APPENDIX A

RESPONSES TO KEY ISSUES FROM THE MWRL PRESENTATION OF REBUTTAL EVIDENCE

ISSUE #1 - How were the detection limits chosen?

Hills Laboratories are IANZ accredited and they were used by the GHD environmental team (Auckland) as the principal provider of water quality analyses.

Hills were contacted to request the lowest detection limit that was available. All the tests requested are performed in accordance with the IANZ accreditation as part of Hills Laboratories' suite of tests for 'clean waters'.

The only other laboratory in New Zealand that can test lower detection levels is the NIWA laboratory.

ISSUE #2 - How reliable are the data samples for TN and are the detection limits appropriate?

The TLI calculations were based on the ECan lake data from 2006-2007 and the 2008 sampling round by GHD.

Dr Gamage has provided in **Attachment 1** a comparison of the WQS data sets and the NIWA data. The approach employed by GHD assumed 50% of detection. Use of 100% of the detection limits is illustrated for comparison - see figures 1 and 4.

ISSUE #3 - How do flood events relate to the condition of Lake Benmore?

Floods reduce residence time, flush plant biomass (Chlorophyll a in the case of phytoplankton), drop sediment in lakes and are associated with discoloured water.

They are not associated with phytoplankton / periphyton growth responses as the peak nutrient concentrations associated with a flood pass through the system in dirty water with a short retention time.

Burns et. al. (2000) highlights the need to de-seasonalise and de-climatise input data to arrive at a comparable annual average to use to assess the change of lake tropic index with time. Flood event data in a hydro-electric impoundment would come under this heading. They should be treated as outliers.

Moreover only the average concentrations of upper 80% of the top mixed layer were used in (Burns et al 1999) study to avoid the thin turbid layer of detritus often present near the thermocline (bottom of mixed layer or epilimnion). This indicates that Burns has not used turbid water for the derivation their empirical equations and use of turbid water can produce biased TLI estimate.

ISSUE #4 - Was the inorganic material tested?

The question was whether the total inorganic component could elevate the December 2008 TP levels. As detailed by Dr Gamage in **Attachment 2** Figure 14 shows that this elevated TP is a result of particulate P.

Brian Coffey's explanation for the effect of nutrients entering the lake during floods as biodegradable material:

The situation is that nutrients enter a lake in a combination of plant-available forms (mineralised inorganic compounds such as nitrate in the case of nitrogen, dissolved reactive phosphate in the case of phosphorus or carbon dioxide in the case of carbon) and "bound" forms that are not currently available for uptake by plants for growth (for example dissolved and particulate organic matter).

At any given time, nitrogen and phosphorus will be in one of the various forms depicted in a typical aquatic nitrogen or phosphorus cycle. Some will be in the form of living plants and animals, some will be in the form of excreta and dead plants and animals, some will be in the process of being mineralised or recycled by decomposers (e.g. bacteria) and some will be in the “available pool” that can be taken up by plants to start of the cycle over again.

There are also losses and gains involved. Fertilisers and organic matter can wash into a lake with surface or groundwater or be blown into a lake, nitrogen can be fixed into plant available forms from dissolved nitrogen in water (nitrification). In terms of losses, phosphorus can be incorporated into lake bed sediments and remain unavailable to re-enter the water column until the water column was to become anoxic. Nitrogen can be converted back to a dissolved gas and be lost back to the atmosphere as a gas. Nutrients are discharged from the outlet of a lake in the full range of plant available or bound forms that cycle between each other.

The concentrations of total nitrogen and total phosphorus in the lake at any given time can be measured. The concentrations of plant available inorganic nitrogen and plant available inorganic phosphorus in the lake at any given time can be measured. The amount of nutrient partitioned in a particular compartment such as the plankton can also be measured at any given time. The rate at which organic detritus is being re-cycled to recreate plant available inorganic nutrients at any given time can also be measured (as biological oxygen demand).

The difference between total nutrient concentrations and plant available nutrient concentrations entering a lake will be particulate or organically bound nutrients that can be recycled / mineralised to re-enter the particular nutrient cycle occurring in the lake.

Not only therefore, is there is the potential for biodegradable material that is getting dropped into the lake to mineralise and over time contribute to the nutrient pool of the lake, this is a normal part of the nitrogen, phosphorus or carbon cycles in a lake.

By measuring both total and plant-available forms of nutrients, the WQS has taken these nutrient cycles into account and did not need to do more. With a residence time of 50 days, the material that has been incorporated into the lake via both flood and non-flood flows (minus losses) will be measured as either total or plant available nutrients.

There is no problem with the WQS in this regard.

ISSUE #5 - Are the outliers in the NIWA data genuine outliers?

The 21 January 2009 outlier sample in the NIWA data is an outlier probably a contaminated sample. The 11 December 2008 is also probably an outlier or possibly a transcriptive error. The reason for this is explained by Dr Greg Ryder in **Attachment 3**.

Further, NIWA have acknowledged in their report at page 44 (paragraph 3) that the outliers could be errors. We have attached this section of the report at **Attachment 4.**

On reading Table F1 in the NIWA appendices it appears they may have left the outliers in for the LTI estimates but they have recognised their potential impacts on root mean square errors for nutrient concentrations as a narrative in the text.

This NIWA report lacks clarity in this regard and the authors should clarify these specific details.

ISSUE #6 - Explanation of the 200% rainfall data in December.
The basis of TLI is the average condition of the lake. Averaging parameters after a flood event can produce elevated averages in comparison to annual averages. Therefore use of average values of four months after a flood event could produce an elevated TLI estimate. This is explained further by Dr Gamage in **Attachment 4.**
ISSUE # 7 - Was the rainfall data adequate?
Dr Gamage has checked the rainfall at Tara Hills Aws, Omarama (Figure 16 in **Attachment 5**). This site shows that December 2008 rainfall is about 2.4 times higher than the average December rainfall. This is consistent with the measurements at Guide Hill.
ISSUE # 8 - How does the WQS compare to Burns et al 1999?
The models proposed by Burns et. al. (1999) and Burns et. al. (2000) are a reliable and robust means of measuring the TLI in Lake Benmore. GHD have used 3 data sets (GHD, ECan, and NIWA) that resulted in 20 - 30 data points. In particular, GHD used 20 samples of Tn and 23 samples of TP to assess the TLI of the Ahuriri Arm and 28 samples of Tn and 30 samples of TP to assess the TLI of the Haldon Arm. This data produces a reliable estimate of current trophic level of Lake Benmore. Accordingly, the WQS has used sufficient data to apply the appropriate TLI equations of Burns et. al. (1999 and 2000) when calculating the TLI of Lake Benmore.