BEFORE THE HEARINGS PANNEL

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

STATEMENT OF EVIDENCE OF KEITH DAVID HAMILL ON BEHALF OF PALMERSTON NORTH CITY COUNCIL

1. INTRODUCTION

Qualifications and experience

1.1 My full name is Keith David Hamill. I hold a Bachelor of Science degree (Geography) from the University of Auckland (1992) and a Master of Science (1st Class Hons) in Ecology and Resource & Environmental Planning from the University of Waikato (1995).

1.2 I am employed as a Principal Environmental Scientist at Opus International Consultants Limited (Opus), based in Hamilton where I am responsible for providing consultancy services in environmental science. My technical speciality is in freshwater aquatic ecology.

1.3 I have 15 years experience in the area of resource management and environmental science. Prior to joining Opus in 2005 I worked in the United Kingdom as a Senior Environmental Scientist for a consultancy called WRc. Prior to this I worked for six years as an Environmental Scientist at Southland Regional Council.

1.4 I have been responsible for designing and implementing state of the environment monitoring programmes, undertaking environmental investigations, and developing environmental policy in New Zealand and Europe. Examples of projects I have worked on include:

(a) Aquatic ecological surveys to assess the potential impacts of wastewater treatment plant discharges, landfill projects, and construction projects in Southland, Otago, Waikato, Bay of Plenty, Hawkes Bay and Auckland.

(b) Review of NZ Cyanobacteria Guidelines for MfE (2009);

(c) Reviewing ammonia standards for protection of aquatic life to optimise urban pollution management for the UK Water Industry Research (2004).

(d) Co-ordinating the European Commission technical secretariat developing guidance for assessing eutrophication for the Water Framework Directive (2004).

(e) Designing and implementing State of the Environment (SOE) monitoring programmes for Southland rivers, lakes, wetlands and estuaries (1996-2002). Co-author of Southland's first State of the Environment report.

(f) Implementing a bathing beach monitoring programme and interagency response strategy for Southland marine and freshwaters (1999-2002).

(g) Member of working groups for developing NZ Bacteriological Water Quality Guidelines (1999-2002) and New Zealand Periphyton Guidelines (1997-2000).

Involvement in project

1.5 I have been engaged by the Palmerston North City Council ("PNCC") to present evidence relating to the Proposed One Plan (POP).

1.6 My involvement in this project has been to:

(a) Review the One Plan to provide specialist ecological advice to PNCC relating to their submission on the POP. This review of the POP focused on the proposed standards and their implications for the PNCC wastewater treatment plant (WWTP) discharge.

Purpose and scope of evidence

1.7 The purpose of my evidence is to discuss the appropriateness and application of the water quality standards in Schedule D of the POP, and in particular those related to the Lower Manawatu Management zone – sub zone Lower Manawatu (Mana_11a) and the Coastal Manawatu (Mana_13a).

1.8 My evidence will address the following:

(a) Water Management Zones;

(b) Expression of water quality standards / targets;

(c) Discussion of selected water quality standards / targets;

1.9 A summary of my evidence is set out in section 2 below.

Expert Witness Code of Conduct

1.10 I have been provided with a copy of the Code of Conduct for Expert Witnesses contained in the Environment Court's Consolidated Practice Note 2006 [2006] NZRMA 357. I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

2. SUMMARY OF MY EVIDENCE

2.1 In my evidence regarding water quality standards in the Proposed One Plan (POP) I discuss the following:

(a) The values set for water quality standards should reflect the way water quality standards are to be applied. Water quality 'standards' that act as a trigger value between a 'permitted activity' and 'discretionary activity' can be more conservative than water quality standards intended to act as an environmental bottom-line. Some of the proposed water quality standards are conservative for standards being applied as environmental bottom lines.

(b) The basis for setting water management zones is sound but there remains considerable natural variability in water quality and biota within a zone. Consequently it is important to have flexibility to how the water quality standards/targets are applied.

(c) The statistic used to define a water quality standard is just as important as the value chosen. In my view, the standards/targets in Schedule D should be expressed in the way that they are intended to apply and in a way that reflects impacts on aquatic ecosystems and river values.

(d) Selected water quality standards are discussed in section 4 and a number of recommendations are made. Key recommendations relate to:

(i) Expressing the standard/target for MCI values in relation to reference conditions;

(ii) Expressing the standard/target for QMCI values in relation what causes a reduction in scores;

(iii) Applying the standard/target for total ammoniacal nitrogen as average values;

(iv) Refining the standard/targets used for toxicants using approaches in the ANZECC guideline decision trees (e.g. apply to filtered samples and modifying values to account for hardness).

(v) Clarifying in the Schedule D Standards Key that the nutrient standards support the standards set for algae biomass and periphyton cover and allowing for discretions and flexibility to be applied to specific situations during the hearing processes.

3. WATER MANAGEMENT ZONES AND APPLICATION OF STANDARDS

Application of water quality standards/targets

3.1 Schedule D of the POP sets numerical ‘water quality standards’ for each water management zone. In general I support the approach of developing numerical water quality standards to achieve values associated with different river types. However, these need to relate closely to particular values to be achieved in particular types of rivers. Much of my evidence relates to aspects of the POP where, in my opinion, application and specificity of proposed water quality standards could be improved.

