APPENDIX B
PRELIMINARY SUMMARY OF ISSUES IN SECTION 42A REPORTS

Dr Mark Schallenberg (Liminology)

Para #	ISSUE IDENTIFIED IN REPORT	RESPONSE
Limitations on calculated nutrient loading rates		
Concerns approach relating to the of assessing impacts on the lakes		
15	**Limited scope of assessment of effects on lakes**: The predictions of lake responses are restricted only to predictions of changes to total nitrogen (TN) and total phosphorus (TP) components of the trophic level index. The TLI normally incorporates two additional components, chlorophyll *a* and Secchi disc depth, to incorporate effects related to phytoplankton biomass and the light climate, respectively. The MWRL approach ignores relationships between nutrient and potentially important ecological responses.	In the method described by Burns, the TLI is calculated separately based on TN, TP, Chlorophyll a, and Secchi Disc Depth and then averaged all 4 TLI values to get average representation of all 4 parameters. However in our report, we have presented TLI based on TN and TP. The measured chlorophyll-*a* levels are very low and below detectable limits on most occasions. Moreover, for these lakes, TLI values based on Secchi may not represent accurate indication of eutrophic levels as glacial flours has changed the colour of water. Oligotrophic and Mesotrophic lakes are mostly non productive lakes and as suggested, a more microscopic type study of changes to phytoplankton community composition may be required if the trophic state of the lake goes below oligotrophic levels.
16	**Over-simplified pressure-response approach**: The TLI calculations in the report assume that the nutrient loads are uniformly diluted by the lake's (or basin's) volume and that no other processes will affect the resultant lake nutrient concentrations. This simplified pressure-response approach ignores chemical, physical and biological processes within the lakes which may modify nutrient concentrations.	Measured data shows no indication of high temporal variability of nutrient concentration within the Lake Benmore and as described above these lakes have very low productivity. No measured data is available at this stage to evaluate N and P retention efficiency and these types of estimate required monitoring of lakes for a considerable period. It is recommended that monitoring of sediment nutrient parameters be included in future monitoring programs. With respect to storage of P in lakes, there was insufficient data to model storage. As an aside, P mass balance was run using the storage coefficients presented in the GPF report. Where Lake Benmore storage was considered (12% retention for N Arm and 31% for the A Arm) there was 3.7 % difference between estimated and observed P losses (derived by concentration of flows leaving the catchment). Where upper lake storage was also considered (45 %, 49% and 39 % for Tekapo, Pukaki and Ohau) in addition to Lake Benmore

Para #	ISSUE IDENTIFIED IN REPORT	RESPONSE
		storage, the estimated losses underestimated the observed losses by 12.4 %.
17	**Temporal resolution is insufficient to assess the likelihood of important lake effects**: Throughout the MWRL report, annual means are relied upon to predict lake responses. However, biological responses, such as algal growth rates, can be rapid and blooms may be related to prior flood events. Thus, an annual mean water residence time or annual mean nutrient load will not necessarily accurately predict the likelihood of algal blooms occurring in the rivers or lakes.	Temporal resolution model at lower scale has already been carried out by NIWA "Lake Benmore Water Quality: a modelling method to assist with assessments of nutrient loadings", August 2009. The findings of NIWA report indicate that the nutrient load caps estimated in the GHD Lake and River report are more conservative.
18	**Predictions ignore effects on ecological variability**: It is a general rule in ecology that population variability increases as the mean population size increases (McArdle et al. 1990). A risk analysis approach accounting for increasing variability in key effects with increasing irrigation, would be an appropriate way to address this issue.	The approach presented in the GHD lake and river report and the NIWA report is a "Deterministic Modelling" approach (estimated by real time modelling based on measured data). Stochastic (statistical) type modelling as suggested may require long period of measured data series and predictions will be associated with uncertainties as well.
19	**Climate change**: No mention is made in the MWRL report of the potential impacts of climate change on the ecology of the lakes and rivers under the various irrigation scenarios.	Climate change has not been considered in our estimates, nor NIWA estimates. The limited work that has been done in NZ indicates that climate change will increase mean annual alpine river flow and reduce groundwater recharge (and therefore nutrient leaching risk) to the east of dividing ranges. We do not expect climate change to impact adversely on water quality in the Upper Waitaki.
20	**Analysis of risks**: Given the uncertainties regarding effects of the proposed irrigation scheme on the water quality, ecology and life sustaining capacity of the lower Waitaki lakes, a risk assessment should be carried out which: i) increases the scope of lake impacts examined as outlined above, ii) examines impacts and risks on monthly time steps, iii) acknowledges that, as the nutrient loading increases, the biological variability and risk of algal blooms will increase disproportionately, and iv) which considers how climate change may exacerbate the	To address the risk factor, the threshold has been set below the Oligotrophic and Mesotrophic boundary (20% below the boundary for total nitrogen and 15% below the boundary for total phosphorus, TLI of 2.75).

Para #	ISSUE IDENTIFIED IN REPORT	RESPONSE
	impacts of the irrigation development on the lakes.	
21	**Adaptive management as a precautionary approach to dealing with uncertainties**: The uncertainties about the ecological impacts on Lake Benmore and other affected lakes are unacceptably high. No adaptive management approach has been proposed in the MWRL report. A major and significant reduction in these uncertainties is required.	The uncertainties have been addressed by setting the threshold at a lower level as described above (para 20). Adaptive management is most useful when large complex ecological systems are being managed and management decisions cannot wait for research to eliminate uncertainty. The specific adaptive management strategies put forward for the basin are outlined in John Kyle's evidence.

