BEFORE THE HEARINGS PANEL

IN THE MATTER	**of hearings on submissions concerning the Proposed One Plan notified by the Manawatu-Wanganui Regional Council**

SUPPLEMENTARY EVIDENCE OF DR ROBERT JOHN WILCOCK

FOR THE WATER HEARING

ON BEHALF OF HORIZONS REGIONAL COUNCIL

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1. PART ONE: INTRODUCTION AND EXECUTIVE SUMMARY

1. I have prepared this report as supplementary evidence to my Section 42A report. It has been compiled in response to evidence received from experts on behalf of submitters. As a result of considering the expert evidence received, and, where appropriate, after meeting and caucusing with those experts, I have revised some of my recommendations as they appeared in my Section 42A Report. These revised recommendations are presented here.

2. This evidence is in three parts:

   Part One: This Introduction and Executive Summary.

   Part Two: Issues raised by submitters' experts and my response, including any revised recommendations as a result.

   Part Three: Clarifications to my original evidence.

3. I have read, and comment on here, the technical evidence of the following expert:
   - Mr Keith Hamill on behalf of Palmerston North City Council.

4. I have met with the following experts, the meeting notes of which outline the outcomes of those meetings:
   - Mr Keith Hamill on behalf of Palmerston North City Council.
   - Mr Paul Kennedy on behalf of Winstone Pulp International and the Territorial Authority Collective.

Table 1. Issues discussed at pre-hearing meetings and caucusing.

Issue discussed	With experts	Meeting notes
Water quality standards in Schedule D and application of ANZECC guidelines	Keith Hamill Paul Kennedy John Quinn Jon Roygard Kate McArthur Myself	A summary has been prepared by Richard Thompson, who chaired the caucus meeting

2. EXECUTIVE SUMMARY OF SUPPLEMENTARY EVIDENCE AND REVISED RECOMMENDATIONS

5. After consideration of the technical expert evidence, and subsequent discussions during, or in association with, caucusing and pre-hearing meetings, I have revised some of my recommendations as presented in my Section 42A Report.

6. I have revised some of my recommendations as presented in paragraphs 20 and 21 of my Section 42A Report, particularly with regard to the Schedule D ammoniacal-N standard.

3. PART TWO: RESPONSE TO ISSUES RAISED BY TECHNICAL EXPERTS

7. I agree that the ammonia standard may apply to *average* values, as recommended by Mr Hamill, provided maximum ammonia values are also specified to avoid acute toxicity as a result of large ammoniacal-N spikes from discharges.
   (a) In those locations where it is important to set soluble inorganic nitrogen (SIN) standards to prevent periphyton growth, the SIN standards should apply.
   (b) I agree that an average concentration of ammoniacal-N can be set, so long as a maximum value is also specified to provide suitable environmental protection.
   (c) The Proposed One Plan (POP) ammoniacal-N standards are 0.400 g N/L (based on the ANZECC guideline trigger value of 35 mg/m^3 un-ionised ammoniacal-N, for 95% protection level) and 0.320 g N/L (for 99% protection and a lower trigger value). The conditions under which the lower ammonia standard (0.320 g N/L) apply are spelt out in Ausseil and Clark (2007).
   (d) The POP standards are based on chronic exposures (at least 4-5 days), whereas acute toxicities will apply to relatively shorter exposure times.
   (e) I agree with Mr Hamill's suggestion of taking the POP ammonia standard and inferring the pH conditions for calculating acute (maximum) ammoniacal-N concentrations, so long as both criteria for un-ionised ammonia are taken into account. The upshot of this is that you may not use Table 8.3.7 (ANZECC, 2000) for both calculations, given that we have different trigger values specified in the POP.
   (f) For a POP ammoniacal-N standard of 400 ppb (0.40 mg N/L) we infer a pH from Table 8.3.7 of ANZECC (2000), of 8.5. Using the USEPA acute ammonia toxicity criteria (p86) gives a permissible maximum value of 2.14 mg N/L.
   (g) One simple way to calculate the maximum (acute) ammoniacal-N concentration for the POP standard of 320 ppb (0.32 mg N/L) is to apply the same acute:chronic ratio (ie. 2.14/0.4 = 5.35), which gives 1.71 mg N/L.
   (h) I favour setting a conservative maximum that may not be adjusted according to prevailing pH and temperature because of the risk of very high ammonia concentrations moving into sensitive downstream waters.
   (i) As I have said, this argument is contingent on the SIN standard being deemed not to apply in waters downstream of discharges likely to exceed the SIN standards, because the SIN standards are already more stringent than the ammoniacal-N standards in Schedule D.