3.2 It is not clear whether the water quality ‘standards’ for each water management zone are intended to be applied as minimum standards that correspond to environmental bottom-lines to be achieved by all discharges[1]; or as 'water quality targets' which the region aspires to achieve by various means[2]; or as guideline 'trigger values' which might indicate when an activity ceases to be 'permitted'. The distinction is important for setting standards that protect the values of aquatic environments and for allowing flexibility for the resource consent process to set appropriate conditions to avoid and mitigate adverse environmental effects.

3.3 For example, more conservative standards may be justified if they are simply acting as a trigger between a 'permitted activity' and a 'controlled' or 'discretionary activity', because the particular consent limits for particular situations will be developed through the consent process on the basis of ensuring sustainable management.

3.4 I understand that Horizons Regional Council has indicated to PNCC that the water quality standards in the POP are actually intended to be water quality 'targets', and hence I have used the terminology 'water quality standards/targets' in my evidence.

3.5 The POP could be more specific, flexible and adaptable if it was more explicit in defining the values intended to be protected. This could be partially done through modifications to the Schedule D Standards Key as discussed in my evidence. Modifications could include distinguishing core standards/targets that directly relate to values (e.g. MCI, periphyton, algae biomass, clarity, *E.coli* bacteria) from supporting standards/targets that more indirectly influence values (e.g. nutrients). In some cases, a narrative explanation could be included to specify how standards should apply.

Water Management Zones

3.6 I support the general approach taken in basing water management zones on the Regional Environment Classification (REC), which allows for differentiation of different river and stream types. However the current water management zones have lost a lot of detail present in the Regional Environment Classification (REC), on which it is based. As a result there will be considerable variability in species composition of different types of streams within a single zone. For example, a small incised lowland creek running through farm land will have very different species composition compared to

[1] Aussell and Clark (2007) define the standards in this way.
[2] Horizons MW staff has suggested that this is the intent in discussions with PNCC.

the main stem of the Manawatu River at Palmerston North which is still influenced by the hill country streams.

3.7 For many aspects of water quality one size does not fit all, and unlike the REC, water quality standards/targets set in the context of the water management zones do not differentiate smaller streams that may have naturally poorer water quality (e.g. lower MCI scores). This suggests a need for allowing discretion in how any water quality standard/target is applied. It may be possible to increase the spatial resolution by introducing more sub-zones over time.

3.8 Flexibility in the application of water quality standards/targets is particularly important for nutrients. Nutrient targets are set to control periphyton cover and biomass, but the response of periphyton to nutrients is complex, being influenced by light penetration, substrate stability, water temperature, current velocity, invertebrate grazing pressure and frequency of flood events. These factors will influence periphyton growth to varying degrees in different situations and seasons.

Conclusion

3.9 My key conclusions about application of water management zones are:

(a) The values set for water quality standards should reflect the way water quality standards are to be applied. Water quality 'standards' that act as trigger values between a 'permitted activity' and 'discretionary activity' can be more conservative than water quality standards intended to act as an environmental bottom-line. As discussed below, some of the proposed water quality standards are conservative for standards being applied as environmental bottom-lines.

(b) The basis for setting water management zones is sound but there remains considerable natural variability in water quality and biota within a zone. Consequently it is important to have flexibility to how the water quality standards/targets are applied.

4. EXPRESSION OF WATER QUALITY STANDARDS/TARGETS

General

4.1 The Proposed One Plan Schedule D Standards Key expresses many of the water quality standards (with the exception of DRP, SIN and changes of pH, temperature and clarity) in terms of maximum values (or "shall not exceed"). In my view a more appropriate expression of the water quality standards would be in terms of a percentile value or an average value. The general reasons for this are as follows:

(a) A maximum value requires 100% compliance but may reflect an instantaneous spike or a measurement error that has little or no impact on aquatic biota.

(b) An average or median value has more biological relevance than a maximum value for many parameters (e.g. Biological Oxygen Demand (BOD), turbidity, QMCI, periphyton, and nutrients). This is because the organisms and biological processes respond more strongly to average concentrations than to an instantaneous peak.

(c) Some of the water quality standards recommended by Ausseil and Clark (2007a) are derived from 10^{th} percentile values (e.g. lower limits of pH) and 90^{th} percentile values (upper limit for pH). The same statistic should be applied to the standard to ensure it is not overly conservative or lenient.

(d) Many generally accepted guidelines are expressed as averages or percentile values (e.g. $cBOD_5$).

4.2 I will discuss appropriate expression of the standards/targets when discussing each parameter below.

4.3 For many parameters there is common agreement between me and experts supporting Horizons Regional Council about what is the most appropriate statistic to use when applying a standard/target (e.g. Dr Quinn regarding $cBOD_5$ and POM). However, there is disagreement about how the standard/target should be expressed in Schedule D of the POP. In my view, the standards/targets in Schedule D Standards Key should be expressed in the way that they are intended to apply and in a way that reflects impacts on aquatic ecosystems.

4.4 I disagree with the implication in Dr Quinn's evidence (paragraph 28) that maximum ("shall not exceed") standards are justified because they are simply targets for Horizon's management. The difference between an average value and a maximum, or a 90th percentile value and a maximum value is often substantial and the statistic used is often just as important as the value set. This can be seen in Table 1 which compares the current water quality in the Manawatu River upstream and downstream of the PNCC wastewater treatment plant (WWTP) based on monthly sampling from January 2004 to June 2007 for Consent No. 101929.