Thomas Heller (Hydrology and Hydrogeology)

Para #	Issue identified in s42A report	Response
64	The reported value for evaporation from Lake Benmore appears high at an annual average of 4,500 L/s over the 7,585 ha surface area of the lake. I consider that a likely range based upon evaporation rates from open water bodies in the upper Waitaki catchment is in the order of 2,200 L/s. However, this component of the water balance has little impact upon the water quality assessment for the lake.	The estimate of evaporation from Lake Benmore is 2,500 L/s not 4,500 L/s. This is presented in Figure 27 – Lake and River report. The actual GHD estimate is close to Mr Heller's estimate. We agree with Mr Heller that this component has little impact on lake water balance.
AUDIT OF GHD SUMMARY REPORT		
Existing Environment - Groundwater		
21,22, 26	The application of the N attenuation factor is questionable and has a large degree of uncertainty. There are no results or calculations given for attenuated N within the mass balances given in the GHD reports. (para 22) The modelled groundwater quality for the Wairepo and Chain Hill sub-catchments appears to be inconsistent with monitoring data.(para 26))	In GHD spreadsheet toolkit. Appendix A groundwater report maps contain input parameters. The recent irrigation development and lag time associated with the manifestation of the impacts of land use on the water quality is used to explain the differences in the Wairepo sub-catchment. The GHD method does not, in fact, apply any attenuation factor to nitrate leached from the soil (only where g/w discharges to s/w). The GHD modelling methodology predicts the full long-term effects of irrigation development on groundwater quality. Consequently it over estimates the current concentration of nutrients in groundwater in areas downstream of recent irrigation development.
Existing Environment - Rivers and Lakes		
28	The mass balance nutrient assessment has relied upon N as "nitrate", there has been no assessment of other forms of N. There is a clear omission within the GHD reporting of sub-catchment analysis of the proportion of total-N associated with riparian activities and not groundwater N transport (para 28).	In GHD spreadsheet toolkit. Appendix A groundwater report maps contain input parameters. In agricultural systems, nitrate is the predominant species to be lost, and therefore will become more important in the areas of proposed agricultural expansion and intensification.

30	I cannot confirm that the residence times given by the applicants' consultants are truly reflective of the average residence time for each of the Northern and Ahuriri Arms of Lake Benmore.	Residence time can vary with the changing lake volumes and mixing depth. The value presented in Section 5.5 is based on lake water level is about 4-5 m below the dam crest level and assuming both arm of the lake as one water body.
Future Environment		
32	For specific sub-catchment or river reach assessments, any significant changes to surface water flow statistics should be accounted for with respect to water quality determination ie to take account of flow reductions as a consequence of abstractions. As far as I can determine, this adjustment for sub-catchment effects analysis has not been undertaken.	The GHD methodology does not take account of the effects of the proposed water takes on the mean annual flow in streams and rivers. However, the maximum annual volume of water proposed to be taken to irrigate an additional 25,000 hectare is less than 1.5% of the average annual volume passing Benmore Dam. This is less than the flow measurement error.
35	From an individual sub-catchment perspective I am unable to audit the projected increases to groundwater N concentration as insufficient detail of these balances is given ie there is insufficient information given on drainage volumes along with information on drainage quality.	The information sought is in the GHD spreadsheet toolkit.
AUDIT OF GHD REPORT APPENDICES		
Modelling		
40	It is not clear from the modelling work what layer geometry has been employed into the model and how the deep groundwater system behaves independently to that of the water table aquifer.	In GHD spreadsheet toolkit. Groundwater system has been modelled as a two layer system. The top layer generally has a higher conductivity than the lower layer. Exchanges of water and nutrients between the top layer and rivers, and the top layer and the bottom layer, is quantified in the GHD spreadsheet toolkit.
42	In terms of groundwater modelling there is a clear lack of hydraulic parameter scale and distribution with regard to model inputs. I am unable to audit the model functionality given the lack of model reporting for hydraulic parameters, fluxes and boundary information provided by the applicants consultants.	Can provide hydraulic parameters, other parameters in Appendix A of the groundwater report. The GHD groundwater model provides an appropriate representation of the groundwater system.
43	General absence of model methodology reporting and/or specific modelling report. Given the absence of such information I cannot provide any detailed audit of the certainty of model prediction	Model methodology is set out in the Groundwater Report.

