IN THE MATTER	of the Resource Management Act
AND	
IN THE MATTER	of Applications for Resource Consents to Take and Use Farm Irrigation Water in the Upper Waitaki Catchment of Lake Benmore
AND	
IN THE MATTER	of Stage One: Mackenzie Water Research Limited Submissions and Evidence on the Cumulative Nutrient Effects (and Mitigation thereof) of the Upper Waitaki Applications

Right of Reply of Dr. Brian Thomas Coffey

1.0 Introduction

Qualifications and general experience

1.01 My name is Brian Thomas Coffey. My qualifications and experience are as stated in my Evidence in Chief.

Purpose and scope of evidence

1.02 Further to my Rebuttal Evidence, the purpose of my Right of Reply is to clarify, correct and / or further rebut a range of statements and assertions made by the following submitters since I prepared by rebuttal evidence.

- Dr. Adrian Meredith in his Section 42A Addendum Report,
- Dr. Michael Freeman in his Section 42A Addendum Report and comments on proposed conditions,
- Ms. Donna Sutherland in her addendum to brief of evidence on cumulative water quality effects,
- Dr Ton Snelder in his addendum to brief of evidence on cumulative water quality effects,
- Mr. Jonathan Bray in his supplementary statement of evidence,
- Dr. Richard Allibone, in his statement of evidence,
- Mr. Peter Ravenscroft, in his statement of evidence.
- Dr. Marc Schallenberg in his Section 42A Officers Report.

1.03 I have structured my Right of Reply by addressing the evidence as listed above, starting with Dr. Meredith, and where a common issue / submission is raised by other staff or submitters, I have referred to my earlier comments on that matter.

Compliance with Expert Code of Conduct

1.04 I have complied with the Code of Conduct for Expert Witnesses in the Environment Court when preparing this Right of Reply.

2.0 Section 42A Addendum Report of Dr. Adrian Meredith

2.01 There is some important common ground between Dr. Meredith and myself where he states in paragraph 31: "*A central tenet of the MWRL proposal is to manage river water quality through periphyton biomass targets at nodes. While I consider this is appropriate, and consistent with ECan pNRRP planning proposals, there remains disagreement on appropriate targets*".

2.02 The reason there remains *"disagreement on appropriate targets"* is a lack of consensus between Dr. Meredith and myself regarding the current ecological condition of waterways in the Mackenzie Basin.

The 25% Periphyton Increase Threshold

2.03 This issue has been re-raised in paragraph 39 of Dr. Meredith's Section 42A Addendum Report.

2.04 As stated in paragraphs 1.5 to 1.9 of my Evidence in Chief, I was retained by the GHD Water Quality Team to provide an experienced New Zealand perspective on ecological matters to an international team of scientists and modellers assembled by Mr John Male of GHD Limited to advance the studies of Glasson Potts Sinclair Knight Merz (2004).

2.05 As stated in paragraph 7.15 and elsewhere in my Evidence in Chief, the reasons I considered a 25% increase in annual average maximum periphyton biomass at nominated downstream nodes would not result in other than a minor effect in streams and rivers relative to their current condition were:

i. periphyton biomass already exceeds a "nuisance" condition at a number of nominated nodes during those times of the year when annual mean maximum periphyton biomass forms,

ii. "nuisance" growths already comprises instream conditions for aquatic animals at a number of nominated nodes,

iii. a 25% increase in annual mean maximum periphyton biomass at most nominated nodes would not therefore, create a "nuisance" condition from an existing "non-nuisance" condition,

iv. a 25 % increase of existing "nuisance" periphyton growths would probably not be noticeable to a casual observer,

v. current annual average maximum periphyton biomass may not yet have responded to existing land use effects and may increase with time (due to a lag effect in groundwater), even if there are no further changes to current land use, and

vi. In the majority of streams, the nutrient mitigation requirement for Lake Benmore to remain oligotrophic, and / or groundwater to remain below trigger levels, means the 25% increase would not be exercised.

2.06 In terms of 2.05 v above, nominating a "no change" scenario for nutrient loads at these nominated nodes could be considered unrealistic or unduly onerous in terms of any further land use development.