4.5 I support the approach of having a supporting document to give additional guidance on how to calculate particular statistics in particular situations. However, in my view, the water quality standards/targets themselves should be expressed in a way as close as practical to the way they are intended to be used, so that their intent is straight forward and clear.

4.6 An example of where supporting documentation would be useful is how to apply a 90th percentile target for determining consent compliance (which requires a reasonably sized dataset). In these situations a commonly used alternative to a 90th percentile value is to express consent limits as "no more than one in ten samples shall exceed…". This is not the same as a 90th percentile value but is a pragmatic expression that achieves the same purpose.

Table 1: Current water quality in the Manawatu River upstream and downstream of the PNCC WWTP. Cells are shaded where standards in the proposed One Plan are exceeded.

Parameter	Statistic	Upstream	Downstream
Temperature (^oC) (max)	max	20.3	20.3
Dissolved oxygen (g/m^3)	min	7.0 (min)	7.6 (min)
BOD_5 (g/m^3)	Mean Max	1.2 4.0	1.1 3.0
POM (g/m^3)	Mean Max	4.8 66	4.9 65
Total ammonia (g/m^3)	Mean	0.030	0.233

	Max	0.029	0.670
Clarity (m)	Min 10^{th} %ile	0.5 0.6	0.5 0.59
DRP (g/m^3) mean	Mean	0.011	0.081
SIN (g/m^3) mean	Mean	0.488	0.697
E. coli (CFU/100mL)	95^{th} %ile Max	5655 11200	2630 15500

Conclusion

4.7 My key conclusions about the expression of the water quality standards/ targets are:

(a) The statistic used to define a water quality standard is just as important as the value chosen. In my view, the Schedule D standards Key should be modified so that standards/targets are expressed in the way that they are intended to apply and in a way that reflects impacts on aquatic ecosystems and river values.

5. DISCUSSION OF SELECTED WATER QUALTIY STANDARDS

Soluble Carbonaceous Biological Oxygen Demand$_5$ (cBOD5)

5.1 I support the changes made to the POP regarding soluble Carbonaceous Biological Oxygen Demand$_5$ (soluble cBOD$_5$). The revised standard/target for the Lower Manawatu (Mana_11a) is now: "*The monthly average five-day soluble carbonaceous biochemical oxygen demand (cBOD$_5$) when the river is at or below 20th percentile flow shall not exceed 2 g/m^3*".

5.2 Elevated concentrations of cBOD$_5$ can reduce dissolved oxygen levels and promote heterotrophic growths. Heterotrophic growths (e.g. sewage fungus) respond to prolonged periods of elevated cBOD$_5$, the concentration of which is better reflected by the mean value rather than a maximum value. MfE (1992) recommend that the daily average cBOD$_5$ concentration is maintained below 2 mg/l to avoid heterotrophic growths. Expressing the results as carbonaceous

BOD_5 ($cBOD_5$) ensures that the effect of nitrifying bacteria do not influence the results.

Particulate Organic Matter (POM)

5.3 I have reservations about the use of POM as a water quality standard/target. As an environmental bottom line I think that the standard/target for $cBOD_5$, clarity and QMCI scores act as suitable surrogate controls for POM and settling of fine sediments.

5.4 Currently the water quality standard/targets apply POM as a maximum concentration and as such it is much stricter than the results of the studies from which the standard was derived (Quinn and Hickey 1993). If POM remains as a standard/target, I agree with Dr Quinn's recommendation that it is applied as an **average** concentration of 5 g/m^3 under low flow conditions (< median flow) (see paragraph 43 of Dr Quinn's evidence).

Aquatic Macroinvertebrate Community

5.5 The composition of macroinvertebrate communities is commonly used as a measure of 'river health' and to reflect the integrated effects of habitat and water quality of a river. The indices Macroinvertebrate Community Index (MCI), Quantitative Macroinvertebrate Community Index (QMCI) and Semi-Quantitative Macroinvertebrate Community Index (SQMCI) are generally accepted and robust measures of ecosystem health.

5.6 There are many factors that influence the macroinvertebrate community and subsequent QMCI scores (e.g. river flows, substrate, water quality, periphyton growth, predation, temperature, riparian vegetation and its debris). This makes MCI and QMCI scores a useful measure to integrate many factors, but it also makes it more difficult to interpret what might be causing any failure to meet a MCI standard. When assessing the impact of a discharge considerable effort is made to isolate causal factors by ensuring that sample sites from upstream and downstream have similar habitat. In my view any standards/targets should be applied to allow sufficient flexibility to identify and isolate the key factors limiting stream ecosystem health – in many cases this will be related to habitat.

5.7 The development of the soft bottomed version of the MCI and QMCI (called MCI-sb and QMCI-sb) with particular sampling techniques has helped extend the techniques to otherwise unsuitable habitats (Stark and Maxted 2007). However, comparison of results with appropriate type-specific reference sites remains critical for interpretation of the results.

