BEFORE THE INDEPENDENT COMMISSIONERS

UNDER	the Resource Management Act 1991
AND	
IN THE MATTER	of the proposed Canterbury Land and Water Plan

SUPPLEMENTARY EVIDENCE OF ROBERT JOHN WILCOCK ON BEHALF OF NGĀ RŪNANGA OF CANTERBURY, TE RŪNANGA O NGĀI TAHU AND NGĀI TAHU PROPERTY LIMITED

4 April 2013

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1. INTRODUCTION

1.1 My name is Robert John Wilcock.

1.2 I hold the position, qualifications and experience outlined in paragraphs 1.2 to 1.6 of my evidence in chief.

1.3 I have prepared this supplementary evidence in response to questions asked by the Hearing Commissioners in relation to my evidence in chief.

1.4 I am familiar with the Code of Conduct for Expert Witnesses in the Environment Court Practice Note and I have complied with it in preparing this supplementary evidence.

1.5 In preparing this evidence I have asked Mr Graham McBride, an expert in water quality statistics, to review the material on percentile standards. I have attached his comments as Appendix 1 to my evidence.

1.6 I have been asked by the Hearing Commissioners to comment on how the Table 1 outcomes might be interpreted. For example, should concentrations in Tables 1a, b and c be means, medians or some other percentile, and should they be related to flow conditions?

2. PERCENTILE STANDARDS

2.1 Arithmetic means are commonly used to measure average, or typical, concentrations, especially where they are symmetrically distributed. In the following examples, histograms show distributions of water quality variable value ranges. The first example (Figure 1 below) shows water temperature in a small, rural stream. The Y axis shows the number of measurements made in each temperature interval of 1˚C (shown on the X axis). Data is approximately evenly distributed above and below the mean of 16 ˚C.

2.2 Most water quality data is not so symmetrically distributed and is skewed, as shown by the following example of ammonium-N concentration from the same small stream (Figure 2 below). In this example, the mean (0.14 mg/L) is not a good estimate of the most 'typical' value because it is biased by a few large values that are greater than 0.8 mg/L. Approximately 95% of the data in Figure 2 are less than

0.65 mg/L. A better estimate of the typical values is the median or 50th percentile value. The median is the mid-point of the data range, and in this example is 0.03 mg/L.

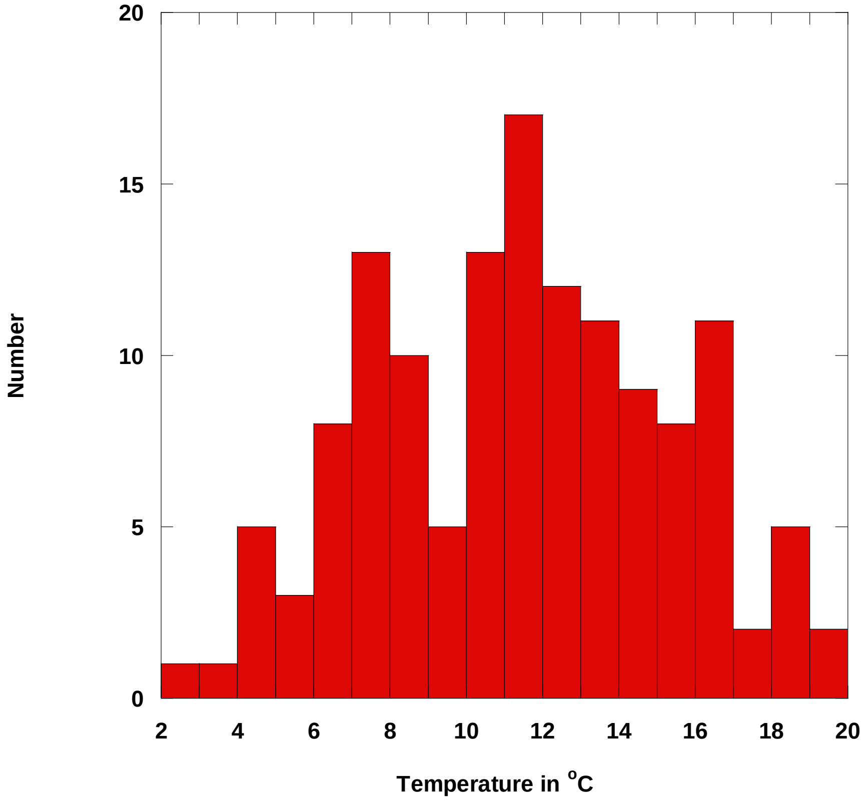

Figure 1 Histogram of water temperature in a small lowland stream.