2.07 In the case of the streams and rivers discharging to the Ahuriri Arm of Lake Benmore, the suggested 25% increase in annual average maximum periphyton biomass at nominated downstream nodes does not apply because of the criteria of maintaining that arm of the lake in an oligotrophic condition (2.05 vi above).

2.08 This proposition was accepted and stated by the collective group of senior international scientists who produced the Water Quality Study.

2.09 In my view, the most significant stumbling block that has arisen during the course of these hearings is a lack of consensus on the current ecological condition of waterways in the Mackenzie Basin. That was the reason that I accepted in my rebuttal evidence (paragraph 6.04) there is a case for a further annual round of monthly monitoring to adequately benchmark the current ecological condition of these waterways prior to further landuse intensification.

2.10 I have seen the conditions now proposed by MWRL and I endorse them as they will set an appropriate basis for irrigation. I have also provided the methodology for periphyton assessment to be used by the applicants which is Appendix C to the draft conditions.

My 2008 and 2009 Periphyton Surveys compared with Wilks et. al., (2007)

2.11 Dr. Meredith is not correct in his paragraph 37 when he states the findings of our studies are at variance with the Wilks et.al. (2009) study that demonstrated nutrient limitation prevented periphyton proliferation in autumn 2007.

2.12 Dr. Meredith is also not correct when implying in his paragraph 37 there is a problem with our measurement of periphyton biomass as Ash Free Dry Mass rather than as Chlorophyll a per unit area. Both measures are equally defensible, both are included in the national standards, and there is a quantitative relationship between the two measures as follows.

Biggs (2000): Provisional biomass and cover guidelines for periphyton growing in gravel / cobble bed streams for three main instream values (AFDM = ash-free dry mass).

Instream value/variable	Diatoms/cyanobacteria	Filamentous algae
Aesthetics/recreation (1 November - 30 April) Maximum cover of visible stream bed Maximum AFDM (g/m^2) Maximum chlorophyll a (mg/m^2)	 60 % >0.3 cm thick N/A N/A	 30 % >2 cm long 35 120
Benthic biodiversity Mean monthly chlorophyll a (mg/m^2) Maximum chlorophyll a (mg/m^2)	 15 50	 15 50
Trout habitat and angling Maximum cover of whole stream bed Maximum AFDM (g/m^2) Maximum chlorophyll a (mg/m^2)	 N/A 35 200	 30 % >2 cm long 35 120

2.13 I have always assumed periphyton biomass accrual is limited by nutrient supply (nitrogen and / or phosphorus) in the un-shaded gravel lined watercourses in the Mackenzie Basin. Indeed we were required to decide whether it was nitrogen and /or phosphorus which were limiting periphyton growth when choosing which of the periphyton model equations to use when calculating maximum annual periphyton biomass at selected nodes.

2.14 The Ecan 2007 studies (Wilks et.al., 2009) necessarily reported periphyton biomass in runs because they needed to incubate growth chambers below water level. We reported periphyton biomass in riffles, which is typically four times higher than in runs (e.g. Figure 16, Biggs, 2000).

2.15 Dr. Meredith re-states his erroneous contention in paragraph 39 of his Section 42A Addendum Report "*The MWRL management proposes a periphyton biomass target maxima..... assuming no nutrient limitation*". That is simply not the case.

2.16 As stated in paragraph 2.09 above, the reason that I accepted in my rebuttal evidence (paragraph 6.04) there is a case for a further annual round of monthly monitoring to adequately benchmark the current ecological condition of these waterways, prior to further landuse intensification, is the lack of consensus on the current ecological condition of waterways in the Mackenzie Basin. In paragraph 38 of his Section 42A Addendum Report Dr. Meredith continues to assert "*it would be expected that upper Waitaki rivers would be consistently nutrient limited and in good condition*". That expectation was not supported by the findings of my two surveys in 2008 and 2009.

2.17 A further description of periphyton and macrophyte biomass for December 2009 – January 2010 at the downstream nodes described by Coffey et. al. (2008) and Coffey (2009) has been provided by Ludgate and Ryder (2010). This document is attached as Appendix A. The invasive diatom *Didymosphenia geminata* (Didymo) had colonised the Tekapo node, the Tekapo River at Lake Benmore, Grays River node, Mary Burn node, Twizel node, Omarama Stream node and the Ahuriri River node since my last survey in April 2009.