5.8 As discussed already, the use of water management zones has helped the POP refine standards/targets to different types of rivers, but there remains considerable variation within any particular sub-zone compared to the Regional Environment Classification (REC). This will be particularly evident in setting appropriate targets for macroinvertebrates which are directly influenced by a wide range of factors (e.g. flow regime, riparian habitat, substrate type, macrophytes, water quality etc). In any one sub-zone there will be rivers with different potential MCI values, yet they are all expected to meet the same MCI standard/target. For example, a target MCI score of 100 is appropriate for the main stem of the Manawatu River (sub-zone Mana_11a), but may be difficult to achieve in a tributary creek running through Palmerston North with soft substrate and intermittent flow. Increasing the spatial resolution of sub-zones could help address this issue.

5.9 In summary, I generally support the development of standards/targets based on indices of macroinvertebrate communities such as the MCI and QMCI. However, they need to be applied in a way that allows flexibility and comparison with appropriate reference sites. There are a number of ways in which this could be achieved, including:

(a) The spatial resolution of subzones could be improved to better reflect the REC;

(b) The standards/targets for macroinvertebrate communities could be expressed in relation to reference conditions to address issues of spatial variability. For example, expressing them as Observed/Expected (O/E) scores (see Joy and Death 2003); and/or

(c) Schedule D could apply MCI scores as a narrative standard (e.g. "*The MCI score shall not be less than 20% of natural reference conditions*"), and include actual scores as supporting standards to apply where appropriate reference conditions have not been defined.

5.10 I support the inclusion of MCI-sb as an alternative to use of the MCI where appropriate. This should also be applied to the QMCI-sb.

5.11 I support the use of a QMCI target applied as a percent change upstream and downstream of a discharge to water, but recommend that the following wording should be added: "<u>*Discharges to water to cause*</u> *no more than a 20% reduction in QMCI score between upstream and downstream of the discharge*." This will help focus attention on the cause of any decline in ecosystem health.

Total Ammoniacal Nitrogen

5.12 The toxicity of ammonia is complex. It is affected by pH, temperature and electrical conductivity. In general terms total ammonia becomes more toxic at higher pH values because at higher pH there is a greater proportion of unionised ammonia in solution; however ionised ammonia can also be toxic. Total ammonia toxicity tables, like those in the ANZECC guidelines, take this into account and are not simply a translation of the proportion of unionised ammonia at a certain pH and temperature.

5.13 The POP standard/target for the lower Manawatu River is based on ANZECC guidelines for protection of 95 percent of species. It converts the unionised ammonia recommendation of 0.035 g/m^3 to an equivalent total ammoniacal ammonia concentration of 0.4 g/m^3, using the maximum POP standards set for pH and temperature (equivalent to a pH of 8.4, temperature of 20°C and electrical conductivity of 100 uS/cm^3) (Ausseil & Clark 2007).

5.14 In using the ANZECC guidelines to set a water quality standard/target for total ammoniacal nitrogen there are three main factors to consider. 1) Should a value be set to protect 95 percent of species or 99 percent of species, 2) how to account for different toxicity at different pH values, and 3) what statistic should it be applied to?

5.15 I agree with the approach recommended by Ausseil & Clark (2007) of setting standards/targets for the lower Manawatu River (sub-zone Mana_11a) based on ANZECC guidelines for slightly-moderately disturbed ecosystems (i.e. for protection of 95 percent of species). I consider this an appropriate level of protection for the values applied to this zone.

5.16 The ANZECC guidelines recommend stricter guidelines for total ammoniacal nitrogen if the aquatic community contains important species that are particularly sensitive to ammonia. For example, the fingernail clam *Sphaerium novaeselandiae* is very sensitive to total ammonia and if it is considered important to protect this species at a site the ANZECC guidelines (2000) recommends using total ammonia values of half the 95-percent trigger value i.e. a value of 0.45 g NH_4-N/m^3 (when pH=8 and temperature=20°C), or using

[3] This equates to approximate 95th percentile values for the Manawatu River at Teaches College.

the trigger value for 99-percent protection of species, i.e. 0.32 g NH_4-N/m^3 (when pH=8 and temperature=20^oC)[4].

5.17 Although *Sphaerium* sp. is typically widespread in lowland rivers it appears to be a minor component or absent from the Manawatu River and other major rivers of the Manawatu-Whanganui region. Macroinvertebrate surveys of the Manawatu River by Cameron (2004) did not identify *Sphaerium* sp. and Horizons MW State of Environment reports from 1999 to 2006 only identified *Sphaeriidae* at two sites, on one occasion in 2000; at both these sites (i.e. Whanganui at estuary and Hautepu u/s Rangatiki) only one individual was found. The apparent absence of *Sphaerium* sp. in the Manawatu River supports the approach of applying the ANZECC guideline for slight-moderately disturbed river systems to the lower Manawatu River (Mana_11a), i.e. 0.9 g NH_4-N/m^3 (when pH=8 and temperature = 20^oC).

5.18 I contend that the total ammonia water quality standard should be based on table 8.3.7 in the ANZECC guidelines (ANZECC 2000). This ensures that the standard/target set is appropriate to the different pH of different rivers and at different times of day. Setting a single number, based on the upper 95th percentile values for pH and temperature, will result in an overly strict standard under most situations. This does not need to be awkward to apply as suggested in evidence by Dr Wilcock, and in my experience table 8.3.7 in the ANZECC guideline works well as a basis for setting consent limits during the consent process. Using this table allows future consent processes to have flexibility for different rivers, seasons and flows.