8. **I recommend that maximum ammoniacal-N values are added to the Schedule D Table D.2a as follows: "Water Management Sub-zones with current ammoniacal-N standards of 0.400 shall have a maximum concentration not to be exceeded of 2.1 grams per cubic metre; those with the current ammoniacal-N concentration of 0.320 shall have a maximum concentration not to be exceeded of 1.7 grams per cubic metre."**

9. Further discussion on the changes to the ammoniacal-N standard as a result of caucus with Mr Hamill is presented in the supplementary evidence of Kate McArthur and in the meeting notes written up by Richard Thompson.

4. PART THREE: CLARIFICATIONS OF ORIGINAL S42A REPORT

10. With reference to paragraphs 13 and 37 of my original S42A report, there are many examples of rivers changing from being nitrogen (N) limited to phosphorus (P) limited, throughout the year and under different flow conditions. For example, the S42A report of Dr Jon Roygard (Box 36, page 119) shows variable N and P limitation at a range of flows, for the Manawatu River at the Hopelands site. In pastoral catchments, nitrate accumulates in the topsoil during dry periods as a result of mineralisation of soil organic matter and plant material, and the input of dung and urine. At times when evapotranspiration exceeds rainfall there is little downward movement of nitrate in drainage water. During this time, vigorous stream plant growth demand for N may exceed supply, causing nitrate concentrations to be negligible. As soil moisture increases, nitrate is flushed from the soil, causing stream concentrations to rise to a maximum value in mid winter. The result of this is that rivers in pasture catchments may be P limited for most of the year, but N limited during summer low-flow periods; this is shown by the following examples (Figures 1 and 2) of dairy catchment streams, where SIN:DRP ratios (shown for simplicity as N:P ratios) above the red line represent P limitation, and those below the red line represent N limitation.

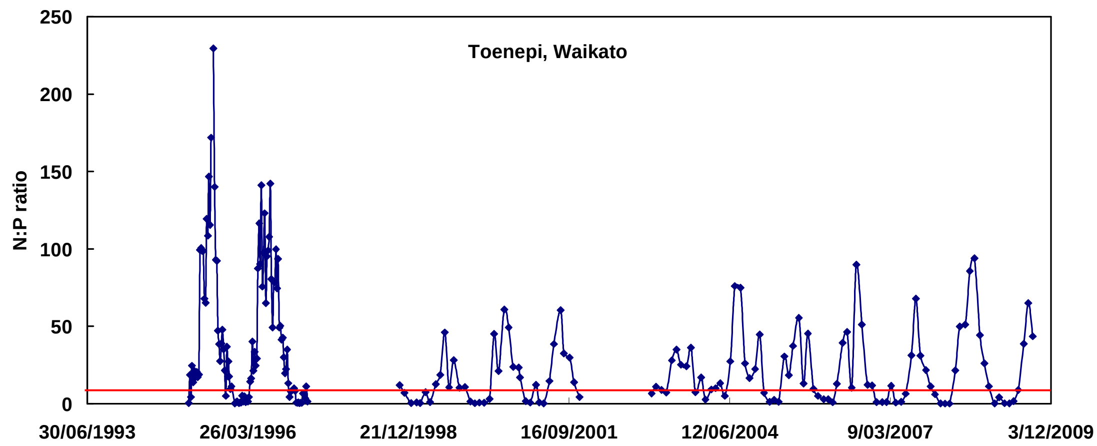

Figure 1. Ratio of soluble inorganic nitrogen to dissolved reactive phosphorus (N:P) for Toenepi Stream, in a Waikato dairy farming catchment. The red line indicates the optimal ratio for algal growth. N:P ratios above are P limited, whereas ratio values below the line are N limited. More comprehensive discussion of this is given in Wilcock *et al*. 2007).

