order similarly has water quality provisions. They are largely of narratives that relate to discharges. They require (amongst other requirements):
  - b(ii) that there shall not be any destruction of natural aquatic life by reason of a concentration of toxic substances; and
  - b(iii) the natural colour and clarity of the waters shall not be changed to a conspicuous extent.

These are generally less restrictive than numerical standards in other discussed guidelines, but it should be acknowledged that b(ii) could be related to exceedence of recent nitrate toxicity guidelines (see paragraphs 21 and 76 below).
20. The continuing reference throughout the reports supporting the application, to the ANZECC 'trigger values' being 'toxicant guidelines' is also erroneous as they are not in any way 'toxicant' guidelines. They are not derived by the standard toxicant assessment methodologies for 'chronic' or 'acute' exposure as set out in ANZECC 2000. Nutrient enrichment responses at lower concentrations are not generally considered toxic responses, but are related to concentrations promoting growth of benthic periphyton growth to [nuisance] biomass levels .
21. It should be acknowledged that toxicity issues for some nutrients such as ammonia and nitrate nitrogen can additionally be considered. A reassessment of the chronic toxicity of nitrate-nitrogen in particular has just been reassessed by NIWA and released as an ECan Technical Report (Hickey and Martin 2009). This revised the nitrate-nitrogen concentration toxicity guideline for environments with high biodiversity or conservation value down to 1.0 mg/l in areas (such as inland basins) from a previous value of 4.9 mg/l, and a chronic guideline of 1.7 mg/l for slightly to moderately disturbed ecosystems (previously 7.2 mg/l).

22. These toxic thresholds are much higher than nutrient enrichment guidelines in Biggs (2000) but are also concentrations frequently encountered in moderately to intensively farmed catchments. These chronic toxicity thresholds will also need to be borne in mind as additional considerations in upper Waitaki groundwaters and at lower river nodes at times when groundwaters may dominate the flows in catchment streams and rivers. As noted in the evidence of Mr Carl Hanson, on groundwater effects, this situation is quite likely in upper Waitaki streams during routine and dry summers (such as over the 2008 summer with continuous low flow recessions exceeding six months).
23. Subsequent to ANZECC 2000, the New Zealand Periphyton Guidelines (Biggs 2000) further developed nutrient guidelines for “detecting, monitoring, and managing” [nutrient] enrichment of streams. This ‘guideline’ is selectively referenced in the GHD summary report when using derived equations, but is not immediately acknowledged as an appropriate or more relevant (effects based) national nutrient guideline,.
24. Furthermore, it is notable that the Biggs (2000) guideline referred to and used the ANZECC (2000) ‘trigger values’, but only as default nutrient concentration values for rivers in lower protection (recreational) target states, and only for those with accrual periods (days between freshes) less than 20 days (i.e. it only proposes the use of ANZECC trigger values for larger unstable rivers with high flood frequencies). For all other rivers and streams with longer accrual periods, specific derived concentration limit guidelines are presented and justified in Biggs (2000).
25. These Biggs (2000) guidelines are more appropriate ‘target’ guidelines for development scenarios and models proposing increased nutrient generation in largely unaffected catchments. These target guidelines are generally an order of magnitude or more lower than the ANZECC (2000) trigger values, but are entirely appropriate for naturally low nutrient environments such as the upper Waitaki catchment.
26. Therefore, the whole approach of using the ANZECC 2000 trigger values as appropriate guideline thresholds for streams and rivers of the upper Waitaki catchment for the purposes of the assessment of cumulative adverse effects is not supported. I would suggest that guidelines from Biggs (2000), or objectives and standards in the proposed NRRP or Proposed NRRP officer reports are more appropriate, being effects based and specifically targeted to the relevant issue of stream enrichment.
27. These target guidelines are considerably lower than ANZECC 2000, and would (where used) require an order of magnitude or more lower concentrations/mass loads, and/or much greater land use mitigations. They would also more likely achieve the clear objectives of no conspicuous or visible change in benthic periphyton biomass or communities, and would more effectively ensure the maintenance or protection of the high in stream values of upper Waitaki catchment water bodies.
28. **Sub catchment nodes and stream reaches:** The selection of subcatchment nodes and stream reaches appears to be an appropriate approach and sites appear reasonable. However, knowledge of groundwater/surface water interaction and relationships are poorly understood, so it needs to be acknowledged that considerable groundwater quantities may bypass some nodes. Catchment boundaries and diversions between catchments are also uncertain in some areas.
29. The use of nodal approaches assumes all measured water quality arises from diffuse areas of land use sources and is matched with accompanying land use modelling and