5.19 Having said this, the POP standards/target for total ammoniacal of 0.4 g/m^3 would be appropriate if the POP standards/targets were simply used as trigger value to indicate a shift from ‘permitted activity’ to a ‘discretionary activity’ and flexibility was retained in the consent process to set an appropriate value for specific situations.

5.20 The ANZECC guidelines (2000) do not explicitly specify a particular statistic to apply to the total ammoniacal guideline. However, they imply using median or average values because:

(a) ANZECC guidelines are based on chronic toxicity (e.g. over a 96-hour period).

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[4] Hickey and Martin (1999) found the No Observed Effect Concentration (NOEC) of total ammoniacal nitrogen to be 0.97 g/m^3 (pH 7.5) for both survival and reproduction of *Sphaerium novaezelandiae*.

(b) The calculations in studies used to derive the guidelines were based on median ammonia concentrations under different nominal doses (e.g. Hickey and Martin (1999) study into the toxicity of ammonia to *Sphaerium* sp).

(c) The ANZECC guideline values already have built-in safety factors. The trigger values were derived by dividing the lowest No Observed Effect Concentration (NOEC) data point by 10 (ANZECC 2000 section 8.3.4.4). The use of NOEC data to derive high reliability trigger values is itself conservative since NOECs are about 2.5 times lower than Lowest Observed Effect Concentrations (LOEC);

(d) The Criteria Continuous Concentration used by the USEPA (1999) is based on a 30-day average concentration. This guideline is broadly similar to the ANZECC guideline (ANZECC guideline = 0.9 g/m^3 compared to USEPA CCC of 1.7 g/m^3 (both at pH 8, temperature 20^{o}C).

5.21 Dr Wilcock contends in his evidence that it “could be complicated to manage and to monitor” the application of total ammonia concentrations as average values. In my experience this is not the case. It is common to specify consent limits in terms of both a median (or average) value <u>and</u> as a 95th percentile (or maximum) value. The USEPA (1999) specifies a Criteria Maximum Concentration (CMC) (one hour average) for total ammonia of 5.6 g/m^3 at pH = 8 and 2.59 g/m^3 at pH = 8.4 and similar numbers could be considered for the POP.

5.22 Using both a mid-point and upper value gives additional certainty for consents. However when applying the standard/target to State of Environment Monitoring, good certainty of compliance with acute criteria will be given by solely using average values based on chronic criteria. This is because average values (unlike median values) incorporate extreme events. Consequently, if a discharge causes a regular breach in the maximum value this will be detected in a breach in the average value. Furthermore, the ratio of acute to chronic values for total ammonia is more than the ratio of average to maximum values typically encountered in rivers. For example, in the Manawatu River at Teachers College the maximum value for total ammonia is 4.5 times higher than the average value (0.074 g/m^3 compared to 0.0163 g/m^3). Assuming the average total ammonia value in the river was at the POP proposed standard of 0.4 g/m^3, then the corresponding maximum value would be 1.8 g/m^3 – well below the USEPA CMC of 2.59 g/m^3 at pH = 8.4.

5.23 In summary, I recommend that:

(a) The standard/target for sub-zone Mana_11a relate to 'slightly-moderately disturbed ecosystems';

(b) Schedule D Standard Key is modified to refer to the <u>average</u> concentration of ammoniacal nitrogen*; and*

(c) Schedule D Standard Key is modified to state that: "*the average concentration of ammoniacal nitrogen shall not exceed the values set in Table 8.3.7 of the ANZECC guidelines (2000) for protection of x% of species*".

Toxicants

5.24 I support the use of ANZECC (2000) guideline trigger values for toxicants in water if applied as trigger values. However the ANZECC guidelines were not intended to be applied as blanket values for all situations and are not always appropriate to translate directly into standards as proposed in the POP, or directly into consent conditions. The ANZECC guidelines put considerable emphases on decision trees to assess risk for particular waterbodies and circumstances. In my view, these decision trees need to be used to refine the ANZECC trigger values for toxicants before translation into a standard/target with potential statutory implications.

5.25 For example the ANZECC guidelines include a decision tree for applying trigger values (including considering site specific factors that may reduce the level of environmental risk). In the case of metals, if the trigger values are exceeded the recommended actions include:

(a) Adjust the trigger values to account for hardness. This is strongly recommended and hardness algorithms are available for Cd, Cr (III), Cu, Pb, Ni, and Zn.

(b) Filter the sample through a 0.45 um filter (or 0.15 um filter for some metals) and compare the filtered concentration against trigger values.

(c) Determine how Dissolved Organic Matter affects toxicity and apply factors to account for this.

(d) Determine the metal speciation and corresponding effects on toxicity.

Clarity

5.26 I support the POP standard/targets for clarity in rivers, however, in my view the wording for the standard relating to percent change should be modified to remove reference to the size of the black disc. When the clarity is low (i.e. <ca. 0.5 m) it is more appropriate to use a 20mm black disc, and removing reference to the size of the black disc will avoid confusion about the appropriate method use.