	made for inclusion into the water and nutrient balance reporting.	
44	There is an absence of model water balance reporting for sub-catchments and I am unable to identify individual groundwater sub-catchment water inputs and outputs.	In GHD groundwater spreadsheet toolkit.
45	Within the groundwater sub-catchments, all groundwater is likely to discharge to surface waters before entering Lake Benmore, with only the lower Ahuriri and lower Tekapo areas having localised groundwater discharges to the lake.	We do not agree. Surface water discharges from sub-catchment through shallow streams or perched watercourses. Significant discharges are through groundwater. Depth to basement around the edges of L Benmore where Tekapo, Pukaki and Ohau rivers converge is reported in Cooksey (2008) to be approximately 20 metres. Such a thickness of post glacial outwash gravels can reasonably be expected to discharge the volume of water to L Benmore that has been estimated by GHD.
46	The methodology employed by the applicants' consultants is deficient in identification of individual reach or key sub-catchment cumulative effects as groundwater volumes and N loads may by-pass individual stream nodes. This is evident in the lower Grays and Tekapo River areas.	We do not agree. Water balances indicate significant groundwater discharge even through the Tekapo River and Grays Hills. The WQS methodology uses monitoring at both surface water and groundwater nodes specifically to avoid missing significant nutrient transport pathways.
48	I am unable to identify where and how soil and riparian attenuation has been applied to the groundwater N balance.	In GHD groundwater spreadsheet toolkit. The WQS method does not, in fact, apply any attenuation factor to nitrate leached from the soil (only through riparian zones where groundwater discharges to surface water).
51,52, 54	An accurate assessment of cumulated water quality impact of irrigation development on specific surface water nodes should have been undertaken at mean annual low flow (MALF) to better represent critical stream flows. By considering just the mean flow condition, the applicants consultants have not assessed any variability in groundwater N inputs, surface water N and P variation, and the effects of resultant stream nutrient concentrations during low flow periods.	Ideally that should be the case. However, data shows highest nitrate concentrations during early winter high flows and lowest concentrations during summer low flows i.e. MALF. Dr Meredith (item 32) recognises the winter "washout" of soil nitrogen. The use of MALF is not robust. In this environment MALF can occur during winter months. At this time biological activity will be constrained by low water temperatures and low solar radiation, not driven by nutrient concentrations. Even if nutrient concentrations are high in winter they may not result in nuisance growths. Reliable estimates of MALF are not available for all relevant streams. It is, however, feasible to estimate mean flow – which is the GHD approach.
62	There appears to be consistency with the Lake Benmore outflows for the total water balance. However as the majority of the inflow is contained within the Ohau canal (about 75% of flow to the lake)	Conservative assumption may indicate that. Calculations in GHD spreadsheet toolkit. It is accepted that the overall water balance is correct, and that the proportion coming in from the canals in correct and that the proportion coming in

	there may be significant errors contained within individual sub-catchment flows whilst maintaining a reasonable overall water balance for the lake.	from the Ahuriri Arm is correct. There are no specific examples of where the mean flows used are not thought to be correct.
63	The Ahuriri Arm inflows are given as approximately 10% of the Northern Arm inflows, which I consider to be correct based upon hydrologic stream flow statistics for mean flow. However, no analysis of seasonality is given for this relationship if variability in cumulative water effects of water quality in Lake Benmore.	Ahuriri Arm inflows as a percentage of Northern Arm flows vary between 6% and 14%. In late summer and autumn the proportion lies between 6 and 9%, due to lower Ahuriri flows and higher power generation flows.
66	Stream flows utilised in the analysis to depict a low flow state have been set at the naturalised 7-day MALF (ECan, 2009a). It should be noted that the natural MALF does not include any hydrologic alteration from water abstraction and is thus less conservative for the environment in that respect.	Naturalised MALF estimates are not reliable because insufficient water take or discharge measurements exist for use in the "naturalisation" process. See ECan report R05/16.
68	It is uncertain that MALF flow conditions may occur for all waterways in respect of the timing of MALF for flow input from the Ohau canal.	See comment on items 51,52 and 54
71	The results for specific waterway N concentrations contained within Table 23 of the GHD Rivers and Streams Report are directly comparable to the mass balances provided by the applicants' consultants. However, these concentrations are unable to be verified, given the lack of mass balance component reporting on a sub-catchment level.	Calculations in GHD spreadsheet toolkit Mass balances are given in Appendix CC including reaches and sub catchments
79	The results given in the GHD reports for mass water and nutrient balances may provide for a broad assessment of regional water quality effects of irrigation development. However I am uncertain that the results are useful on a sub-catchment scale due to the deficiencies identified with respect to groundwater and surface water mixing, and that the relative nutrient inputs determined and reported are unable to be audited. I also consider that the methodology for providing mass balances to be flawed.	The information sought is in the GHD spreadsheet toolkit. There is sufficient information in them to enable auditing.

AUDIT OF GROUNDWATER REPORT		
Groundwater subcatchments		
81	There appears to be higher LSR and overall recharge volumes in sub-catchments provided in the GHD report to that given in SKM (2004). However, the SKM report had only focused on rainfall recharge to aquifer zones and did not consider interzone or catchment water transfer or lake and stream leakage. Whilst I consider that the overall values for aquifer recharge may be suitable for groundwater subcatchments in the assessment, I cannot provide a complete audit of this as the calculation of recharge components for groundwater sub-catchments is not transparent.	Calculations in GHD spreadsheet toolkit. The increased irrigated area will increase LSR in sub-catchments. This is reflected in the GHD recharge volumes.
Groundwater modelling		
90	In general, there is an apparent lack of hydraulic parameter detail for model generation and output processes. This makes it inherently difficult to asses the adequacy of the model and to be able to assess individual sub-catchments with respect to groundwater flows and N fluxes. This is also apparent for model calibration and verification, whereby only a single set of observation data has been given to validate the model. The correlation, whilst showing that the model does behave similar to the piezometric data, the variation of modelled to measured levels is quite large at some elevations (up to a 20 m difference). However, as stated previously, I cannot provide any further detailed audit of the models based on the inadequacy of reported model data.	Can provide hydraulic parameters, other parameters in Appendix A of the groundwater report. The piezometric head in bores monitored "is likely to be variable both laterally and vertically due to the variable nature of outwash gravel deposits and from re-working by subsequent glacial processes" (Cooksey, 2008)
Groundwater environment		
92	I am unable to quantify how highland recharge is calculated for each sub-catchment. This form of recharge is significant when compared to other forms of recharge. However, apart from the Ahuriri highland recharge (122.8 Mm3/annum) other groundwater sub-catchment highland recharge appears to be of the correct	Detailed discussions and examples are in Chapter 7 of the groundwater report. See section 7.1.1, Table 5 and schematic Figure 10