groundwater processes. The supporting applicant technical reports do not explicitly or consistently identify these 'other' significant sources of nutrients from point source or alternative effluent sources. In particular, high nutrient concentrations (above those modelled) are measured in some catchments such as Omarama Stream and Stony River.

30. It is not immediately obvious from the reports that Omarama Stream receives a significant discharge with elevated nutrient concentrations from the Omarama Sewage Treatment Plant (STP). Likewise, it is not clearly stated that the high nutrient load in Stony River arises predominantly from a major discharge of border dyke irrigation wipe-off water (paddock border-end run-off) that is collected and subsequently discharged to make up and dominate residual flows. It is likely that similar confounding situations may arise from Wairepo Stream and Willowburn diversions and wipe off water. These activities need to be well clarified before determining whether the subsequent 'observed' water quality data represent 'reasonable' trophic status arising from current levels of land use development alone. I would contend that from limited knowledge many of these catchments, stream assessments are not a clear reflection of diffuse nutrient loss from areas of current land use alone.
31. **Measured Stream and River Water Quality:** The measured stream and river water quality presented in the applicant reports and forming the basis of assessments of current state and condition of catchments is a very limited data set, and this limitation is poorly illustrated in the summary report presentation. The accompanying tables do not list sample number (n) or give any indication of the representative distribution of the data, and that must be individually checked from accompanying appendices.
32. Examination of the recently received appendices show that sampling conducted by GHD were generally limited to samples taken in December and January (mid summer) and often represented by three samples taken at fortnightly intervals in warm and dry summer conditions in December/January 2008/09. In places this data is supplemented by data accessed from UWWQT sampling or ECan sampling. Again, these were only available at some sites (likewise, which sites not readily identified in summary report tables), and largely also encompass summer sampling only. It therefore does not encompass the full range of environmental conditions that would normally capture the natural variability of water quality (such as winter 'washout' of soil nitrogen, or overland flow of phosphorus).
33. I therefore consider that the water quality data portray a very limited or skewed distribution of annual water quality of the upper Waitaki streams and rivers, and may not portray a good basis for estimating mean or median annual concentrations, or mass loads of contaminants (particularly nutrients). I would expect the observed data presented to under estimate the median and range of phosphorus concentrations, and represent a limited range of nitrogen concentrations.
34. The water quality data presented encompass a large proportion of data that appears to be at or below laboratory detection limits. In some places data are listed as below detection limit (e.g. <0.004 mg/l) and in other places list a detection limit value without such limitation. The three water quality data sets accessed also appear to have quite different detection limits for some water quality parameters. Subsequent 'observed' mean data tend to indicate that such detection limit data has been used as 'real data' without any obvious 'censoring', or in places may have been deleted entirely. It is important in such data sets, that data are validated, screened and censored appropriately before subsequent analysis, and that treatment of censored data is

clearly described. The indications from the report are that the data has not been appropriately censored and flagged in these reports and subsequent modelled outputs.