Periphyton

5.27 I support the POP standards/targets and recommendation made in evidence by Dr Biggs for periphyton cover. i.e. a maximum cover of visible stream bed by filamentous algae >2 cm long of 30%, and a maximum cover of visible stream bed by diatoms/cyanobacteria more than 0.3 cm thick of no more than 60% cover, as stated in the New Zealand Periphyton Guideline (Biggs 2000).

5.28 For the sake of clarity, I recommend that the wording in the Standards Key regarding algae biomass is modified to specify <u>filamentous</u> algae. This is consistent with the New Zealand Periphyton Guideline (Biggs 2000).

Dissolved Reaction Phosphorus (DRP) and Soluble Inorganic Nitrogen (SIN)

5.29 In general I support the approach of using periphyton as the primary value on which to base stream nutrient standards (i.e. effects based standards) and modifying the values upwards if naturally occurring nutrient concentrations already exceed this standard.

5.30 The POP standards/target set for DRP and SIN support the standards set for periphyton and algae. Ausseil and Clark (2007a) used the model in the NZ Periphyton Guidelines (Biggs 2000) to derive nutrient standards/targets specific to the Mean Days of Accrual and applicable periphyton biomass standard for each water management sub-zone. In the Mana_11a sub-zone the nitrogen guideline was relaxed on the basis of phosphorus being limiting and the SIN concentration being much higher than the guideline value. The nutrient standards are intended to apply throughout the year on the basis that the blooms could occur at any time of year and that periphyton growth and vigour is influenced by antecedent water quality. On this basis only flood conditions (> 20th percentile flow) are excluded from the nutrient standards.

5.31 In general I consider this approach to be sound. However I am not convinced about the need to apply the standards throughout the year. There are three main arguments for applying nutrient standards/targets throughout the year rather than on a seasonal basis. These are:

(a) Periphyton can grow throughout the year and it is possible that periphyton can reach nuisance levels at any time of year;

(b) Some periphyton species can take up phosphorus in excess of their immediate needs and this luxury uptake of nutrients could be used to stimulate periphyton growth even after phosphorus concentrations in the water column have reduced;

(c) Nutrients attached to sediments could settle on the river bed and mineralise at a later date to release nutrients in a form available for algae and plant growth.

5.32 While these scenarios are all possible, I contend that some types of nutrient discharges could occur during winter without compromising standards set for periphyton biomass or cover.

5.33 The NZ National Water Quality Monitoring Network monitors water quality at three sites on the Manawatu River – Weber Road (WA7), Teaches College at Palmerston North (WA8) and Opiki Bridge (WA9). The sites and monitoring methods are described in Quinn and Raaphorst (2009). Figure 1 shows the number of times periphyton guidelines are exceeded by filamentous algae or mats at each site. Figure 2 shows the mean cover of filamentous algae over the stream bed for each month in comparison with the guideline value for filamentous algae of 30%. The figures cover data from 1990 to 2009, but excludes data between 2003 and 2006 that was labelled as ‘dubious’. The number of data points available for each month ranged from 6 to 16, with generally fewer observations recorded for the winter months.

5.34 This data shows that a nuisance level of periphyton cover in the Manawatu River is predominantly an issue in summer and autumn. In 18 years of monitoring the guidelines have only ever been exceeded once at each site during the months of June to November. All exceedances between May and October occurred at flows less than median flow and half were at flows less than half the median flow.

Figure 1: Number of times periphyton cover guidelines are exceeded at sites on the Manawatu River. i.e. cover >30% filamentous algae or > 60% periphyton mats.