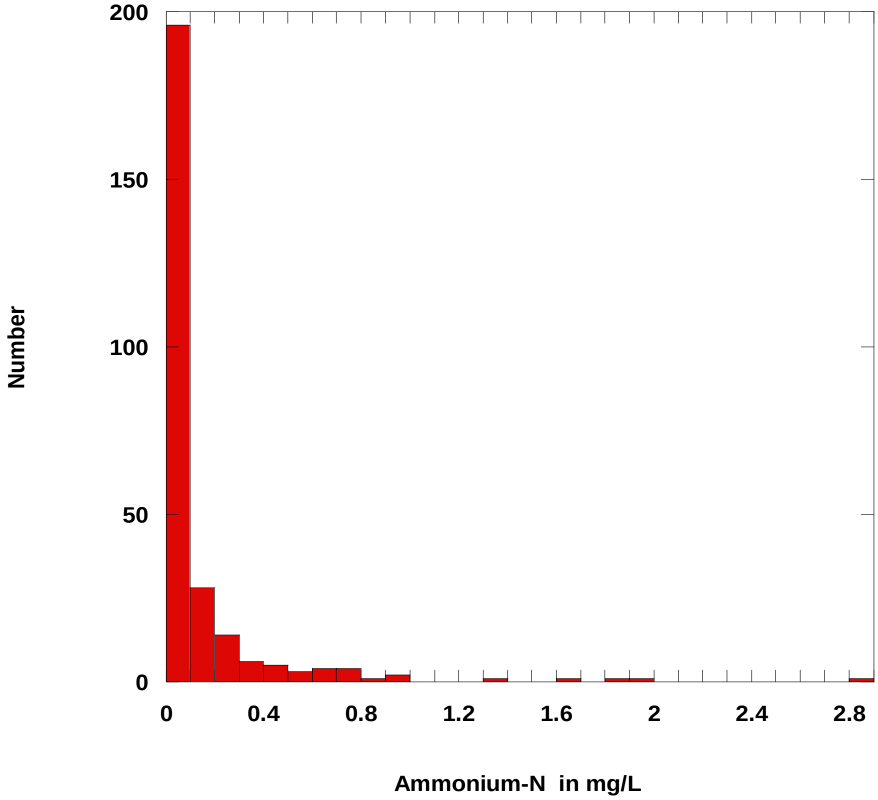

Figure 2. Histogram of ammonium nitrogen (N) in a small lowland stream.

2.3 The median is widely used to characterise monitoring data, because it is the mid-point of a given data range and is not easily affected by extreme values. Half the data are equal or higher than the median, and half are equal or lower than the median. Because of that, it may not be a suitable metric for setting water quality limits, particularly if data have a large range and the large values are a cause for concern. A higher percentile value is often preferred because it confers greater protection for water resources.

2.4 A percentile standard for data is the value below which a given percentage falls. For example, if the 95th percentile is 8, then only 5% of the data are greater than 8. Higher percentile standards (than the median) are increasingly being adopted by resource management agencies because they confer greater protection of water values. Water quality management is increasingly using percentile standards, in response to dissatisfaction with standards based only on means or maxima (McBride 2005).

2.5 The range of data between the 25th percentile and 75th percentile values is also called the interquartile range, or the mid-spread, and is a measure of statistical dispersion. Data that spans the 5-95th percentile range are often used to characterise the 'normally occurring' range, with values less than the lower bound or higher than the upper bound being deemed 'statistical outliers' or atypical values.

2.6 The Decision of Council with respect to Proposed Plan 6A (Water Quality) to the Regional Plan: Water for Otago (27 March 2013) amended receiving water standards from medians to 5-year 80th percentile values when water flow is at or below median. "The new standards are more stringent than median values."