35. Below detection limit (<DL) results may represent data anywhere between zero and the detection limit, so it is common or standard practice to apply protocols to treat this data in a standardised manner and be careful of inferring too much from any data dominated by such results. Generally accepted protocols are to treat such data, when they must be used, as a value of half of the detection limit. However, in the summary report it appears that such data has been transformed into 'detection limit' values. It is also not immediately obvious how much <D/L data is in each site compilation. A consequence is that many data means are almost certainly an over estimate of the real stream nutrient concentrations. This has significant consequences where such data is then transcribed into formulae or models to calculate corresponding periphyton biomass. It also tends to give an inflated view of the current or natural nutrient status of many rivers or streams, especially in cases where specific laboratory detection limits are higher.
36. The preponderance of below detection limit data, particularly for dissolved reactive phosphorus (DRP), also appears to have led to the presentation and use of 'Total Phosphorus' data in the models and report, in place of dissolved reactive phosphorus data (but frequently not Total Nitrogen). There is also reference in the accompanying technical reports of using existing TP:DRP ratios to determine synthetic DRP concentrations where they are otherwise 'below detection'. These suggestions raise a range of questions of what data is actually used in analyses, and their validity. These are not well clarified in the report, such as where synthetic data is used, whether it is appropriate to treat TP data as largely a dissolved source for matching estimated to observed data, and whether all or most of the TP phosphorus is 'available phosphorus' and is of ecological significance.
37. In Canterbury and elsewhere in New Zealand it is common practice to consider much of the TP phosphorus content to be biologically 'unavailable' and consider the difference between TP and DRP to be tightly chemically bound 'Total Particulate Phosphorus'. Use of TP data in models is therefore further over-estimating 'observed' phosphorus concentrations in rivers and thereby assuming higher trophic states of rivers and subsequent calculated periphyton biomass based on observed concentrations.
38. Since the water quality data has largely been gathered in summer under lower flow situations, the data largely fails to account for a range of significant sources such as: those intermittently derived from overland flow; those originating in the winter when aquifer levels rise and greater seasonal outwash of soil stores (particularly of nitrogen) occur; from situations when periphyton biomass is eroded and transported downstream; and from periods when seasonal periphyton biomass is low and so would not have been stripping nutrients from the water column to drive periphyton development. As I discuss later, I believe the reasons for the unusually high periphyton biomass at many sites will also have a significant bearing on (low) observed (measured) nitrogen and phosphorus concentrations in stream water.
39. For these reasons, the observed water quality data presented in tables in the summary report and supporting reports is not considered particularly representative, auditable, or reliable for full seasonal (median) assessments, or as a check on mass balances. The water quality data is so seasonally skewed that it does not adequately represent data that can be portrayed as 'annual median' or 'mean' data.

40. I consider that conclusions and calculations drawn from this measured or observed water quality data are not reliable or representative of the rivers for the consideration and presentation of mean annual concentrations and annual mass loads. Conclusions drawn should therefore be considered tentative at best.
41. **Estimated water quality:** The source and accuracy of ‘estimated’ concentrations of nutrients (P and N) cannot be readily audited from the summary report or the GHD ‘Rivers and Lakes’ report. I assume they are derived from land use models, groundwater ‘drainage’ estimates, and hydrology (Mean and MALF) flow distributions, but there is insufficient referencing for me to track back the sources of these data columns. I therefore can make no independent informed comment on their derivation, accuracy, or reliability for determining stream and river water quality effects.
42. In the reports, a series of statements are made as to the uncertainties in estimated nutrient concentrations, and likely reasons for variations between estimated and observed ‘mean’ concentrations. I agree with the array of confounding factors that have been identified that prevent accurate direct measurement and estimation of nutrient loads at nodes. However, they subsequently appear to make no corrections or adjustments to measured data to account for these factors or processes, or assess the subsequent level of uncertainty in assessments arising from them.
43. The stated check, that overall P mass balance for the catchment, shows a good relationship between estimated losses from land and observed losses from Lake Benmore, are a simplistic and unfounded rationale. There are some further major confounding processes between the land losses and Benmore dam, such that it would both be surprising if both matched, and there is no reason to expect them too. In my opinion, these crude observations therefore do not lend any specific confidence to the data and models presented.
44. I therefore cannot comment usefully on the process or presentation of estimated nutrient concentrations at river and stream nodes.
45. **Ecological condition:** The two assessments of ecological condition conducted by Brian T Coffey and Associates (2008 and 2009) are described as sampling in two different hydrological flow conditions. The reports are largely just descriptions of a range of broad ecological indices from single spot sampling occasions over a 2-3 day period in autumn. They ideally require some clear climatic context to explain the findings, but such climate context descriptions are simplistic narratives or missing.
46. The 2008 assessment is subsequently acknowledged as “... *after a prolonged period of warm dry weather...*”. In fact, my examination of hydrographs from several sites in the basin indicate that this sampling occurred following a period of almost six months without significant rain and therefore represented a six month hydrograph (low flow) recession period. Therefore, this sampling is indicative of sites after accrual periods of in excess of 180 days (or a FRE3 index value of 2). Therefore, not surprisingly most sites had unusually high periphyton biomass and ecological conditions could be described as more degraded than generally expected. These are a hydrological condition that I consider are an ‘extreme’ or ‘worst case’ and little can be deduced as to ‘normal’ or average conditions (let alone suggest they might represent target conditions (+25% biomass?).
47. To avoid development of nuisance periphyton conditions under such (low FRE3) conditions, use of Biggs (2000) would result in recommended management of nutrient concentrations to near unmeasurable (low) concentrations. Also not surprisingly, the