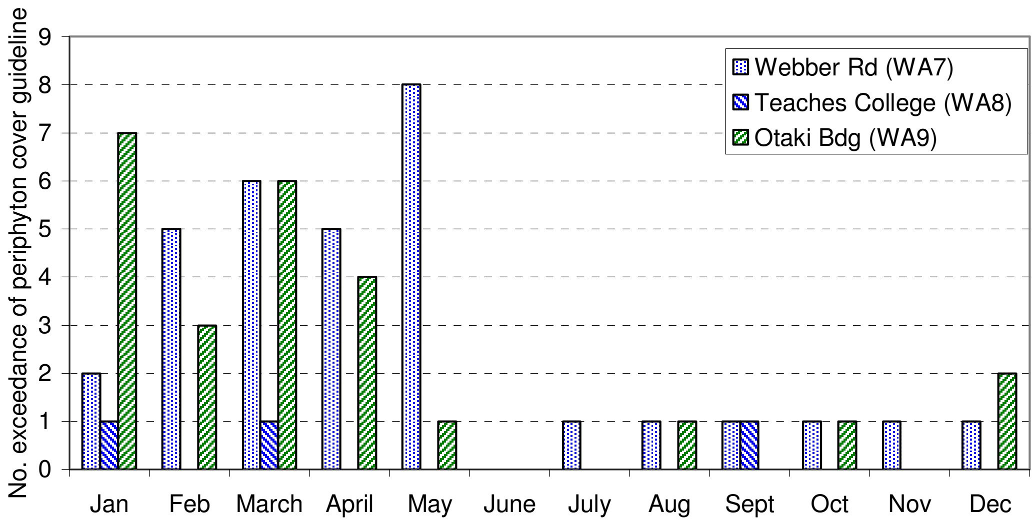
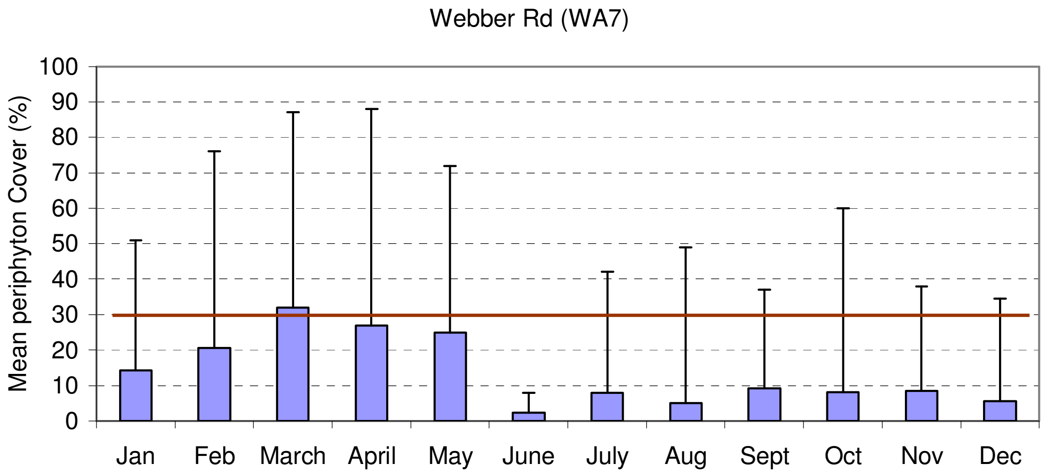
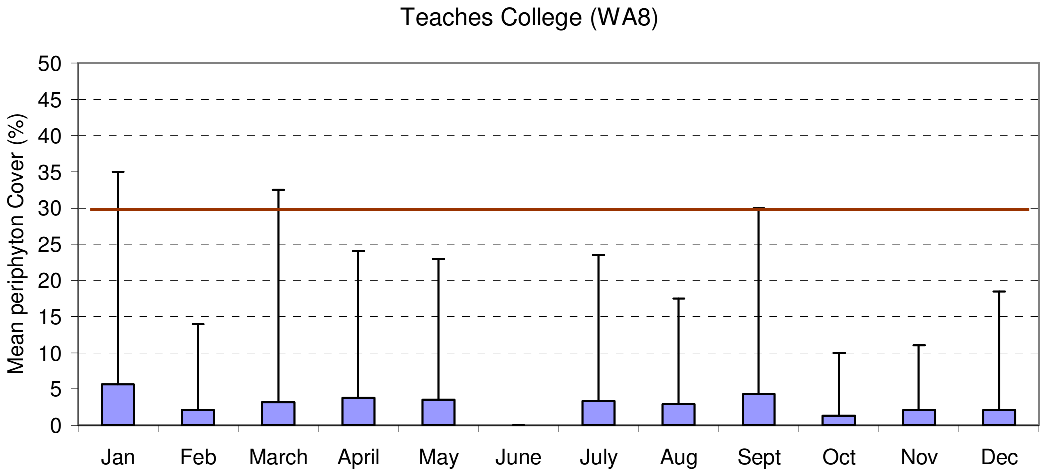
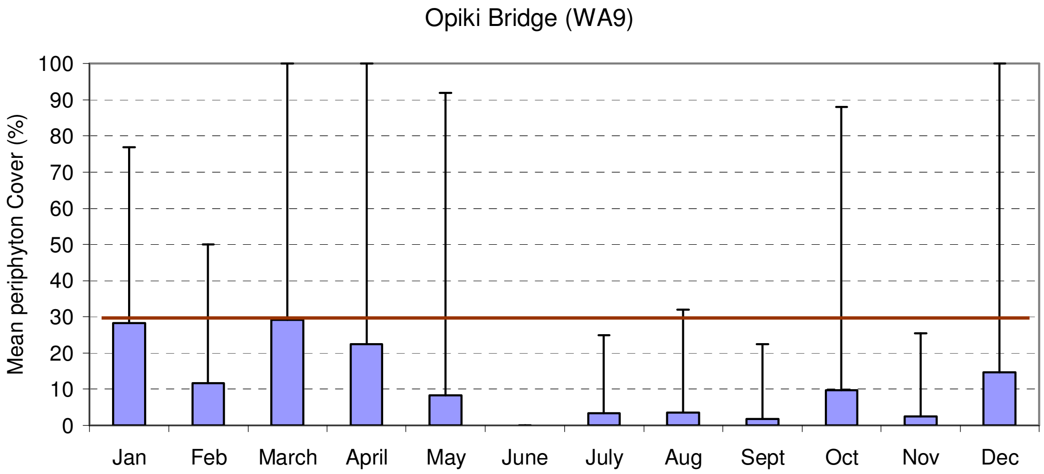


Figure 2: Mean periphyton cover in the Manawatu River at Webber Road, Teaches College, and Opiki Bridge. Error bars show maximum periphyton cover in each month for the period Jan 1989 – March 2009.







5.35 The response of periphyton to nutrients is complex, being influenced by light penetration, substrate stability, water temperature, current velocity, invertebrate grazing pressure, velocity and frequency of flood events. These factors will influence periphyton growth to varying degrees in different situations and seasons. Many of these factors converge in the winter to make the likelihood of prolific periphyton growths much less likely.