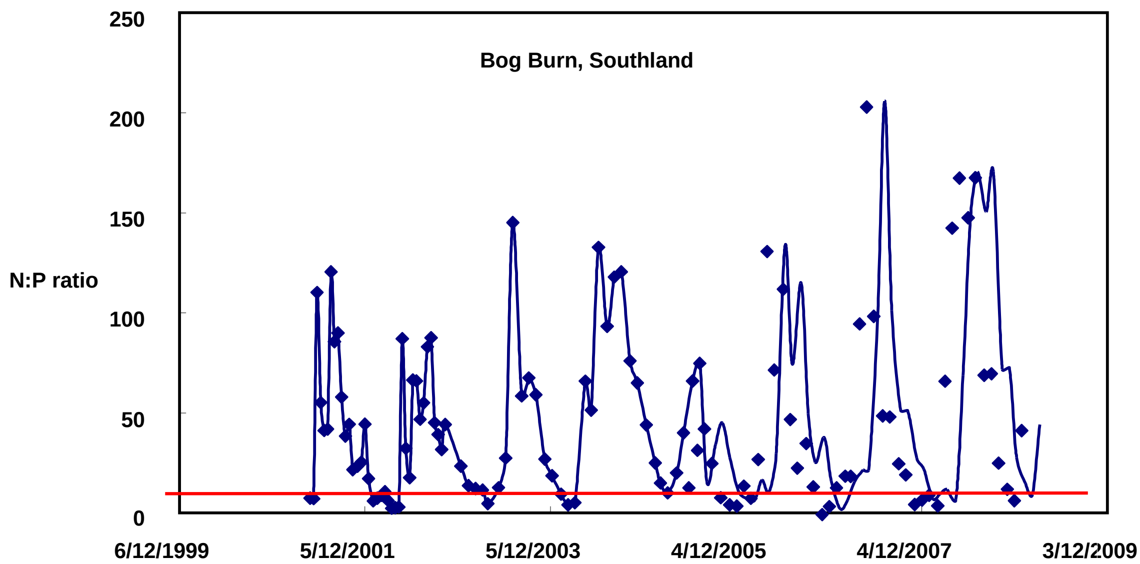

Figure 2. Ratio of soluble inorganic nitrogen-to- dissolved reactive phosphorus (N:P) for Bog Burn, in a Southland dairy farming catchment. The red line indicates the optimal ratio for algal growth. N:P ratios above the line are P limited, whereas ratio values below the line are N limited. More comprehensive discussion of this is given in Wilcock *et al*. 2007).

11. In some parts of my evidence I will refer to additional supporting argument that is provided in other evidence being presented in Section 42A reports to the Hearing Panel, viz.

Wilcock Paragraph No.	Subject	Other evidence
12	Coastal waters	Dr Zeldis
14	Periphyton growth	Dr Biggs
15	Nutrient diffusing substrate	Dr Biggs
23	*E. coli*	Dr Davies-Colley
24	Best management practice	Dr Monaghan

12. With reference to paragraph 18 of my S42A report, some examples may illustrate this point. Dairy farming with effective measures in place to reduce P losses (eg. agronomic optimum P fertiliser use, slow-release fertiliser, dung management) may still release 20-35 kg N per ha per year, and also cause unacceptable faecal pollution of water bodies. Hill-land sheep and beef farms generally have much lower exports of N and P than do dairy farms, but commonly have much higher sediment yields, as exemplified in Table 2 (below) comparing concentrations and total yields of nutrients, sediment and faecal bacteria for upland pasture streams and a lowland pasture stream (modified from Parkyn and Wilcock, 2004).

13. Paragraphs 20 and 21 of my original evidence have been addressed at a caucus meeting with the submitters (Mr Hamill and Mr Kennedy).

14. *E. coli* is the preferred faecal indicator organism for <u>freshwater</u> environments. The word “freshwater” was missing from my original evidence. Enterococci is the preferred faecal indicator organism for the saltwater environment, not *E. coli*.

Table 2. Comparison of concentrations and yields of nutrients, sediment and faecal bacteria (*E. coli*) for upland pasture streams and a lowland pasture stream (modified from Parkyn and Wilcock, 2004).

Attribute	**Upland pasture**	**Lowland dairy**
Nitrate (NO_3-N mg/L)	Up to 2 (native forest 0.2)	Up to 6
Dissolved reactive phosphorus (DRP mg/L)	Up to 0.05 (guideline < 0.03)	Up to 0.6
Faecal coliform indicator (*E. coli*/100mL)	Median 635	420
Yield		
Total nitrogen (TN kg/ha/y)	10-23 (native forest 2)	35
Total phosphorus (TP kg/ha/y)	1.5-3.2 (native forest 0.6)	1.2
Suspended solids (SS kg/ha/y)	1000-3200 (native forest 320)	142

5. REFERENCES

ANZECC. (2000). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australia and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Ausseil, O.; Clark, M. (2007). Recommended Water Quality Standards for the Manawatu-Wanganui Region: Technical Report to Support Policy Development. Report 2007/EXT/806, Horizons Regional Council.

Parkyn, S.; Wilcock, R.J. (2004). Impacts of agricultural land use. In: Harding, J.; Mosley, P.; Pearson, C.; Sorrell, B. ed. Freshwaters of New Zealand. New Zealand Hydrological Society and New Zealand Limnological Society. Caxton Press, Christchurch. Pp 34.1-34.16.

USEPA 1999. (1999). Update of ambient water quality criteria for ammonia. EPA/822-R-99-014. U.S. Environmental Protection Agency Office of Water, Washington, DC.

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