unusually high periphyton biomass was composed of what are generally considered 'oligotrophic taxa', (see table 6 in Biggs 2000) but at eutrophic biomass levels. This unusual finding is almost certainly a consequence of the exceptionally long accrual period. The taxa described also included a significant proportion of low enrichment cyanobacteria taxa, such as *Nostoc* sp.. These are also expected to proliferate in such situations and can grow in low nutrient conditions 'fixing' their own nitrogen compounds.

48. The finding of these periphyton communities being largely dominated by cyanobacteria mats (*Nostoc*, *Phormidium*, *Oscillatoria* sp. etc.) is also consistent with these streams being nitrogen poor and/or correspondingly (relatively) phosphorus concentration driven. This further illustrates that under such settled summer flow conditions these streams should be considered particularly oligotrophic (nutrient limited).
49. A further observation from this sampling, is that very long accrual periods can and do occur in upper Waitaki catchment streams and rivers, and so nutrient guidelines and targets should reflect the potential for such long (summer) accrual periods and their corresponding effect sensitivities. Again such nutrient guidelines from Biggs (2000), to prevent excessive nuisance periphyton development, would appropriately require very low monthly median nutrient concentrations, certainly much lower than those listed for ANZECC 2000 trigger values.
50. Furthermore, high periphyton biomass originating from very long accrual/ low nutrient conditions, would visually contrast very differently with high periphyton biomass from higher nutrient concentration conditions arising from agricultural eutrophication. The latter community would be composed of very different taxa (green and brown algae) and growth forms (filamentous algae).
51. High biomass of oligotrophic taxa such as *Nostoc* is not uncommon in other Waitaki tributaries (Norton and Rouse 2007) and would not be observable as conspicuous or unusual (even in the April 2008 conditions). However, corresponding taxa in a higher nutrient condition would likely comprise of filamentous algae taxa (often bright green and brown) and would be very conspicuous and notable to any observer. This latter condition is very undesirable from an ecological (biodiversity) condition, very undesirable from recreational (e.g. Angling etc.) use, and from a public perception of water quality and overall ecological condition. Such filamentous growth forms (whether at existing or +25% increased biomass) would be perceived by almost all users as a 'polluted' or 'degraded' condition, in an environment otherwise valued for its 'high naturalness'. It would also result in degraded ecological communities and persistences of valued rare and endangered taxa and/or valued sports fishes.
52. The period prior to the 2009 biological sampling was described as a very different climatic pattern, with generally wetter conditions. However, again, climatic patterns such as hydrographs illustrating time since last fresh and fresh frequency were not explicitly presented. Furthermore, if they represented ecology at sustained wetter conditions, these do not match with the corresponding measured water quality presented elsewhere in the reports. Spot water quality is presented in the biological report but such data does not appear to be used in the water quality reports.
53. The two sampled ecological conditions are therefore interesting, but contrasting and represent extreme rather than 'average' conditions. They match poorly with the "average" condition approach of the water quality modelling and justifications in the assessment report.

