In the Environment Court
at Wellington

in the matter of: appeals under clause 14 of the First Schedule to the Resource Management Act 1991 concerning proposed One Plan for the Manawatu-Wanganui region

between: **Federated Farmers of New Zealand**
(ENV-2010-WLG-000148)

and: **Minister of Conservation**
(ENV-2010-WLG-000150)

and: **Horticulture NZ**
(ENV-2010-WLG-000155)

and: **Wellington Fish & Game Council**
(ENV-2010-WLG-000157)

and: **Andrew Day**
(ENV-2010-WLG-000158)
Appellants

and: **Manawatu-Wanganui Regional Council**
Respondent

and: **Fonterra Co-operative Group Limited**
Section 274 Party

Statement of evidence of **Dr Michael Robert Scarsbrook** for Fonterra Co-operative Group Limited

Dated: 14 March 2012

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STATEMENT OF EVIDENCE OF DR MICHAEL ROBERT SCARSBROOK FOR FONTERRA CO-OPERATIVE GROUP LIMITED

INTRODUCTION

1 My full name is Michael Robert Scarsbrook.

2 I have a BSc (1989) and a PhD in Zoology from Otago University, conferred in 1996.

3 I am employed by DairyNZ Ltd as Development Team Leader – Sustainability, and lead DairyNZ's Environment Programme. I also lead a Primary Growth Partnership funded programme (Train the Trainer – Nutrient Management). I have worked for DairyNZ for 3 and a half years.

4 Prior to this I worked for the National Institute of Water and Atmospheric Research (*NIWA*) for 13 years where I was employed as a Freshwater Biologist and filled roles as Leader of the National Centre for Water Resources and Group Manager – Stream Ecology. I was heavily involved in state of the environment (*SOE*) monitoring and reporting, providing input to national and regional water quality assessments. One of my areas of expertise was the analysis of water quality trends.

5 I have contributed to a number of regional (e.g. Southland, West Coast, Hawkes Bay and Auckland) and national SOE reports. I was a major contributor to the Freshwater Chapter of the Environment New Zealand 2007 SOE report (Scarsbrook 2006), as well as assisting the Ministry for the Environment (*MfE*) with OECD reporting on two occasions (e.g. Scarsbrook 2004). I have also been involved in the development of a Water Quality database (WQIS: https://secure.niwa.co.nz/wqis/index.do), which provides a web-accessible storehouse for data from the National Rivers Water Quality Network. I was the principal author of MfE's Best Practice Guidelines for the statistical analysis of freshwater quality data (Scarsbrook & McBride 2007). I have authored and co-authored more than 40 scientific papers and book chapters and produced more than 50 technical reports for commercial clients.

6 Recently, I have been a member of the Land and Water Forum's Limit Setting Working Group, which is tasked with defining processes for setting water quality and quantity limits in New Zealand's waterbodies.

7 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. I confirm that the issues addressed in this brief of evidence are within my area of expertise, except where I

state I am relying on what I have been told by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

8 I am familiar with the Proposed One Plan (*POP*) to which these proceedings relate. In 2004 I was involved in POP design as a member of a Water Quality Technical Advisory Group. As a designated Project Manager in NIWA I helped the Manawatu-Wanganui Regional Council (*Council*) to set up Envirolink-funded projects using NIWA expertise and provided sign-off review for one of the NIWA reports[1] that formed the basis of standards setting within the POP. I also presented evidence at the Council-level hearing in relation to the water chapters of the POP on behalf of Fonterra Co-operative Group Limited (*Fonterra*).

SCOPE OF EVIDENCE

9 My evidence will deal with the following:

9.1 The definition of Water Management Zones (*WMZs*);

9.2 The setting of values and objectives for individual WMZs;

9.3 The process of setting of water quality standards (now referred to as "numerics") in Schedule D to the POP and issues with "effects-based" standards versus reference-based standards;

9.4 A description of existing water quality state and trends in the Manawatu-Wanganui Region (*Region*), highlighting the disconnect between nutrient standards and actual nutrient levels in the Region's rivers;

9.5 The process of determining relative nutrient loads from point sources and non-point sources and the load scenarios developed by Dr Jon Roygard;

9.6 Comments on the uptake of best environmental practices on-farm to drive reductions in nutrient losses, under Ms Clare Barton's (for the Council) (*Council Version*) and Mr Gerard Willis' (for Fonterra) (*Fonterra Version*) POP planning regimes; and

9.7 Design of the SOE monitoring network for the Region and opportunities for adaptive management.

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1 Wilcock et al. (2007).