	order from my review of the resulting values.	
94	The irrigation drainage is also presented by the applicants' consultants (based upon work completed in Aqualinc, 2008) being based around "Irricalc" irrigation demand and the resulting soil water drainage for an average seasonal demand year. The irrigation depths provided by Irricalc may be at the higher end of expected use for an average season, which also corresponds to greater drainage depths than expected. However, for the purposes of the cumulative water quality effects assessment, the drainage depths indicated are then conservative, as a greater N-load in groundwater is likely to result. However, as indicated in evidence of Mr Hanson, the specific calculations of groundwater flow and nutrient input are not transparent and are unable to be audited.	Calculations in GHD spreadsheet toolkit
95	Stream or lake leakage contributions to aquifer sub-catchment recharge is not given within the GHD report and I am unable to identify where this flux is applied to modelling or water balances within the cumulative water quality assessment. These flow gains and losses are only presented in Figures (contained in the report) and are not shown in water balances or groundwater recharge calculations.	Calculations in GHD spreadsheet toolkit
97	The general groundwater flow vectors provided by the applicants' consultants describe broadly the groundwater movement within the region and in each groundwater sub-catchment. There is insufficient resolution within the model output to accurately describe groundwater movement at an individual property scale. However, a broad estimate of sub-catchment groundwater movement may be sufficient to obtain appropriate mass balances for annual average water quality estimates.	The cumulative model not targeted to individual properties.
98	However, when considering Table 5 and Table 8 of the groundwater report, the values for groundwater sub-catchment recharge are difficult to follow. For instance, the volumes of groundwater flow in mass balances are lower than that given for the total groundwater through-flow in Table 5 and Table 8. Given	Calculations in GHD spreadsheet toolkit

	the lack of detail of these components and how they are applied in modelling and mass balances, I am unable to agree that the applicants' consultants have provided a useful cumulative effects assessment.	
99	The applicant's assessment of individual sub-catchments or individual stream reaches (other than at nodes) is somewhat incomplete. The assessment has not been achieved at any reaches or nodes for a low-flow scenario. It is suggested that the equivalent 7-day MALF is the appropriate low flow to assess such impacts upon specific stream reaches or nodes within sub-catchments.	See comment on items 51,52 and 54, Calculations in GHD spreadsheet toolkit

Carl Robert Hanson - Groundwater

Para #	Issue identified in s42A report	Response
Assessment methodology - nitrate loading		
23 - 26	The shortfall in this methodology is that it does not account for variations in stream flow at the discharge nodes. While groundwater discharge at the node may be relatively constant throughout the year, surface flows vary considerably. In periods of low flow, when the surface flow is dominated by groundwater discharge, nitrate-N concentrations could be similar to the groundwater concentrations listed in Table 17 of the Summary Report. Many of these concentration are considerably greater than 1 mg/L, and this could cause unacceptable water quality effects in surface water.	Corrected in final report We agree with use of average annual values for N concentration in g/w. Suggests that at low river flows there will be limited capacity to dilute any groundwater discharges thus causing acute nutrient impact in river. See response to Heller 51,52, 54.
Assessment methodology - nitrate-N Concentrations in groundwater		
28	Beneath the Canterbury Plains, the average nitrate-N concentration in shallow groundwater (groundwater recharged primarily by land surface drainage rather than by losses from rivers) is on the order of 5 to 6 mg/L (Environment Canterbury unpublished data). This concentration is considerably lower than the drinking-water standard. However, there are many locations across the Plains where average concentrations are higher than this, and in some locations average concentrations do exceed 11.3 mg/L.	This is not expected even under worst case model scenarios. Not an issue because generally water supply bores do not take water at the water table (which is where the highest N concentrations are usually found). People prefer to go deeper to gain a more reliable water supply and therefore higher quality water.
29	Moreover, seasonal peak concentrations greater than 11.3 mg/L are common in shallow groundwater across most of the Plains, particularly after wet winters (Hanson, 2002; Hanson and Abraham, 2009; Environment Canterbury unpublished data). In the latest of Environment Canterbury's annual, region-wide groundwater quality surveys, conducted in the spring of 2008, the samples from 35 of the 302 wells surveyed had nitrate-N concentrations greater than 11.3 mg/L (Abraham and Hanson, 2009). These peak concentrations may only persist for a few months at a time, but since the drinking-water standard is based on the health risk from shortterm exposure (Ministry of Health,	Discussed in the Groundwater Report and may be controlled through monitoring. The issue is whether nitrate concentration exceeds the drinking water standard at the depth from which water is pumped. Given that the predicted nitrate concentration, averaged over the thickness of the shallow aquifer, is typically less than 1 mg/l, it is reasonable to expect that groundwater that meets the drinking water standard will continue to accessible.