5.36 The luxury consumption of phosphorus by periphyton and bacteria is a well documented phenomenon that is utilised in some wastewater treatment plants. However the amount able to be assimilated and stored is proportional to the periphyton biomass. When periphyton biomass is low, there is a limited amount of phosphorus that can be stored, consequently, luxury consumption is a more important consideration closer to periods of peak growth and less important earlier in the winter and when total periphyton biomass / cover is low. There are a number of ways to address concerns that allowing Palmerston North WWTP to discharge phosphorus during winter will lead to luxury consumption of phosphorus and subsequent stimulating periphyton growth. These include monitoring periphyton growth downstream of the Palmerston North WWTP discharge in late winter to spring, and resuming phosphorus treatment if periphyton cover increases to a predefined trigger level.

5.37 It is possible that discharges of phosphorus to a river will augment the phosphorus pool in the river sediments, which could later be mineralised and add to the internal load of phosphorus to the river. In many aquatic systems the internal cycling of nutrients from sediments is a significant component of nutrient loads. However, for some discharges (like the Palmerston North WWTP discharge) the contribution of phosphorus to the river or estuarine sediment pool will be minor because the phosphorus is mostly in a dissolved form or a colloidal form that will not always settle out of solution.

5.38 When the Palmerston North WWTP is not treating for phosphorus, the concentration of total phosphorus (TP) in the discharge is on average 6.1 g/m^3. Seventy eight percent of the TP is in the form of dissolved reactive phosphorus (DRP), which is a form available for periphyton growth but periphyton uptake will be limited when biomass is low (e.g. during the winter).

5.39 To provide a rough estimate of the proportion of this TP that may settle out on the river bed we used an acid washed Imhoff cone to settle effluent for four hours. A sub-sample was collected prior to settling and tested for total suspended solids and TP. After four hours the supernatant was again tested for TSS and TP. Four hours of settling reduced the concentration of total phosphorus in the effluent by 5.3% (3.8 g/m^3 to 3.6 g/m^3) - suggesting that in sections of the river water column that experience extended quiescent conditions, about 5% of the phosphorus derived from the WWTP may settle out (or adsorb to settled sediments) on the river bed[5].

5.40 These estimates indicate that most of the phosphorus from the Palmerston North WWTP discharge will travel to the sea[6] either as DRP or in a form that will stay in suspension. Consequently, during periods of limited periphyton growth such as winter, the contribution of the discharge to the phosphorus pool in the sediment will be limited.

[5] Only a small proportion of the water column will be exposed to similar extended quiescent conditions.
[6] It takes about 36 hours for the Manawatu River to travel from PN to the sea under median flow conditions.

5.41 In summary, I contend that there will be situations where the proposed standards for DIN and DRP are not necessary to control periphyton biomass to the required standards. I recommend that a note is provided in the Schedule D Standards Key explaining that the standards set for nitrogen and phosphorus in rivers are there to support the standards for periphyton and algae; and that there may be some specific situations where the nutrient standards are not necessary and discretion should be exercised during the hearing process (e.g. some types of discharges during winter).

Conclusion

5.42 My key conclusions about water quality standards /targets are:

(a) I support the changes made to the POP regarding $cBOD_5$, that applies the standard/target to a monthly average soluble $cBOD_5$ when the river is at or below the 20^{th} percentile flow.

(b) I recommend that any standard/target for POM is applied as an **average** concentration of 5 g/m^3 under low flow conditions (< median flow). This corresponds more accurately to the study from which the standard is derived.

(c) In general I support the development of standards/targets based on indices of macroinvertebrate communities such as the MCI and QMCI. However, they need to be applied in a way that allows flexibility and comparison with appropriate reference sites. One way to achieve this is to express the standard in relation to appropriate reference conditions and include the current MCI scores as standards/targets to apply where appropriate reference conditions are not defined.

(d) I support the use of a QMCI target applied as a percent change upstream and downstream of a discharge to water, but recommend that the following wording should be added: "*<u>Discharges to water to cause</u> no more than a 20% reduction in QMCI score between upstream and downstream of the discharge*." This will help focus attention on the cause of any decline in ecosystem health.

(e) Standards/targets of total ammoniacal nitrogen for the lower Manawatu River are overly strict because they are applied as maximum values. I recommend that the standard/target is applied as an average value and

Tables from the ANZECC guidelines are used to avoid the POP standard being overly conservative or overly lenient

(f) The POP has directly translated ANZECC trigger values for toxicants into a standard. The ANZECC guidelines were not intended to be applied as blanket values. I recommend that the values used in the POP standard are refined using approaches in the ANZECC guideline decision trees (e.g. modify values to account for hardness, apply to filtered samples etc).

(g) I support using the New Zealand Periphyton Guideline (Biggs, 2000) as a basis for standards relating to periphyton cover and biomass. A recommendation is made to clarify the use of these guidelines.

(h) I support the general approach used to set nutrient standards. However, in my opinion the nutrient standards should be used to support the standards set for algae biomass and periphyton cover. I recommend including a note in the Schedule D Standards Key acknowledging that there may be specific situations (such as winter months) where the nutrient standards may not be appropriate for control of periphyton growth and allowing for discretions and flexibility to be applied during the hearing processes.

Keith David Hamill
October 2009

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