2.18 Overall, the December 2009 and January 2010 surveys of periphyton in rivers in the Upper Waitaki basin found the cover of thick diatom / cyanobacteria mats were low and below Ministry for the Environment (2000) guideline levels at all sites, except at two sites in the Tekapo River (Ludgate and Ryder, 2010). Cover of long filamentous algae was also generally low and below guideline levels at all sites, except in the Stony River where the filamentous diatom *Melosira* was dominant (Ludgate and Ryder, 2010). Macrophyte cover was generally low at soft-bottomed sites, with the highest cover levels of aquatic plants at the Willow Burn site (Ludgate and Ryder, 2010).

2.19 This additional survey data does not necessarily support either my or Dr. Meredith's position as it relates to late spring - early summer and was conducted some 3 to 4 months earlier than the late summer surveys reported by myself and Wilks et. al. (2009).

2.20 However, reference to Figure 4 of Ludgate and Ryder (2010) illustrates a significant increase in the cover of cyanobacterial mats > 3 cm thick at nodes that were scored in both December 2009 and January 2010 (Grays River, Mary Burn and Omarama Stream) and a significant increase in the cover of filamentous algae that were > 2 cm long at the Mary Burn, Quailburn

and the Omarama Stream nodes between December 2009 and January 2010 (the exception being the Twizel River where there was a decrease of filamentous algal cover between late spring – early summer).

2.21 Similarly, Figure 5 of Ludgate and Ryder (2010) shows mean Ash Free Dry Mass (AFDM) and mean chlorophyll a (Chl. a) per unit area generally increased at sampling nodes during the six-week period between 8 December 2009 and 19 January 2010 (the exceptions being the mean AFDM at Twizel River node and the Quailburn). Given the rate of periphyton accrual between December 2009 and January 2010, it appeared more than likely than in the absence of flushing flows periphyton biomass and cover had the potential to approach and / or exceed guideline values at a number of these nodes by the end of the summer.

2.22 I agree more information is required to reliably establish the extent to which waterways in the Mackenzie Basin currently comply with NZ Periphyton guideline targets (paragraphs 25, 29 and 31 of Dr. Meredith's Section 42A Addendum Report). This is the purpose of my recommendation (paragraph 6.04 of my rebuttal evidence) that a further annual round of monthly monitoring is required to benchmark the current ecological condition of these waterways prior to further landuse intensification.

2.23 I also agree with Ludgate and Ryder (2010) that the correct application of the guidelines to rivers dominated by Didymo has yet to be established. This matter is under investigation by a variety of workers including Meridian Energy and should be clarified in the foreseeable future.

2.24 In paragraphs 43 to 47 of his Section 42A Addendum Report, Dr. Meredith raises similar concerns to Ms. Sutherland (paragraph 59 of evidence) with regard to the appropriateness of the Ahuriri River node and the need to monitor the ecological condition of the headwater deltas in the two arms of Lake Benmore and the Wairepo Arm of Lake Ruataniwha. On the basis that a proportion of groundwater may enter these receiving waters directly rather than surface at the Wairepo, Twizel and Ahuriri nodes, I agree there is a case to monitor the ecological condition of these three lacustrine deltas. Methodology for monitoring these sites should be consistent with Vant (1987); Burns et. al. (2000), Champion et. al. (2002), Elliot and Sorrell (2002), James et. al. (2002), Rowe and Graynoth (2002) and Clayton and Edwards (2006) with a particular emphasis on aquatic plants (submerged macrophytes, periphyton and phytoplankton).

2.25 In his paragraph 49, Dr. Meredith raises concern with contaminants other than plant nutrients that are associated with the intensification of land use. These issues were clearly identified in Section 2.4 of my Evidence in Chief. However, by adopting mechanisms that reduce the export of nitrogen and phosphorus from farms, these other contaminants will also be limited and managed.