	2008), these short-term exceedences are important.	
30	Nitrate-N concentrations observed in groundwater in the Upper Waitaki Basin (see discussion below) have been much lower than the concentrations observed beneath the Canterbury Plains, and it is unlikely that current concentrations anywhere in the basin approach the drinking-water standard at any time of year. However, Table 17 on page 52 of the Summary Report lists predicted long-term average concentrations up to 8.7 mg/L (for the Willow Burn sub-catchment under Scenario 4). If such average concentrations did develop, then it is likely that concentrations at some locations within that sub-catchment would exceed the drinking-water standard on some occasions. Such exceedences would be most likely down-gradient of large irrigated areas, such as those proposed in the Willow Burn, Wairepo, Ahuriri, and Pukaki sub-catchments. Furthermore, the section 42A report by Dr Clothier (report 4b) indicates that the nitrogen loading estimates in the assessment could significantly under-estimate the potential loadings. If that is the case, the nitrate-N concentrations in groundwater could be significantly higher than the assessment predicts.	Parameters are listed in Appendix A of the groundwater report. Corrections have been made in Aqualinc for Table 5. The proposed modelled groundwater concentrations for highly developed scenario, such as that quote for the Willow Burn are unmitigated. IN reality significant mitigation targets for all proposed irrigated land draining into the Ahuriri Arm are proposed.
Lack of information to support assessment conclusions		
36,37,38	The area of each land use in each sub-catchment. Details of how the AgResearch model results were incorporated into the calculation of sub-catchments nitrate-N loading. For each sub-catchment, the areas of all combinations of irrigation, rainfall and soil pore-available water (PAW) for which Aqualinc (2008) modelled soil drainage rates.	In GHD spreadsheet toolkit.
40	The discussion of highland recharge is very confusing. I cannot find the areas used to calculate these recharge volumes to be listed or mapped in any of the assessment reports.	The dry Pukaki River shown is due to Pukaki Lake regulation and the magnitude of groundwater discharge to the Tekapo River has been calculated and presented in the groundwater report.
41	Confused by the discussion of deep, regional groundwater flow. It is not clear to me where this regional flow comes from. Where it goes, or how it is involved in groundwater nitrate concentrations and discharges	Detailed discussions and examples are in Chapter 7 of the groundwater report. See section 7.1.1, Table 5 and schematic Figure 10

	to surface water.	
44	Phosphorous in groundwater is almost virtually ignored by the WQS. IT is not clear whether groundwater provides a pathway for phosphorous to enter surface water. The assessment appears to assume that groundwater discharges are not a source of phosphorous in surface water. The reports discuss phosphorous losses from farms, but it is not clear how the phosphorous is lost or what happens to it.	The WQS analysis assumes that all phosphorous lost from farms enters surface water directly. This is a worst case scenario for phosphorous concentration in rivers and streams.
Monitoring		
52	The number of monitoring points are not sufficient to monitor the effects of the proposed development.	States that many more bores are required than has been proposed for monitoring effects. The explanation given is appropriate for a regional council investigation of g/w structure and function, but unnecessary for monitoring the effects of the proposed activity.

Dr Brent Clothier - Modelling of Nitrogen leaching losses

Para #	Issue identified in s42A report	Response
21	Using the "Highly Developed" option provides and upper limit on the nutrient losses from the properties.	We agree.
22	Lack of comparison between the AgResearch estimates of nutrient losses and earlier work by Green (2005). .	Such a comparison was presented in Para 43-44 of the evidence of Snow (2009). In summary Green (2005) assumed different irrigation inputs, fertiliser inputs, and farm management systems that all will cause higher estimated leaching than the assumed inputs and management in the AgResearch assessments.
23	New modelling with SPASMO that might produce even higher leaching estimates than the Green (2005)	This is of some concern because the 2005 nutrient loss estimates were already too high to be consistent with measured water quality in the Basin.
24	Dr Clothier does not agree with the values of the nutrient estimates produced but argues that it is the modelling of the inputs rather than the OVERSEER® methodology that is at fault.	We agree with, and are heartened to see, the statement in Para 24 that Dr Clothier endorses OVERSEER® for work in the Mackenzie Basin and finds that it should be useful in assessing and auditing mitigations. While we do not agreed with Dr Clothier's statements about the inputs, the corollary of Dr Clothier's statement is that when 'real', rather than modelled, input and production data are available from irrigated farming systems then more reliable nutrient calculations will be produced and that they will be suitable within an audited nutrient discharge management system.

