BEFORE THE HEARING PANEL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of application by Tararua District Council to Horizons Regional Council for application **APP-1993001253.02** for resource consents associated with the operation of the Pahiatua Wastewater Treatment Plant, including earthworks, a discharge to Town Creek (initially) then to the Mangatainoka River, a discharge to air (principally odour), and discharges to land via seepage, Julia Street, Pahiatua

STATEMENT OF EVIDENCE OF ADAM DOUGLAS CANNING (FRESHWATER ECOLOGY) FOR THE WELLINGTON FISH AND GAME COUNCIL

08 May 2017

Introduction

1. My name is Adam Douglas Canning. I am a Doctoral Researcher in Freshwater Ecology in the Institute of Agriculture and Environment – Ecology at Massey University. I have a Bachelor of Science with Honours – First class (Biological Sciences and Environmental Science) also from Massey University.

2. I am a member of the Ecological Society of America, the International Association for Ecology (INTECOL), and the New Zealand Freshwater Sciences Society, the International Society for Ecological Modelling, the Australasian Society for Fish Biology, and the Society for Ecological Restoration. I have presented research at conferences held across New Zealand, Australia and the USA and published internationally.

3. My research is focussed on understanding community and ecosystem thresholds to ensure ecosystem health (life supporting capacity) of freshwater and estuarine systems in New Zealand. I am very familiar with literature relating to ecological community stability, ecological thresholds, and the nutrient and environmental determinants of New Zealand freshwater ecosystem health.

4. I have read the Environment Court's Code of Conduct for Expert Witnesses and I agree to comply with it. My qualifications as an expert are set out above. Other than those matters identified within my evidence as being from other experts, I confirm that the issues addressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Scope of evidence

1. In this evidence I:
    a. Discuss the ecological health of a river and explain how periphyton blooms can affect ecosystem health.

       Discuss the potential influences of the Pahiatua Wastewater Treatment Plant (WWTP) on ecological health.
    b. Provide recommendations to ensure One Plan ecological health targets are achieved.

Lotic biological communities

2. Within the flowing water ecosystems there is Periphyton, Detritus, Terrestrial Plant and Animal matter, Aquatic Invertebrates, and Fish. Periphyton (the coating of slightly furry green or brown algae on rocks) and detritus (both in-stream and terrestrial derived plant matter, e.g., leaves) form the basis of the stream food web. Some periphyton is required as food for many aquatic invertebrates; however, too much algal growth can dramatically change the ecology and habitat conditions of a river. Aquatic invertebrates consume the periphyton and plant matter either directly (along with other organic sources) or indirectly by predating the smaller grazing invertebrates. Native and sport fish eat these invertebrates and some terrestrial inputs. All of the biological components of a river food web require the correct habitat, water quantity and water quality in order to maintain healthy populations and functioning ecosystems.

3. Macroinvertebrates are important contributors to a river food web's functioning and stability (important aspects that comprise ecosystem health). However, not all macroinvertebrates are equal contributors, contrast those presented in figure 10. Some invertebrates are more energetically rewarding with lower foraging costs for fish. Maintaining the diversity of these energetically rewarding invertebrates is important for the stability of fish diet. Large grazers are also important for down-cutting periphyton. Rivers with good water quality are dominated by mayflies, stoneflies and caddisflies, whereas rivers with poor water quality are dominated by worms, snails and midges and do not support the same abundance, biomass or diversity of fish that the former communities do. Fish that feed on poor invertebrate communities become stressed, susceptible to disease

and develop poor condition as a result of undesirable dietary changes (Dean & Richardson, 1999; Franklin, 2013).