2.7 The Freshwater Microbiological Guidelines (MfE/MoH 2003, Table H2, page H26) refers to 95th percentile *E. coli* concentrations for beach grading for primary contact recreation. This is based on QMRA (Quantitative Microbial Risk Assessment) model for campylobacteriosis, a notifiable disease.

2.8 The Queensland Government has adopted 80th percentile standards for most physico-chemical water quality indicators[1] in its Environmental Protection (Water) Policy 2009 but notes that the choice of percentile is arbitrary.

2.9 The State and Trends in the National River Water Quality Network (1989-2005) report published by Ministry for the Environment shows calculated 5th, 20th, 50th, 80th and 95th percentile values across the NRWQN sites[2]. The 50th percentile gives a picture of what is happening in a national "average" river in terms of annual median water quality data. The 20th and 80th percentiles concentrations are stressor levels that are potentially harmful for aquatic ecosystems (ANZECC 2000). The 80th percentile relates to stressors that cause problems at high concentrations (e.g. ammonium-N, temperature), whereas the 20th percentile relates to stressors causing problems at low concentrations (e.g. dissolved oxygen). The 5th and 95th percentiles tell us about state and changes over time in our "best" and "worst" rivers.

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[1] http://www.ehp.qld.gov.au/water/pdf/deriving-local-water-quality-guidelines.pdf
[2] http://www.mfe.govt.nz/publications/ser/water-quality-network-nov06/html/page3.html

2.10 In summary, 80th percentile values are increasingly being accepted as limits for water quality variables that cause problems at high concentrations, and 20th percentiles for stressors causing problems at low concentrations. These criteria are only applicable to regularly monitored variables for which there are sufficient data to evaluate percentile values.

3. RECOMMENDATION

3.1 I recommend that 80th percentile values be used for monitoring the following water quality variables in Tables 1a, 1b and 1c of the pLWRP: temperature, chlorophyll *a*, microbial indicators (viz. *Escherichia coli*), fine sediment (depending on the frequency of monitoring), trophic level index, lake colour, and groundwater nitrate nitrogen. I recommend that 20th percentile values be used for assessing dissolved oxygen data. The remaining variables (QMCI, emergent macrophyte cover, total macrophytes, lake SPI, groundwater levels and saltwater intrusion) unless monitored at least quarterly (three times a year) are probably best assessed individually for each occasion. If they are monitored at least quarterly, then the 80th percentile values should be used for their assessment.

3.2 Flow criteria only apply to Table 1a (Outcomes for Canterbury Rivers). I have no recommendation to make about restricting assessment to any particular flow range, because the variables other than suitability for contact recreation (microbial indicators) apply to low-flow conditions. Microbial indicators could be restricted flows not exceeding the 80th percentile.

Dr Bob Wilcock

4 April 2013

References

1. ANZECC (2000). National water quality management strategy: Australian and New Zealand guidelines for fresh and marine water quality. (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, Australia.)

2. McBride, G.B. (2005). using statistical methods for water quality management. John Wiley & Sons, Inc. Hoboken, New Jersey.

3. MfE/MoH (2003). Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Ministry for the Environment and Ministry of Health, Wellington, New Zealand. (http://www.mfe.govt.nz/publications/water/microbiological-quality-jun03/)

Appendix 1

Some standards are expressed as percentiles *of time*. In this case one has to then consider what burden-of-proof should be adopted when considering a data-based estimate of the time percentile. That was a supremely important issue in the development of Ministry of Health's drinking-water standards. MoH wanted 95% confidence that a critical value might have been exceeded for no more than 5% *of a compliance assessment period*. That meant taking a precautionary approach, in which case the risk to the consumer is minimised (as it should be, in public health terms). If MoH had said no more than 5% *of the data* should exceed the critical value, then they would have a compliance rule that takes an "even-handed" approach to compliance assessment — it would have been much less onerous on the "producers" (water suppliers). That is, if the true 95%ile were to be equal to the critical value, a random sampling regime would infer compliance in about 50% of the compliance assessment periods. But under their precautionary approach they would infer compliance (for this borderline case) for only 5% of the time.

It was also a big issue in the UK, where a permissive approach to 95%ile wastewater consent compliance rules was taken (so more than 5% of samples could exceed a critical value and still be judged "compliant").