54. The measured periphyton biomass from the Coffey reports may therefore exceed the peak biomass recommended in Biggs (2000), but I would contend that (in 2008 in particular) it resulted from extreme 'natural perturbations' (a concept well founded in the RMA), rather than sanctioning such biomass as natural, average, or as a result of existing nutrient loss from non point source discharges.
55. I consider that the periphyton biomass data from Coffey (2008 and 2009) should therefore be interpreted/used with caution for a number of different reasons. His suggested biomass target allowing +25% biomass of that recorded (because it would not be conspicuous), is flawed, as the observed biomass assessments were unusually high for natural perturbation reasons. Any equivalent biomass resulting from significant land use development and corresponding increase in nutrient loads would be composed of very conspicuous 'mesotrophic' or 'eutrophic' taxa (as in Table 6 of Biggs 2000), and would correspondingly likely to be very conspicuous and detrimental to human perceptions.
56. I consider that periphyton targets in this situation should therefore conform to biomass targets in Biggs (2000), pNRRP and pNRRP officer reports, and/or must take into account the taxa and growth form composition of the periphyton community. I further consider, the periphyton targets suggested by Coffey and which form the major basis of the MWRL/GHD proposed river and stream nutrient management regime cannot be supported in any logical or objective manner.
57. Corresponding periphyton growths observed and measured during nutrient limitation studies in seven upper Waitaki streams in 2007 (Wilks and Norton, in prep.) were all of low biomass, composed of oligotrophic taxa, and showed distinct nutrient limitations (either P or co-limited). Furthermore, there was evidence that in some situations natural macroinvertebrate communities exerted strong grazing pressure limitations on periphyton growth and development. The Wilks and Norton study gives further weight to the observation that upper Waitaki streams are currently oligotrophic, normally with low biomass, and maintained by high (nutrient limited) water quality and/or diverse macroinvertebrate grazing pressure..
58. Other biological metrics (MCI, QMCI, EPT, %EPT) are also presented for nodes and sites. Scores are somewhat more degraded than might be expected in this environment, and this is likely to be associated with the described climatic conditions at the time of sampling. As with the periphyton assessments the sampling conditions can be considered to have occurred at hydrological extremes and so little can be read into them. They generally cannot be considered in any way representative of annual mean condition. Macroinvertebrate communities are dynamic communities that change over time from regular 'resetting' (flood) events. Optimal sampling is generally at least 3 weeks after a fresh, but generally not after an extended (6 week) recession of stable flows (Harding et al. 2000). It is therefore unfortunate that sampling occurred at sub-optimal and non-representative times.
59. **Calculated Periphyton Biomass Thresholds:** The summary report specifies that NZ periphyton guidelines are not appropriate to apply because they are conservative, and instead proposes a calculated guideline/threshold based upon a 25% increase in [theoretical] periphyton biomass calculated from equations in Biggs (2000).
60. The summary report also states that where 'sites' are soft bottomed sediments, that periphyton biomass thresholds are not appropriate, and simple ANZECC 200 trigger values should apply. This rationale assumes that the soft sediment habitats at these 'sites', are 'natural' and fully representative of these whole catchments and that we

should consider the streams 'soft bottomed' throughout their catchment. This is inappropriate and highly unlikely given their parent geology, and there are likely to be considerable reaches with hard sedimentary bed forms prone to periphyton accumulation in all upper Waitaki streams and rivers. Therefore, periphyton targets should be applied to all streams reflecting their overall geological setting (and stream REC type) rather than ad hoc ANZECC 2000 target values proposed for localised soft sediment conditions.