2.26 In paragraph 50 of his Section 42A Addendum Report, Dr. Meredith expresses concern at the possible influence of novel organic and endocrine active compounds that are increasingly the subject of international study. However, it is municipal wastewater treatment plant effluent rather than intensive landuse effects that has been identified as a primary pathway of hormones and alkylphenols to the aquatic environment (Desbrow et. al., 1998; Ternes et. al., 1999; Johnson and Sumpter, 2001 and Lee et al, 2008).

3.0 Section 42A Addendum Report of Dr. Michael Freeman

3.01 In Dr. Freeman's Table 1 (under paragraph 7), his third technical issue is stream WQ modelling. Both here and in paragraphs 12 and 13 he raises the same issues with the 25% maximum annual periphyton biomass increase guideline that have been raised by Dr. Meredith and that I have addressed under my paragraphs 2.03 to 23.11.

3.02 In Dr. Freeman's Table 4 (under paragraph 46), his audit response that "Any new or replacement application that is based on a proposal to allow increased nutrient discharges in accordance with '25% periphyton increase' approach -recommend not grant" is considered unreasonable for the reasons stated in my paragraphs 2.09 and 2.10 above.

3.03 I disagree with Dr. Freeman when he states in Table 1 (under his paragraph 7) "*ANZECC nutrient concentration guidelines are of limited applicability and a 25% increase in modelled periphyton biomass highly inappropriate*". The ANZECC (2000) water quality guidelines are

commonly used as a national standard throughout New Zealand. The regional alternative advocated by Dr. Freeman (his paragraph 12) in the form of the Proposed Natural Resources Regional Plan (PNRRP) in my opinion, is still very much a work in progress and as acknowledged by Dr. Freeman in his paragraph 14, there has been concern expressed with regard to the following aspects of this Plan:

- the achievability of the specific water quality outcomes,
- the applicability of "natural state" to some waters and river beds,
- the linkages between the text of the objective and detailed provisions in Table WQL5,
- the level of numerical and narrative specificity, and
- potential difficulties in meeting section 104D requirements (memorandum dated 30 June 2008 from NRRP hearing commissioners).

3.04 As mentioned earlier in my Right of Reply, I am concerned about the achievability of proposed periphyton guidelines in this plan and whether they are appropriate standards in the Upper Waitaki Catchment.

3.05 The relevant changes recommended in PNRRP officer reports 12A and 33 are contained in Appendix 2 of Dr. Freeman's evidence. *The new Table WQLAA (Water Quality objectives for Lake Benmore) for example, states the minimum acceptable Trophic Level Index for Lake Benmore score should be three. All other parties at these hearings have stipulated the maximum acceptable Trophic Level Index score for Lake Benmore should be less than three.* This error highlights the point under paragraph 3.03 that the PNRRP is still very much a work in progress and should not be substituted for the ANZECC (2000) guidelines at this stage.

3.06 In my opinion, the recommended early warning and environmental standard triggers outlined under paragraph 20 of Dr. Freeman's second Section 42A addendum report are premature and should be based on a further 12 months monitoring data as recommended in paragraph 6.04 of my rebuttal evidence.

3.07 I understand that Dr. Freeman does not consider that one year's worth of data would not be of any value on the basis that even if the condition was fully and properly specified, one very dry or very wet year could produce some interesting outcomes. Other ecological experts (Greg Ryder, Ton Snelder and Donna Sutherland) agreed further monitoring (preferably 18 months of monthly sampling) for periphyton, flow and nutrients desirable to establish baseline and goodness of fit between modelled and measured maximum annual periphyton biomass (see caucusing notes on aquatic ecology).

3.08 To counter Dr. Freeman's concerns with the proposed conditions it is necessary to re-state that the periphyton triggers in the WQS were calculated values for maximum annual periphyton biomass based on mean annual SIN / SRP concentrations and particular flood frequencies at particular nodes. They were not based on measured maximum annual periphyton biomass at these selected nodes. The equations used to calculate maximum annual periphyton biomass (see Appendix C of recommended conditions) include a FRE3 value that accounts for a wet or dry year. The purpose of the additional 12 months monitoring of water flow, periphyton biomass and plant nutrients I recommended in paragraph 6.04 of my rebuttal evidence was to test / confirm the goodness of fit for predicted and measured maximum annual periphyton biomass at these nodes. There is a different predicted maximum annual periphyton biomass at these nodes during a dry year (with a lower FRE3 value) than during a wet year (with a higher FRE3 value).