30-38	Dr Clothier states, in Paragraphs 30 to 38, that in his opinion the modelled irrigated pasture growth from EcoMod produced production values that were unrealistically high. He compares the EcoMod pasture production against measurements from trials conducted during the 1980s in the Mackenzie Basin.	Those measurements produced irrigated yields generally of the order of 5 t DM /ha /yr on the lighter soils and 10 t DM /ha /yr on the heavier soils that can store more plant-available water. The EcoMod yields were generally about 15 t DM /ha /yr. There is a sound reason for the differences. The irrigation trials in the 1980s were done with a return interval or 14 or 21 days where as the irrigation design for the consent applicants is for pivot irrigation with return intervals of 2 to 4 days. When EcoMod is setup with 14- or 21-day return intervals irrigation then yields consistent with those measured in the earlier trials are obtained. This is shown on page 47 of the evidence produced by Snow (2009). I suggest that rather than EcoMod estimating pasture yields that are too high, it is more the case that the old irrigation trials are not a good indication of likely growth under modern irrigation systems. This conclusion is supported by the Farmax modelling of properties with existing areas of pivot irrigation in the Basin which suggested higher growth rates than those modelled by EcoMod.
28	Dr Clothier compares the growth rates from EcoMod against those used in farm scenarios prepared by Macfarlane Rural Business (2009). In those scenarios the pasture production used was 11.5 t DM /ha /yr in the sheep/beef scenarios and 10.4 t DM /ha /yr in the dairy scenarios.	I have corresponded with Mr Hugh Eaton (Macfarlane Rural Business, Ashburton), senior author of the report. Mr Eaton replied that there was no reliable measured pasture growth under modern pivot irrigation systems in the Mackenzie District available and that "... the pasture growth rates were estimated from clients' actual farming systems in the Fairlie and Mackenzie Basins not trial data. One model has to represent a range of soil types and rainfall [and] ... a range of management ability to grow grass and utilise it. We have assumed good average management skills. Consequently the pasture production used in the modelling will probably be significantly less than the potential that could be reached on a good site from cage cuts. We did not want to overestimate financial returns from irrigation by using unrealistic pasture production. Individuals with good soils, and intensive pivot irrigated farming systems will be able to achieve the pasture growth rates you are suggesting of 12-14t but we chose to be conservative for model farm systems representing a range of properties."
29	Contrary to the Eco Mod modelled predictions of Ag Research, location, rainfall zone and soil type can have a significant effect on growth rate.	Dr Clothier has extrapolated a statement well beyond the context in which it was made. He is correct in that the report describing the pasture growth modelling (Snow and King 2008) stated that there was no significant effect of soil type or rainfall zone on modelled irrigated pasture growth. However this was clearly in the context of using the pivot irrigation systems designed by Aqualinc (see Aqualinc Research Limited 2008) that were tailored to the soil type and rainfall zone concerned. It is clearly not appropriate to take the statement out of that context and apply it to very different irrigation systems. Modelling of irrigation systems similar to those in the trials that Dr Clothier cites was reported in the evidence (see

		Appendix 5, Snow 2009) and compares well against the data he cites.
30-31	In Paragraph 30 Dr Clothier states that "... there seems to be some issues with how the EcoMod model predicts pasture growth since it does not reflect the observations that pasture growth rates and yields vary across the different landscapes of the Upper Waitaki basin". The crux of Dr Clothier's concerns about the effect of the pasture modelling is given in Paragraph 31 as "...Such an over-prediction of pasture yield, such that silage can be made rather than using imported feed, would when used as an input into OVERSEER® likely result in an under-prediction of nitrate leaching"	This is only partially correct as if the pasture yield is not achievable on farm then the effect of this will depend on the management actions of the farmer. If the stocking rate and target production is maintained and feed gap is filled with N fertiliser then leaching will increase. If the feed gap is filled with imported silage there will be no effect on leaching. If the feed gap is filled with imported concentrate then leaching will likely decrease. If stocking rate or target production declines to meet the pasture production then, all other things being equal, leaching will decline as well. In all cases the farmers will be capped to their assigned NDA so the point will become moot.
35-36	Paragraphs 35 and 36 are again concerned with trials of pasture production levels under irrigated conditions with a 14-day return interval and with treatments including the addition of N fertiliser. Dr Clothier chose to include the growth pattern of a single-species planting of Apanui cocksfoot (see Figure 2 in Clothier 2009; reproduced from Figure 3 in Scott and Maunsell 1981) to demonstrate that the summer growth rates used in the AgResearch modelling were unrealistically high.	A more realistic comparison, despite the differences in the irrigation systems, would have been the higher growth rates achieved by the ryegrass-white clover mixture that were presented in the original publication (Scott and Maunsell 1981). Dr Clothier's interpretation of the work of Scott and Maunsell (1981) shown Figure 4 in Dr Clothier's evidence is in conflict with the original text of the publication. Dr Clothier interprets the vertical axis as an annual yield in t DM /ha where as the original text gives the yield response as "... increase in yield relative to unamended soil ..." (Scott and Maunsell 1981, page 287) so the figure is more correctly interpreted as a 15-fold response rather than a 15 t DM /ha /yr yield (Clothier 2009, Paragraph 36). This response was also for grass-only treatments rather than the normal grass-legume mix that will likely be used in irrigated pastures in the Basin.
38	Green (2005) used SPASMO to predict nitrate leaching. They considered 10.2 t-DM/ha/yr would be eaten from pasture receiving 200 kg-N/ha/yr of fertiliser.	We have not been able to find any reference to describe the "GROW" model and have not yet discussed this with Mr Ford so cannot provide comment here.
40	Paragraph 40 and Table present modelled leaching from a dairy farm for a range of different soil types reproduced from Green (2005, Table 10).	It is interesting to note that the SPASMO modelling in 2005 predicted greater leaching from sheep systems than from the dairy systems (see Green 2005, Table 8 compared to Table 10) which is contrary to most expectations and only seen in our modelling when comparing the most intensive sheep and beef systems to the lowest intensity dairy systems under the "Highly Developed" scenario. As soil organic matter will generally accumulate after the dryland systems are irrigated, this might suggest some quirks in SPASMO's calculations of C and N dynamics in soil.