61. As stated earlier, the guidelines in Biggs (2000) and subsequently in pNRRP and pNRRP officer reports are appropriate for all upper Waitaki Streams. This is because these constitute a naturally low nutrient environment compared to the cited studies in Waikato, Manawatu, and Canterbury Plains which are more highly developed areas, and with higher background nutrient concentrations. I consider it is therefore not appropriate to immediately consider that the NZ Periphyton Guidelines are too conservative to be applied in the upper Waitaki catchment.
62. Secondly, the proposed 25% increase over a theoretical mean annual maximum periphyton biomass is a somewhat ad hoc proposal based upon a biomass derived either from some very limited data, or broad models.. Furthermore, the upper Waitaki catchment is a novel environment that is very different to the environments that were used by Biggs to derive principles, equations, and relationships.
63. It is difficult to follow the methodology by which the "calculated average annual maximum chlorophyll a concentrations" (CAAMCAC) were derived. In places I am not convinced that the methods truly calculate 'average annual MAXIMUM' values but more likely generate 'average annual MEAN' values because of the limited range of input data, and annual mean input data used.
64. The report states that the predicted periphyton biomass increase has been calculated for nitrogen and phosphorus "being in balance" and does not rely on one limiting nutrient. It is unclear what this functionally means for the calculations, but I can only assume it means that the biomass adopted is the highest of separate determinations for N and P equations, each with the other in surplus respectively? This is inappropriate if one nutrient is likely to be consistently limiting, and will immediately over-estimate the appropriate biomass threshold. Such an analysis is therefore inappropriately very optimistic rather than conservative.
65. For example, dissolved reactive phosphorus (DRP) concentrations in the 'observed' data are dominated by below detection data, and so are effectively represented by water quality data that could conceivably be close to zero. However, this appears to be ignored, or mis-represented by either representing this as detection level data, or ignoring this and accepting biomass based upon equations incorporating higher and nitrogen concentrations and assuming surplus P was available. Both are clearly flawed assumptions. Consequently, CAAMCAC based upon observed water quality are largely meaningless, except for the sites (Stony River, Omarama River with consistently measurable concentrations (and previously described as resulting from discharges as much as from diffuse land use sources).
66. The example stated in the report, is of "*periphyton biomass as calculated from mean nutrient concentrations show that the Mary Burn site would not meet any of the periphyton guidelines.*". This is despite the fact that the Maryburn site had all observed (measured) DRP values below detection level (~0). It is only portrayed as exceeding all guidelines because of a [relatively] high mean nitrogen concentration. In

reality these features should result in low periphyton biomass, as is reflected in the relatively low measured biomass data also presented.

67. I cannot readily comment on the accompanying periphyton biomass based upon modelled water quality, except to say that this becomes a second order model (modelled biomass based on modelled water quality) and so errors in both processes are likely to lead to very high errors or uncertainty in these resulting levels.
68. The subsequent presentation of measured periphyton biomass at nodes in April 2009 alongside modelled outputs bears little relationship to these modelled outputs. Again I consider this is a reflection of long or variable accrual times, and novel oligotrophic periphyton communities that are responding very differently to those in more nutrient enriched waterways generally studied elsewhere in New Zealand. It further suggests that the modelled outputs are very uncertain and cannot be relied upon with any surety as likely 'outcomes'.
69. Overall, the baseline or threshold periphyton biomass approach is not convincing and in my opinion is not robust and is based upon flawed logic. The simplistic approach and analysis (as far as can be assumed) would not represent an appropriate or robust way of ensuring appropriate protection or outcomes for the nutrient status and sustainable primary production (periphyton growth) status of upper Waitaki streams under the proposed development scenarios.
70. **Calculated water quality under development scenarios:** The calculated water quality under development scenarios presented estimated mean nitrogen and phosphorus concentrations at mean flows (section 5.2). Again, concentrations are related to ANZECC 2000 trigger values to determine 'significance' and I continue to consider that that is not the appropriate target.
71. Furthermore, this (high) target is already exceeded at some partially developed catchments, and at Willow Burn is estimated to also exceed new nitrate toxicity guidelines. These estimated nitrate nitrogen concentrations are calculated to exceed the NZ periphyton guidelines at all sites (nodes) except the Ahuriri River node.
72. The corresponding phosphorus table displays both TP and DRP, and it is uncertain whether or what the TP data is being used for. A footnote also suggests that estimations will be an over-estimate so allude to further scaling by the ratio between estimated and observed 'current' situation data. The logic for this is unclear but indicates further data censoring. For reasons discussed previously, observed P (and particularly DRP) data are not particularly representative, are largely inappropriate 'synthetic' (detection value) data and offer a skewed seasonal picture. Therefore, this data, and such further data censoring cast significant doubt on the validity and reliability of this calculation and subsequent model data.
73. Calculated annual average maximum chlorophyll a concentrations (CAAMCAC) are then further calculated from modelled and predicted water quality data. Again this is a second order model (modelling using modelled data) and so there would be expected to be considerable additive uncertainty in this. I also consider that the modelled outputs are not CAAMCAC as the whole modelling exercise is based upon mean flows and mean water quality. Therefore outputs are largely MEAN chlorophyll a concentrations' rather than annual average MAXIMUM chlorophyll a concentrations. These are very different, and would give different conclusions. I therefore consider the graphical output to be a significant under estimate of likely MAXIMUM periphyton biomass that is the primary management outcome concern. It could therefore be