STRUCTURE OF EVIDENCE

10 Broadly, my evidence is split into three parts:

10.1 **Part A** sets out my broader views on the water management framework established as part of the POP and highlights some weaknesses in the methodologies, available data and assumptions used by the Council witnesses.

10.2 **Part B** responds to matters raised in the supplementary evidence of Dr Biggs, Dr Quinn, Dr Roygard, Mr McBride and Ms McArthur who appeared for the Council at the Council-level hearing. I also address matters raised in the Council's End of Hearing Reports in Part B.

10.3 **Part C** addresses matters arising from the additional joint technical expert statement of Dr Jon Roygard, Kate McArthur and Maree Clark dated 14 February 2012 and the Supplementary Statement by Jon Roygard and Maree Clark on Nutrient Load Scenarios and Methodology dated 24 February 2012. I also make brief comments on the technical report submitted as appendix 1 of the evidence by Roygard et al. on 24 February 2012 (Gibbs, M. (2011). Lake Horowhenua Review. NIWA Client Report HAM2011-046). My evidence has been structured in this way to respond to the Council evidence in chief, which primarily comprises the statements from the Council-level hearing, but includes more recent work from Dr Jon Roygard, Kate McArthur and Maree Clark.

11 I also note that I have addressed a number of areas that were included in my evidence from the Council–level hearing (for example the process leading to the setting of the Schedule D standards (now called numerics) for nutrients). Although I acknowledge that these areas may be less relevant to the outstanding issues in the case, I have commented on them to provide background and context to some of the primary issues discussed at the Council hearing, which remain relevant in setting the scene.

SUMMARY OF EVIDENCE

Part A summary

12 I support the general approach taken by Horizons to setting up a water management framework in the POP, as now refined by the decisions version of the POP (*DV*).

13 The process can be summarised in seven steps, which I have used to structure this evidence. In summary, those steps and my comments in relation to them are:

13.1 ***Step 1 – Define WMZs***

This enables the separation of a large and geographically diverse region into manageable sub-catchment units and provides opportunities for focussed community-scale action. I generally support this approach, but would point out that there are flaws in the way it has been used to convey water quality information. In my view, the Council's approach leads to exaggeration of regional water quality issues.

13.2 ***Step 2 – Identify community values***

The POP process has identified a range of values that have been assigned to different WMZs. This step is fundamental to effective resource management. However, the trade-offs that need to be made when attempting to achieve differing, and at times conflicting environmental, social, economic and cultural objectives need to be recognised and explicitly dealt with.

13.3 ***Step 3 – A sub-set of values have been assigned water quality numerics***

(a) The numerics have been set using a combination of existing scientific knowledge, expert panel assessments and modelling. I consider that the Council lacked a rigorous periphyton monitoring programme prior to notification of POP. Consequently, there was limited data to determine background levels of periphyton in the Region's rivers, or allow validation of the model used to aid definition of nutrient numerics that seek to control periphyton. The process has therefore led to a suite of nutrient numerics in Schedule D that appear to me to be overly conservative and largely unachievable in a number of the Region's rivers. It is therefore important that the numerics are only used as general guidelines.

(b) I note that the Council now has access to nearly three years of periphyton data for river sites around the Region. I have reviewed this data and have related it to nutrient concentrations later in this statement. This preliminary analysis indicates that much lower maximum periphyton biomass can be expected in the Region's river than was predicted by the national model presented by Dr Biggs and Dr Roygard in their evidence. This suggests that problems with algal growth in the Region's rivers are less than predicted. The analysis also indicates that target levels for SIN used as numerics in the DV POP are highly conservative when used to predict levels of maximum periphyton biomass.