4. Periphyton growth can change invertebrate community composition in two ways:
    a. Increased periphyton changes the relative ratios of primary producers. Therefore, more periphyton leads to relatively more invertebrates that graze on periphyton relative to those that feed on vegetation/particulate organic matter (POM). The increase in periphyton grazers increases the habitat competition with those grazing on vegetation/POM (Quinn, Cooper, Stroud, & Burrell, 1997; Towns, 1981).
    b. When periphyton biomass builds to high levels the lower layers start to rot. This can dramatically reduce the oxygen levels and change the pH of the water leading to significant adverse effects on many invertebrates and fish. Whilst oxygen concentration may be very high during the day time from high rates of photosynthesis, at night the lack of light prevents oxygen from being released into the water and oxygen levels can plummet to lethal levels with increased bacterial activity (Dean & Richardson, 1999; Franklin, 2013). Figure 1 shows dramatic dissolved oxygen fluctuations in the Mangatainoka River during March 2014. By way of comparison, moderate reductions in fish and invertebrate production occur when dissolved oxygen is <5mg/L and 50% of common bullies will not survive an hour below 3mg/L (Dean & Richardson, 1999; Franklin, 2013). The most tolerant invertebrates are typically small bodied with low metabolic demand and consequently undesirable for fish (Landman, Van Den Heuvel, & Ling, 2005). Thus many fish and invertebrate species are unable to survive, regardless of high oxygen concentrations that are recorded from daytime measurements, leading to differences in community composition.

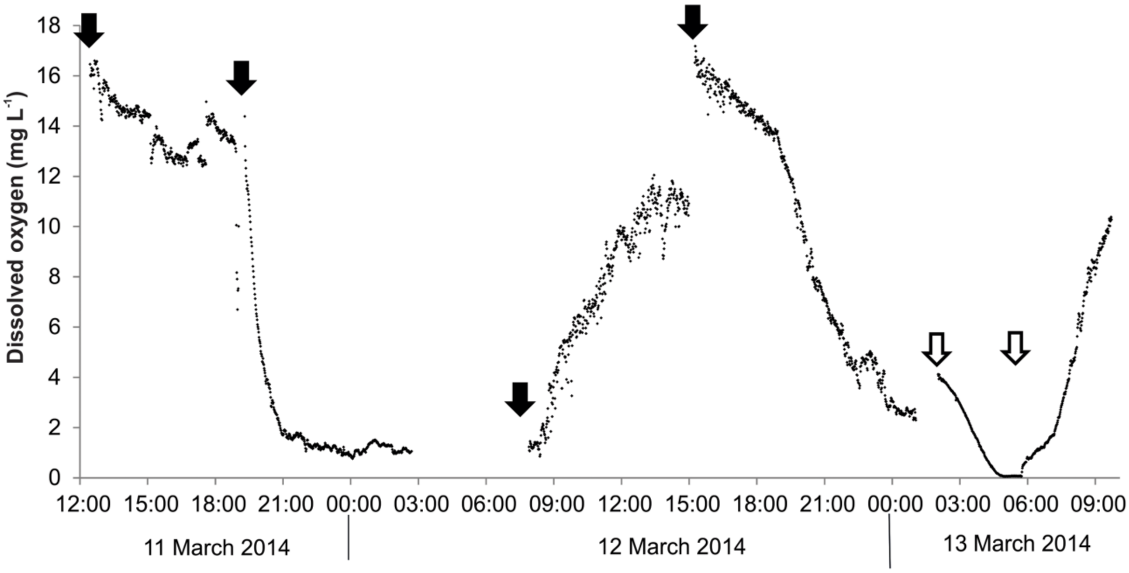


Figure 1. Dissolved oxygen concentration in the Mangatainoka (11 March to 13 March 2014) measured using a water quality sonde (EXO2, YSI, USA) logging at 5-min intervals. Imaged duplicated from:

Wood, S. A., Depree, C., Brown, L., McAllister, T., & Hawes, I. (2015). Entrapped Sediments as a Source of Phosphorus in Epilithic Cyanobacterial Proliferations in Low Nutrient Rivers. PLOS ONE, 10(10), e0141063. doi:10.1371/journal.pone.0141063

5. Various indices of community structure have been developed as biological measures of life-supporting capacity and ecosystem processes, such as the MCI (Macroinvertebrate Community Index). Freshwater communities are largely a product of their environment, that is, for species to persist then environmental conditions must be within their tolerance zones. As freshwater organisms are always present in the water they are sensitive to environmental disturbances that may otherwise go un-noticed if we relied simply on traditional physicochemical spot samples. Physicochemical samples are hypervariable and only indicate on the moment we conduct the spot test. Figure 1 exemplifies the diurnal fluctuations and natural variability associated with oxygen. Therefore, spot physicochemical test results are largely dependent on the time and day samples are taken. Even using periphyton biomass as a metric of ecosystem health, as mandated in the National Policy Statement on Freshwater Management, is often a poor direct measure of ecosystem health as it is highly influenced by the level of stone movement which is driven by variable flows. Macroinvertebrate communities are slow to develop, maintain relatively consistent compositions and can provide excellent insight into ecosystem health just from one off annual surveys. Therefore, the composition of macroinvertebrate communities can be used as excellent indicators of overall ecosystem health.