3.09 Dr. Freeman also posed the following questions regarding Appendix C to the proposed conditions that provides the equations to calculate the current maximum annual periphyton biomass at a given node and to quantify a 25% increase in annual periphyton biomass above the current maximum at a given node.

- how will a determination be made to ID which nutrient is limiting?
- what if changes occur over time, and
- what if both N and P are limiting?

Determination of limiting nutrients can be inferred from SIN/SRP ratios or determined by in situ nutrient enrichment studies and can change seasonally or with time. Where there is co-limitation of periphyton growth by N and P the higher estimated response is used for modelling.

4.0 Ms. Donna Sutherland Addendum to Brief of Evidence on Cumulative Water Quality Effects

4.01 I accept Ms. Sutherland's challenge to my statement that *Lagarosiphon major* does not "thrive" in mesotrophic waters. It can continue to form nuisance submerged weed beds in mesotrophic lakes where it is not competing with other taxa such as *Ceratophyllum demersum* or *Egeria densa*. My statement was intended to highlight that *Lagarosiphon major* is most competitive in oligotrophic lakes and less competitive in mesotrophic lakes.

4.02 However, I do not accept the case she is making in paragraphs 21 to 23 of her addendum to brief regarding benthic respiration and anoxia where she states that she has concerns with the implications of increased nutrients to macrophyte beds.

4.03 It has been well illustrated that super saturation of dissolved oxygen and high pH values can occur within the canopy of *Lagarosiphon* beds at and around midday and that reduced oxygen concentrations and low pH values can occur in the canopy of *Lagarosiphon* beds at dawn (particularly where carbon is limiting photosynthetic activity). However, I have never encountered anoxic conditions within *Lagarosiphon* beds in oligotrophic or mesotrophic lakes.

4.04 With regard to paragraph 24 of Ms Sutherland's addendum to brief, I accept that periphyton and phytoplankton growth rates and biomass accrual would increase in Lake Benmore if water quality were to shift from an oligotrophic to a mesotrophic condition. However, the basic premise of the Water Quality Study is that this must be avoided. I do not accept Ms. Sutherland's contention that "during calm periods and low flows there will most likely be long enough residence time to allow phytoplankton communities to bloom" (in the headwater delta of the Haldon Arm of Lake Benmore). This matter has also been addressed in the evidence of Dr. David Horn who agrees the residence time of water within the Haldon Arm delta is and will continue to be too short to permit phytoplankton blooms.

4.05 Ms. Sutherland has raised the issue of Didymo in paragraphs 26 to 30. As I mentioned in paragraph 2.21 above, the correct application of the guidelines and nutrient limitation in waterways dominated by Didymo has yet to be established.

4.06 Ms. Sutherland considers (paragraph 30) the observed differences in didymo growth between the upper and lower halves of the Ohau B - C canal may be the result of groundwater intrusion (and recent intensification of landuse). However, given the Ohau canals are entirely man-made from local materials, lined with waterproof compacted clay gravels and have an armour layer of gravel between the canal lining and the flowing water (Meridian, 2008), this seems most unlikely. I consider she provided a far more plausible explanation for increased Didymo growth in the downstream section of the Ohau B – C Canal in paragraph 32 of her Evidence in Chief, where she associated nutrient increase responses by Didymo within and downstream of salmon farms in the canal.

4.07 Norton et al. (2009) and Dr. Romeros in his evidence acknowledge that there is some further irrigation planned for the Wairepo sub-catchment (that discharges to the Wairepo Arm of Lake Ruataniwha and thence into the Ohau B – C Canal) but that nutrient loads in this input would not be significant in relation to the very large flow in the Ohau B – C Canal. Notwithstanding Norton et al. (2009) and Dr. Romeros in his evidence concluding the WQS (GHD, 2009) loads substantially underestimated nutrient loads of the Ohau C Canal, it appears unlikely that mitigated nutrient discharges from land use intensification in the Wairepo sub-catchment would exacerbate an existing Didymo problem in the Ohau B – C Canal (paragraph 29 of Ms. Sutherland).