considered that considerably greater nutrient surpluses, and therefore greater levels of mitigation would be required at ALL catchment nodes.

74. Error bars on the nutrient load graphs appear to be of debatable relevance, as they are stated to represent an [ad hoc] 30% variation in nutrient concentrations. There is no stated basis for this, and so the error bars are not representative of any meaningful or well justified statistic.
75. Furthermore, for reasons discussed earlier, the NZ Periphyton guideline threshold portrayed on the graph, IS the appropriate threshold target, rather than any 25% increase from current levels. This would mean that ALL catchments would be expected to currently and following development, exceed guideline thresholds, and all catchments would require significant mitigation (provided all other reservations are ignored).
76. The predicted groundwater nitrogen concentrations, cause further grounds for concern as they are all subsequently 'diluted' in mean stream flows. However, it is conceivable that under dry summer (MALF – mean annual low flow) conditions, some streams may be composed predominantly of groundwater and stream concentrations could approach the predicted groundwater concentrations. Under such situations, the preceding modelled outputs are therefore gross under estimates, and significantly higher periphyton biomass could be expected leading to high MAXIMUM (CAAMCAC) periphyton conditions occurring. Furthermore these high predicted nitrate nitrogen concentrations are also well within the effects range for nitrate toxicity on aquatic biota, (as discussed previously at paragraph 21).
77. **Thresholds, and Predicted permitted nutrient loads:** The final output of the models and scenarios are thresholds and predicted permitted nutrient loads at stream and river nodes for the development scenario. I cannot support these figures (Summary report Table 19), for the reasons of the range of issues with the sampling, modelling and calculation issues I have raised throughout my report. Likewise the alternative table 20, reporting against ANZECC 200 trigger values cannot be supported for similar logical, and rational reasons. I believe that there is so much uncertainty in the methods, modelling steps and adoption of targets, that likelihood of achieving the targets (whether they are the relevant ones or not) is very uncertain. I would therefore hold grave doubts for the continued maintenance and management of the state of the nutrient and periphyton status of upper Waitaki streams and rivers if based on these models and analysis.
78. **Monitoring:** I provide a number of comments on the proposed monitoring from the perspective of identifying robust meaningful monitoring information. My comments should not be misconstrued as indicating that I consider that the water quality effects of the proposed irrigation developments are acceptable.
79. A stream and river monitoring programme is proposed as section 7 of the summary report. This proposed monitoring programme is proposed at the identified nodes. This would be appropriate. However, monitoring is primarily focused at water quality parameters, and monthly monitoring is proposed. However, the primary 'output effect' is on the periphyton community, and yet proposed monitoring of periphyton is only annually (at no prescribed time).
80. A key monitoring objective would be verifying that any changes to the periphyton community are 'minor' and 'inconspicuous', and so primary monitoring of nodes should be of this periphyton community. Such monitoring should be of both biomass

assessment and community composition (whether it be mat or filamentous, and whether composed of oligotrophic or conspicuous mesotrophic/eutrophic taxa). Accompanying water quality data collection is therefore largely explanatory data to help explain the periphyton 'outcome' monitoring.