41		In reference to Dr Clothier's calculations the difference is not "42% to 85% less than" but is actually "42% to 85% of" or "58% to 15% less than".
40		While we have concerns over the validity of the input assumptions and the SPASMO modelling we do agree that the nutrient estimates in the AgResearch modelling are likely to be low for the lighter soils (Snow 2009, Paragraph 51 and 52; Monaghan 2009, Paragraph 16 and 17) and probably under-states the soil-to-soil variation. The spread of the leaching estimates in Dr Clothier's Table 1 might give a better indication of the spread across soil types. Properties are unlikely to have only one soil type so considering the average of the two lighter soil compared to the two heavier soils this gives a range of about 15 kg N /ha /yr. As a worst-case scenario perhaps the leaching from the dairy farms on the lightest might be 7-15 kg N /ha /yr higher than that modelled and presented in Figure 7 and Table A3 of Snow (2009).
42	Dr Clothier assumes that if EcoMod has over-estimated pasture production then this will automatically lead to an under-estimate of nutrient losses from OVERSEER®.	This is not correct. If the pasture yield is not achievable on farm then the effect of this will depend on the management actions of the farmer. If the stocking rate and target production is maintained and feed gap is filled with N fertiliser then leaching will increase. If the feed gap is filled with imported silage there will be no effect on leaching or a decrease is a feeding pad is used. If the feed gap is filled with imported concentrate then leaching will likely decrease. If stocking rate or target production declines to meet the pasture production then, all other things being equal, leaching will decline as well.
43	Dr Clothier states that neither OVERSEER® nor SPASMO take account of urine patches.	It is true, we assume, that SPASMO does not take account of urine patches – this is clearly stated by Green (2005, page 55). This is not true of OVERSEER® (Monaghan 2009, Paragraph 13) which does take account of urine patches and does so because it is not possible to adequately model N leaching from grazed pastures without doing so.
44	Dr Clothier has concerns that the median modelled nutrient losses are low and they could result in "significant downstream implications".	However Dr Clothier has failed to note that the farmers will be constrained by the agreed nutrient discharge allowances. Dr Clothier has agreed that OVERSEER®, given sensible inputs, will produce sensible estimates of leaching. If pasture production is not as high as wished, or modelled, and farmers are tempted to remedy this by applying more N fertiliser then OVERSEER® modelled nutrient losses will increase. They however will not be able to do this beyond the agreed nutrient discharge allowance and this renders much of Dr Clothier's concerns about the EcoMod-Farmax-OVERSEER® modelled leaching moot. The farm discharges will be assessed using actual production and actual farm inputs and these can be put directly into OVERSEER®.

45-55	Paragraphs 45 to 55 are concerned with the within- and between-year variation in drainage and leaching. Dr Clothier is concerned that the modelling has ignored this effect and that this will affect water quality.	We argue that the temporal smoothing resulting from transport through the vadose zone, varying distance from receiving water, and paddock-to-paddock variation within farm will so smooth out the pulses in leaching that this is not an issue of any real concern. The exception to this is the need for best practise management, at all times and places, but particularly near surface water bodies where the temporal smoothing is limited.

Dr Adrian Meredith - Consideration of values and effects of rivers and streams.

Para #	Issue identified in s42A report	Response
14 - 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.	We support the use of nutrient concentrations and loads as the stressors to be monitored under the WQS approach, and by which farm management activities are to be constrained, because they are directly related to the nature and intensity of land-use.
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.	The reports are precisely what they claim to be. They are descriptive stream surveys conducted during low flow late summer conditions when maximum annual periphyton biomass is expected to be present.
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?).	As we only had the opportunity to conduct one survey per year, we targeted the "worst case scenario" in terms of periphyton biomass. We did not intend or claim to be describing normal or average conditions. The 25% increase was not on top of what had been surveyed by Dr Brian Coffey in his survey in April 08. The annual average maximum periphyton was calculated using the modelled water quality at the node point. Then the 25% was applied and the N and P load for a balanced system were calculated relating to this 25 % increase in PB. Where greater than 25 % was predicted (again using the water quality modelling) mitigation was required.
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	We do not agree with Dr. Meredith. Our reports identify a mix of oligotrophic, mesotrophic and eutrophic periphyton taxa as being present. The dominance of oligotrophic periphyton taxa tended to be more common

	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.	at upstream sampling sites.
48	The finding of these periphyton communities being largely dominated by cyanobacteria mats (*Nostoc, Phormidium, Oscillitoria 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).	We do not agree with this generalisation proposed by Dr. Meredith. He is failing to appreciate is that there were significant differences in periphyton biomass at downstream relative to upstream sampling sites in these waterways. His proposition that these waterways are pristine and oligotrophic is simply not supported by the findings of our reports. Our reports indicate these waterways are far from in a natural state. They are highly modified and would benefit greatly from the establishment and maintenance of functional riparian margins.
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.	We agree with this generalisation proposed by Dr. Meredith. However, what he is failing to appreciate is that there were significant differences in periphyton biomass at downstream relative to upstream sampling sites in these waterways. His proposition that these waterways are pristine and oligotrophic is simply not supported by the findings of our reports. Our reports indicate these waterways are far from in a natural state. They are highly modified and would benefit greatly from the establishment and maintenance of functional riparian margins.
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).	This is not the case. A number of "nuisance growths" of periphyton described in our reports were composed of long green 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	This is not the case. A number of "nuisance growths" of periphyton described in our reports were composed of long green filamentous algae.