4.08 I agree with the theoretical contention of Ms. Sutherland in paragraph 25 of her addendum to brief. If nutrients were to increase in the Haldon Arm, the level of protection that the Haldon Arm water exchange offers the Ahuriri Arm would be diminished. However, if as is intended, both arms are to be maintained in an oligotrophic state, I do not see this would be an issue. My understanding is that there was no modelled dilution effect of the Northern Arm in the Ahuriri Arm of Lake Benmore in the GHD Water Quality Study (WQS) and therefore permitted nutrient load calculations for the Ahuriri Arm in the WQS would tend to be conservative.

5.0 Dr. Ton Snelder Addendum to Brief of Evidence on Cumulative Water Quality Effects

5.01 I have responded to paragraphs 8.1 and 8.2 of Dr. Snelder's addendum to brief in section 6 of my rebuttal evidence.

5.02 With regard to paragraph 9.1 of Dr. Snelder's addendum to brief, I have agreed in paragraph 6.04 of my rebuttal evidence and in paragraph 6.04 of this Right of Reply, that further monitoring work is required to reach consensus on the current state of waterways in the Mackenzie Basin and the extent to which the Biggs (2000) periphyton model is applicable in these watercourses.

6.0 Mr. John Bray Supplementary Statement of Evidence

6.01 In paragraphs 14 to 17 of his supplementary evidence, Mr. Bray has challenged the use of national periphyton guidelines (Biggs, 2000) in the Upper Waitaki Catchment (see Table under paragraph 2.13). Given that Dr. Meredith has advocated the use of these criteria as the most suitable guidelines (paragraphs 25, 29 and 31 of his Section 42A Addendum Report) I think it is useful to clarify that there are a number of aspects to the guidelines.

6.02 In a particular region of New Zealand, it may be that additional instream values / variables could be added to the current three (i.e. aesthetics / recreation, benthic biodiversity and trout habitat / angling) listed by Biggs (2000). In response to the Meridian submissions for example it may be that power generation might be added as a value / variable that warrants a specific periphyton biomass threshold in hydro-electric canal habitats in the Canterbury region.

6.03 However in this instance, Mr. Bray (paragraphs 14 to 17) and Dr. Snelder are arguing it is necessary to re-develop a specific model that links nutrient levels and periphyton growth in the Upper Waitaki Catchment as conditions for periphyton growth are significantly different than in those rivers used to link nutrient levels and periphyton growth for the current national guidelines. A similar argument has been made for the Manawatu-Wanganui region (Kilroy et. al., 2008).

6.04 Moreover, as highlighted by Ludgate and Ryder (2010), the correct application of the guidelines to rivers dominated by Didymo has yet to be established. It may be that a different link or modelling relationship is required between nutrient availability and periphyton growth / biomass accrual for periphyton communities where Didymo is present and where Didymo is not present.

6.05 Given the national guidelines are just that, they are guidelines, it would appear reasonable that regional variations to the national periphyton guidelines could be incorporated in appropriate plans such as the PNRRP.

6.06 This would require an objective and defensible description of both current periphyton communities and nutrient concentrations in the region's waterways.

6.07 In paragraph 18 of his supplementary evidence, Mr. Bray has criticised the description of "worst case" periphyton biomass (maximum seasonal biomass). However, this is the only biomass condition that can be predicted using the current periphyton guidelines (Biggs, 2000).

6.08 Mr. Bray is correct in paragraphs 21 – 23 and 26b of his supplementary evidence that I have not considered enrichment effects on the habitat of *Galaxias cobitinis* and *Galaxias macronasus*. That is because I consider that a 25% increase in maximum seasonal periphyton biomass (rather than an increase in mean or median periphyton biomass [if this could be measured]) would not have other than a minor effect on instream community structure.

6.09 I agree with Mr. Bray (paragraph 26j of his supplementary evidence) that the use of created wetlands, swales draining to wetlands, denitrification treatment walls or denitrification beds could also be considered over and above those considered to minimise nutrient losses.