81. Furthermore, monitoring would also need to address outcomes for other water quality and habitat issues as discussed at paragraph 13 of this evidence.
82. Finally, a monitoring programme should have an output beyond just "annual reporting". The whole assessment methodology has been phrased around maintaining or achieving predetermined periphyton biomass thresholds. Whether these are appropriately determined as being based upon NZ Periphyton guidelines) or pNRRP targets (my suggestion<sup>0</sup>, or ANZECC 2000 trigger values, or calculated periphyton biomass +25%, the monitoring results should be related back to whether such thresholds are being breached or not. Such breaches should trigger reviews, and/or consequential steps (such as reduced areas of land intensification, further mitigation steps, etc.).
83. **Avoidance, Remediation and Mitigation:** I have not commented on scope of individual nutrient mitigation plans, because they had not yet been provided. Furthermore, such mitigations are more in the area of explicit expertise of experts in farm management. My expertise is primarily on activities in closer proximity to waterways such as riparian fencing and riparian management. I would anticipate commenting on mitigation once I have received and read mitigation reports and proposed individual property mitigation plans,

## **CONCLUSIONS**

84. The assessment of cumulative effects and subsequent modelling of river and stream water quality only considers nutrient enrichment effects, but should consider a full suite of effects on river and stream water quality, habitats and ecology. Additional effects that should be included are effects on sediments, clarity, toxicants and novel contaminants, human health issues, habitat features and ecological functioning.
85. Water quality and periphyton thresholds and targets proposed are not considered appropriate to the upper Waitaki catchment river environments, and are considered overly permissive. They would in my opinion most likely result in significant increases in periphyton biomass in many rivers and streams and consequently result in significant detrimental changes for the ecology of those waters and reduce the suitability of those waters for a range of uses and values. I considered that the NZ Periphyton guidelines and subsequent pNRRP officer recommendations provide a more appropriate threshold and target for nutrient enrichment effects in the upper Waitaki catchment.
86. Consideration of nutrient responses and targets additionally illustrate nitrate concentrations can also breach recent toxicity thresholds as well as nutrient enrichment thresholds.
87. The subcatchment nodal approach is supported, but should additionally clearly identify where point source discharges and other novel discharges confound nutrient generation and effect models. Currently they do not.

88. Measured background water quality and periphyton sampling conducted and presented is very limited and is not truly representative of mean or annual distributions. I consider that conclusions and calculations drawn from the very limited measured or observed water quality data are not reliable. I do not consider that the data presented can be relied upon to be representative of the rivers for the consideration and presentation of mean annual concentrations and annual mass loads.
89. Overall, the baseline or threshold periphyton biomass approach is not convincing and in my opinion is not robust. The simplistic approach and analysis (as far as can be assumed) does not represent an appropriate or robust way of ensuring appropriate protection of outcomes for the nutrient status and periphyton biomass of upper Waitaki streams and rivers.
90. The calculated water quality and biomass under development scenarios are particularly uncertain and based upon a wide array of assumptions and limited data. Subsequent thresholds and predicted permitted nutrient loads are similarly considered uncertain and of debatable reliability for ensuring appropriate outcomes are achieved.
91. Comments are provided on monitoring only to highlight technical issues and should not be misconstrued as an endorsement of the proposals. The proposed monitoring proposed is spatially sensible, but focuses on causative factors (water quality) rather than outcomes anticipated (periphyton biomass and community). Monitoring should primarily focus on regular (monthly) periphyton monitoring, and on whether specified outcomes are being achieved. Consequences (review or further mitigation requirement) should be a major component of any monitoring programmes, reflecting whether limits are being breached or not. Additional monitoring components would also be required for other water quality and habitat issues not considered in the assessments to date.
92. Mechanisms to avoid, remedy and mitigate effects of land use development are not commented on as proposals are yet to be received.

#### **ADDITIONAL REFERENCES CITED.**

Hickey, C. and Martin, M. 2009: A review of nitrate toxicity to freshwater aquatic species. Environment Canterbury Technical Report R09/57. 46pp.

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Wilks, T and Norton, Ned 2007 (in prep.) Periphyton growth and nutrient limitation in the upper Waitaki catchment. Environment Canterbury Technical Report in prep.