6. The Macroinvertebrate Community Index (MCI) and its quantitative variant (QMCI) are popular and simple indices of macroinvertebrate community health (Stark, 1993). Each species is assigned a value between 1 and 10 depending on their sensitivity/tolerance to enrichment. Depending on the species present within a stream/river an overall score of sensitivity is derived. High scores indicate a community with many sensitive species, which only persist when environmental conditions are optimum; whereas low scores indicate a community with low sensitivity which occur when environmental conditions are poor. The QMCI is similar to the MCI, however it accounts for both species and abundance in its calculation of community sensitivity. It should be noted that the MCI is primarily an indicator of enrichment and does not indicate all aspects of a community's ecological health. Ecosystem health represents the state in which an ecosystem has the "ability to maintain its structure (organization) and function (vigor) over time in the face of external stress" (stability) (Costanza and Mageau 1999).

Review of *Pahiatua WWTP discharge effects on the Mangatainoka River to the Makakahi River*

7. Effects on freshwater quality:
    a. I have also compared the raw data between the upstream and downstream monitoring sites of Pahiatua WWTP and agree with Dr Olivier Ausseil that there is no statistically significant difference in SIN concentration between the paired sites and changes in QMCI (Quantitative Macroinvertebrate Community Index) are not more than a 20% reduction from the upstream site. The downstream DRP were significantly higher across all flows and below 20th FEP. Periphyton (as measured by chlorophyll a) was greater downstream than upstream and exceeded the One Plan limit more frequently. Roygard, McArthur, and Clark (2012) also found that the Pahiatua WWTP contributes to 0.6% of the current SIN load and 16% of the current DRP load in the Mangatainoka River. This suggests that the periphyton in Mangatainoka River is, as also noted by Dr Ausseil, likely to be phosphorus limited and heightened phosphorus levels from the Pahiatua WWTP should be reduced to reduce excessive periphyton biomass.
    b. The One Plan MCI (Macroinvertebrate Community Index) target for the reach is a minimum of 120. However, neither the reach upstream nor downstream of the Pahiatua WWTP is at 120 or higher. Therefore, even if the WWTP was non-existent,

the MCI would still not meet the One Plan MCI target. This does not mean the effects of the WWTP on MCI should be dismissed. Firstly, the MCI is affected by the cumulative affect of many incremental impacts, with the WWTP exacerbating upstream conditions. Secondly, if inputs upstream are reduced then the relative impact of the WWTP on MCI will increase.

c. As explained above, too much periphyton is the primary driver of poor macroinvertebrate and fish communities. Just how much periphyton is too much? Matheson, Quinn, and Hickey (2012) and Matheson, Quinn, and Unwin (2016) used Quantile Regressions to investigate relationships between MCI, QMCI and Periphyton biomass (measured in terms of chlorophyll a density in mg/m2). They found that to achieve an MCI of 100 or QMCI of 5 with ≥85% compliance then Chlorophyll a density needs to be ≤120 mg/m2, or for an MCI of 120 or QMCI 6 then Chlorophyll a needs to be <50mg/m2. Therefore, the chlorophyll a targets (and consequential nutrient concentration targets) needed to achieve the One Plan MCI target of 120 will need to be more stringent than those identified in the One Plan.

d. Periphyton is controlled principally by:

   i. Ensuring natural hydrological variability is maintained so that freshes and floods can regularly scour periphyton growth from gravels.

   ii. Keeping nutrient inputs sufficiently low (for example, SIN concentrations at approximately 0.1-0.4mg/L). Both SIN and DRP need to be sufficiently low – simply managing one nutrient will be insufficient (Francoeur, 2001; Keck & Lepori, 2012).

   iii. Ensuring sufficient riparian vegetation to shade rivers and lowering temperatures, thereby preventing growth.

e. Whilst the One Plan Chlorophyll a limit is at 120mg/m2, in order to meet the One Plan MCI target of 120 then Chlorophyll a should be kept below 50mg/m2. Chlorophyll a both upstream and downstream of the WWTP exceeds the recommended 50mg/m2 threshold.