7.0 Evidence of Dr. Richard Allibone

7.01 In his evidence (paragraphs 58 – 60) Dr. Allibone has argued the effects assessment in the WQS should have considered all fish species but with significant attention to three key species, lowland long jaw galaxies, bignose galaxias and koara. My response is provided in paragraph 6.07 above.

7.02 I accept Dr. Allibone's criticism in paragraphs 63 to 63 of his evidence that I did not extend my assessment of the ecosystem to consider the full potential of effects and that there is no assessment of the effect of ecosystem change effects on diet and survival of key threatened fish. That was because I consider that a 25% increase in maximum seasonal periphyton biomass (rather than an increase in mean or median periphyton biomass [if this could be measured]) would not have other than a minor effect on instream community structure.

8.0 Evidence of Mr. Peter Ravenscroft

8.01 In paragraphs 40-50 of his evidence Mr. Ravenscroft has raised concerns with flushing flows in the habitats of long jaw or bignose galaxiids and that as individual small creeks and spring–type systems have not been studied as part of this application, it is difficult to properly assess the likely impacts on these receiving environments. Flushing flows do occur (albeit at relatively infrequent intervals) in all natural waterways in the catchment of Lake Benmore.

8.02 The reason I did not study individual small creeks and spring-type systems as part of this application is because the scale of the WQS was at a catchment and subcatchment level. Smaller receiving environments such as creeks are considered in individual Farm Environmental Management Plans. Moreover, I consider that a 25% increase in maximum seasonal periphyton biomass (rather than an increase in mean or median periphyton biomass [if this could be measured]) would not have other than a minor effect on instream community structure.

9.0 Section 42A Officers Report of Dr. Marc Schallenberg

9.01 In paragraph 18 of his report, Dr. Schallenberg states the risk of key effects thresholds being breached increases exponentially with increasing nutrient loads (i.e. biological productivity). Consequently, as the nutrient loading of the lakes increases, the temporal variability in ecological responses (e.g. algal biomass) will also increase, augmenting the risk of algal blooms in a multiplicative way.

9.02 In this regard, I refer to Table 3, under paragraph 6.6 of my Evidence in Chief that classifies oligotrophic lakes as having no risk of toxic algal blooms and a very low risk of a green colour in very clear water. The issues that Dr. Schallenberg is highlighting in terms of "exponential risks" occur on the boundary of mestotrophic and eutrophic lakes, not on the boundary of oligotrophic to mesotrophic lakes and the management objectives of the WQS (GHD, 2009) is to ensure neither arm of Lake Benmore exceeds an oligotrophic status.

References

ANZECC and ARMICANZ, 2000. Australia and New Zealand guidelines for fresh and marine water quality, Volume 1, The guidelines. National water quality management strategy; no.4. *Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand, Canberra. ISBN 09578245 0 5, ISSN 1038 7072.*

Biggs, B., 2000: New Zealand Periphyton Guideline. Detecting, Monitoring and Managing Enrichment of Streams.
NIWA report prepared for the Ministry of the Environment June 2000.

Burns, N., Bryers, G and Bowman, E., 2000: Protocol for Monitoring Trophic Levels of New Zealand Lakes and Reservoirs.
Lakes Consulting Client Report: 99/2 prepared for the Ministry for the Environment, March 2000.

Champion, P., Clayton, J. and Rowe, D., 2002: Lake Manager's Handbook. Alien Invaders.
A report prepared for the Ministry for the Environment, PO Box 10-362, Wellington, New Zealand. ISBN: 0-478-24068-6 ME number: 444, June 2002.

Clayton, J and Edwards, T., 2006: LakeSPI A method for monitoring ecological condition in New Zealand lakes

National Institute of Water & Atmospheric Research Ltd Technical Report Version 2, June 2006. NIWA Project: CRBV062.

Coffey, B., 2009: Upper Waitaki Basin – Follow up Stream Surveys to Assess the Effects of Irrigation on Nutrient Runoff to Waterways. April 2009.
Brian T. Coffey and Associates Limited: S.S. Up. Waitaki /GHD/ V.1 July 2009. A report prepared for GHD Limited, P.O. Box 76477, Manukau City (2241).