	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.	This is simply not the case. The 2009 report makes no such comment.
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.	This is simply not the case. The water quality report also models the annual maximum chlorophyll-a concentration rather than an "average" condition.
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.	This is an unfounded contention in this instance.
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	We do not accept my biomass target is flawed on the basis that we did not record mesotrophic or eutrophic taxa in our surveys. We did record such taxa and they are clearly identified in our reports.

	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 offcer 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.	We consider that periphyton targets suggested by Dr. Meredith cannot be supported in any logical or objective manner until the highly modified waterways in the catchment of Lake Benmore have been rehabilitated by establishing and maintaining ecologically constructive riparian margins around these waterways..
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 n 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.	The MWRL experts have only just received a copy of this report which is in "draft" form so have not yet had time to form an opinion. However, the statement regarding oligogtrophic taxa is incorrect. No information on the floristic composition of periphyton was included in this publication.
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-	This is simply not the case. The water quality report also models the annual maximum chlorophyll-a concentration rather than an "average" condition.

	optimal and non-representative times.	

Claire Penman - Planning

Para #	Issue identified in s42A report	Response
46	Concludes that the effect of section 88A is that an application must continue to be processed, considered and decided for the type of activity that it was for, or was treated for being for, at the time the application was first lodged.	Under section 15 of the Waitaki Catchment Act, ECan is precluded from addressing allocation issues in any other regional plan. Accordingly, the WRP is the sole plan in relation to allocation in the Waitaki Catchment, and as far as allocation of water is concerned neither the TRP or the NRRP are relevant.
54	Transitional Regional Plan is operative and applies to all applications. The report notes that the water abstraction activities are discretionary activities, discharge and land use consents are also discretionary under the TRP. Although on previous page notes that because of the Waitaki Act section 88A (requiring an application to be processed as and when it was lodged) does not apply to water permits in the Waitaki.	Consent is not required under the TRP for water abstraction activities.
64	Discharge permits require consent under the NRRP.	Only relates to those applicants who have specifically applied for discharge permits e.g. to discharge excess irrigation water back to water.
82-86	Concludes that Rule WQL19 is not applicable, but that Rule WQL62 is. However the approach being adopted by ECan is not to require consent at this time, and that the effect of Rule WQL19 and WQL62 are already being considered as part of the overall assessment of the applications. It is also noted that because of the NRRP hearings these rules could be significantly amended.	As outlined in the planning evidence on behalf of MWRL Rule WQL62 is not contravened provided the properties prepare a farm management plan as required by Rule WQL19. However agree that the effect of Rules WQL19 and 62 are largely addressed in assessing these applications.
	Conditions – water management, metering and fish screens.	Conditions proposed are deemed to be acceptable.

Mike Freeman

Para #	Issue identified in s42A report	Response
39	The report includes an overview of the relevant planning provisions and concludes that both the Waitaki Regional Allocation Plan and the NRRP contains provisions which have relevance to cumulative water quality and landscape effects.	Regional plans do not contain provisions which address landscape effects, any provisions within the Regional Plans relate to the landscape quality of the water bodies, beds, banks or riparian margins and not the "greening" of the landscape.
32	The report confirms that by the combination of Policy 13, and the fact that the objectives are incorporated by reference and the Waitaki Regional Allocation Plan definition of the NRRP mean that the water quality objectives of the NRRP effectively have considerable weight.	This is consistent with the interpretation of Policy 13 as discussed in the planning evidence on behalf of MWRL.
39	The report states that the following provisions are of relevance in regard to cumulative landscape effects: • Chapter 5 (Water Quantity) of the NRRP – Objective WQN1 • Chapter 6 (Beds and Margins of Lakes and Rivers) of the NRRP – Objective BLR1 • Chapter 7 (Wetlands) of the NRRP – Objective WTL1 • District Plan objectives	Chapter 5 of the NRRP is not relevant to applications in the Upper Waitaki. Provisions within Chapters 6 and 7 relate to the water body only. An assessment of District Plan objectives only relevant if consent is required, not a regional issue. This is a matter that will be addressed by applicants on individual basis.
72	Report concludes that there are a number of issues with the GHD water quality that need to be addressed, at or prior to the hearing. The report states that because of the significant limitations it is not feasible or appropriate at this stage to undertake an analysis of cumulative effects on Lake Benmore in the context of the various planning provisions.	The water quality study is sufficiently robust and an assessment of the relevant planning matters has been undertaken in the planning evidence on behalf of MWRL.
	Part 2 Statutory Assessment has been undertaken and concludes that in light of the significant uncertainties and technical concerns it is difficult to assess whether the activities are consistent with Part 2 of the Act.	The water quality study is sufficiently robust and an assessment of the relevant planning matters has been undertaken in the planning evidence on behalf of MWRL.
40	Concludes that under section 104(1)(c) allows the regional authority to consider the objectives of the relevant district plans.	See above, not something that is relevant unless consent is required from the District Council. Many of the activities eg water intake structures, pump stations, irrigation (outside OLA areas) are permitted activities in terms of the District Plan provisions. This is a matter for

		individual applicants.
100	Report concludes that Section 104D assessment can not be made in regards to cumulative water quality effects, until further information is provided.	Water quality study is sufficiently robust and an assessment of the relevant planning matters has been undertaken in the planning evidence on behalf of MWRL.