f. In order to achieve the One Plan's target MCI, nutrient concentrations will need to be lowered. What level should the nutrient concentrations be lowered to in order for an MCI of 120 to be achieved? I recommend using a multiple lines of evidence approach.

i. Matheson and others (2016) used quantile regression on data from several regions, including Manawatu, and concludes that to achieve a chlorophyll a concentration of 50 mg/m2 then SIN needs to be below 0.1mg/L.

ii. Clapcott and others (2013) used data collected between 2007 and 2011 from over 1000 reaches around the country to predict (using random forests) MCI at all locations around the country (r=0.83). The predicted MCI values were then regressed (ln(y)=x) against modelled nutrient data from Unwin and Larned (2013). For an MCI of 120, SIN concentration should be approximately 0.02mg/L (r^2=0.54, p<0.00001) and DRP concentration approximately 0.004mg/L (r^2=0.39, p<0.0001).

iii. Assuming a scouring event does not occur for 30 days, then according to Biggs (2000) to achieve a maximum monthly chlorophyll a concentration of 50 mg/m2 then SIN needs to be below 0.1mg/L and DRP needs to be 0.0039mg/L.

iv. A private collection held by Prof. Russell Death of macroinvertebrates from 962 sites throughout the lower North Island collected between 1994-2007 measured (Death, Death, Stubbington, Joy, & van den Belt, 2015) were regressed with (Unwin & Larned, 2013). For an MCI of 120, SIN concentration should be approximately 0.11mg/L (r^2=0.35, p<0.00001) and DRP concentration approximately 0.008mg/L (r^2=0.18, p<0.0001).

- <u>Therefore, to achieve the One Plan MCI target of 120, average SIN should be between 0.02-0.1mg/L and DRP between 0.0039-0.008mg/L.</u>

g. The nutrient concentrations required to meet the One Plan MCI target of 120 will need to be more stringent than the nutrient concentration targets/limits in the One Plan. The current nutrient concentration limits in the One Plan will not achieve the One Plan’s target MCI for the Mangatainoka River. Ultimately, if the One Plan MCI target is to be achieved then the whole catchment loads will need to be reduced, a part of which is the WWTP. Given that the river nutrient concentrations will need to reduce to ~0.1mg/L for SIN and DRP ~0.006mg/L, then I have determined the contribution of the WWTP to those required nutrient concentrations. Assuming the theoretical concentration increases in the Mangatainoka River from the Pahiatua WWTP provided in the *Response to Section 92 Further Information Request – Pahiatua Wastewater Treatment Plant* then at:

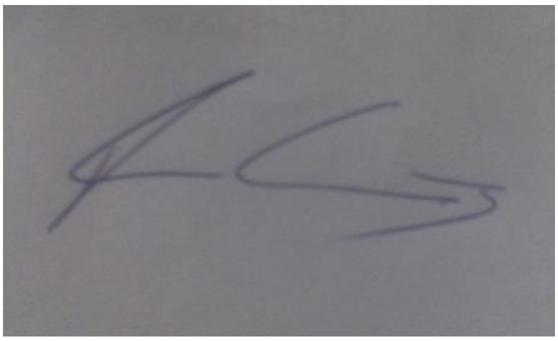
i. Mean annual flow, the WWTP will contribute to 2.7% of the required 0.1mg/L SIN concentration and 11% of the required 0.006mg/L DRP concentration.
ii. Summer low flow, the WWTP will contribute to 3.5% of the required 0.1mg/L SIN concentration and 26% of the required 0.006mg/L DRP concentration.
iii. Mean annual low flow (MALF, extreme summer flow), the WWTP will contribute to 10.7% of the required 0.1mg/L SIN concentration and 73% of the required 0.006mg/L DRP concentration.

8. It is evident that at all flows, the Pahiatua WWTP will have a very small contribution (except at MALF when contribution is moderate) to the SIN concentration required to achieve the MCI target of 120. The WWTP will have a moderate contribution to DRP concentration at mean annual flow, and large contributions at low flow considering the in-river DRP concentrations required to achieve the MCI target of 120.
9. To have the most significant reduction in impact on ecological health then I suggest measures that substantially reduce DRP load from the WWTP be applied during Summer low flow periods.

Adam Douglas Canning

Aquatic Ecologist

19th of July 2016



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