Coffey, B., Anthony, M. and Leckie, H., 2008: Upper Waitaki Basin – Accumulated Effects of Nutrient Runoff: Selected Stream Survey, April 2008.
Brian T. Coffey and Associates Limited: S.S. Up. Waitaki /GHD/ V.2 June 2008. A report prepared for GHD Limited, P.O. Box 76477, Manukau City (2241).

Desbrow, C., Routledge, E.J., Brighty, G.C., Sumpter, J.P., and Waldock, M., 1998, Identification of estrogenic chemicals in STW effluent—1. Chemical fractionation and in vitro biological screening.
Environmental Science and Technology, v. 32, p. 1,549–1,558.

Elliott, S. and Sorrell, B., 2002: Lake Manager's Handbook. Land-Water Interactions.
A report prepared for the Ministry for the Environment, PO Box 10-362, Wellington, New Zealand. ISBN: 0-478-24066-x ME number: 442, June 2002.

GHD, 2009: Cumulative Water Quality Effects of Nutrients from Agricultural Intensification in the Upper Waitaki Basin. Rivers and Lakes Report.
A draft and confidential report prepared for Russell McVeagh on behalf of Mackenzie Water Research Limited, April 2009.

James, M., Mark, A. and Single, M., 2002: Lake Manager's Handbook. Lake Level Management.
A report prepared for the Ministry for the Environment, PO Box 10-362, Wellington, New Zealand. ISBN: 0-478-24067-8 ME number: 443, June 2002.

Johnson, A.C., and Sumpter, J.P., 2001, Removal of endocrine-disrupting chemicals in activated sludge treatment works.
Environmental Science and Technology, v. 35, p. 4,697–4,703.

Kilroy, C., Biggs, B. and Death, d., 2008: A periphyton monitoring plan for the Manawatu-Wanganui region.
NIWA Client Report: CHC2008-03 preparted for Horizons Regional Council, April 2008.

Lee, K.E., Yaeger, C.S., Jahns, N.D., and Schoenfuss, H.L., 2008, Occurrence of endocrine active compounds and biological responses in the Mississippi River—study design and data, June through August 2006.
U.S. Geological Survey Data Series 368, 27 p. with Appendix.

Ludgate, B. and Ryder, G., 2010: Mackenzie Water Research Limited. Node Periphyton and Macrophyte Surveys.
A report prepared by Ryder Consulting Limited, 2010.

Meridian, 2008: Discover the Waitaki Hydro Scheme.
Meridian Energy MFS0009 11/08 MED0104

Norton, N., Spigel, B., Sutherland, D., Trolle, D and Plew, D., 2009: Lake Benmore Water Quality: a modelling method to assist with limits for nutrient loadings.
NIWA Client Report: CHC2009-091 June 2009 NIWA Project: ENC09515. A Report prepared for Environment Canterbury.

Rowe, D. K. and Graynoth,., 2002: Lake Manager's Handbook. Fish in New Zealand Lakes.
A report prepared for the Ministry for the Environment, PO Box 10-362, Wellington, New Zealand. ISBN: 0-478-24069-4 ME number: 445, June 2002.

Sinclair Knight Mertz, 2004: National Cost Benefit Analysis of Proposals to Take Water from the Waitaki Catchment.
Contract report prepared for New Zealand Ministry of Economic Development by Sinclair Knight Mertz.

Ternes, T.A., Stumpf, M., Mueller, J., Haberer, K., Wilken, R.D., Servos, M., 1999, Behavior and occurrence of estrogens in municipal sewage treatment plants—I. Investigations in Germany,

Canada, and Brazil.
Science of the Total Environment. v. 225, no. 1–2, p. 81–90.

Vant, WN (ed.) 1987. *Lake Manager's Handbook.*
Water and Soil Miscellaneous Publication No. 103. National Water and Soil Conservation Authority: Wellington, New Zealand. 222 p.

Wilks, T., Norton, N and Meredith, A, 2009: Periphyton growth and nutrient limitation in rivers of the upper Waitaki catchment.
Environment Canterbury Report No. R09/106. ISBN: 978-1-877542-58-9 December 2009.