13.4 ***Step 4 – Assessment of the State of the Environment (SOE)***

(a) The Council's advisors have estimated the gap between the current state and desired state through comparisons between measured water quality indicators and the defined numerics, rather than through comparison with reference (natural) conditions. Based on the most recent full assessment by the Council witnesses, only 2 out of 77 monitored water management subzones currently comply with all recommended water quality numerics.

(b) A number of the sites that failed to comply were from catchments which are predominantly in native forest (i.e. reference sites), suggesting that the numerics are more strict than the natural water quality of the Region and therefore, are unachievable as targets for managing human impacts on waterways.

(c) An assessment of current state, such as that presented in Appendix 1 of the Joint Statement of Roygard, McArthur and Clark (14 February 2012), is also just a snapshot in time. Analysis of changes, or trends over time, are often more informative for resource managers, particularly when looking to implement major policy shifts. Analysis of recent trends in the Region's rivers indicates that despite land use intensification over the last ten years (2001-2010), there are improving trends for nitrogen (N) and phosphorus (P) in the Manawatu and Rangitikei rivers. This raises the question of what further management actions are needed to ensure these improving trends continue.

(d) From the above analysis I conclude that nutrient levels in the Manawatu and Rangitikei rivers are either stable or have been improving over the past decade. This suggests that the imperative for Region-wide controls on diffuse nutrient inputs to streams has reduced. I am not suggesting that **no** controls be placed on diffuse nutrient inputs, because the levels of nutrients in some waterways are significantly elevated and will require action over time to bring them down further. What I am suggesting is that decreasing trends in nutrient levels indicate that current controls and management actions are working.

(e) Notwithstanding the improving trends in nutrient levels, there are significant water quality issues in a number of WMZs, which need to be properly addressed by farmers, industry and the Council. A number of assessments have been carried out that summarise the state of water quality in the Region. It is clear from these assessments that levels of sediment, nutrients and *E. coli* are elevated in a number of the Region's rivers. I consider that management of sediment and faecal contaminants in the Region's rivers should be of principal concern to both the Council and MfE.

13.5 ***Step 5 – Identifying the causes of degraded values***

Identifying the cause of the gap between current and desired state (Step 4) is difficult, because waterway values are often influenced by multiple stressors that interact in complex ways. The Council's experts have taken a narrow view of the effects of land use on waterway values by focussing on point source and non-point source nutrient loads (and more specifically focusing on non-point source discharges from dairy farms), and largely ignoring the interacting effects of temperature, sediments and other physical habitat conditions on life supporting capacity.

13.6 ***Step 6 - Define controls on land use***

I have made only limited comments on setting of limits on farm nutrient outputs in my evidence. I understand this matter is discussed in the evidence of Sean Newland, Dr Stewart Ledgard, Dr Terry Parminter, John Ballingall and Gerard Willis for Fonterra.

13.7 ***Step 7 – Monitoring and reporting***

This involves design and implementation of a SOE monitoring programme that will allow the Council to assess progress towards its desired outcomes. Since 2008 the Council has made significant changes in the design of its SOE network[2]. These changes were made to address identified gaps in the knowledge base as highlighted during investigations for the POP[3]. As noted earlier, current scientific knowledge in the Region regarding background levels of nutrients and inputs from human uses and other natural inputs was limited, but has been dealt with to some extent in the supplementary statements of Roygard, McArthur and Clark (14 February 2012) and Roygard and Clark (24 February 2012).

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2 The evidence of Mrs Kathryn Jane McArthur; Section 4.1, pg 37.

3 Ausseil & Clark (2007) see Section 9.1.

Part B summary

14 There are a number of areas where the evidence of the Council's witnesses are at odds with my own evidence. These are briefly summarised below.

The most appropriate time period for trend analysis and the level of importance placed on trend analysis results versus a measurement of current state.

15 I am of the view that analysis of trends in the recent 10 year period are more useful to assist with the current planning process than utilising the full sampling record that stretches back more than 20 years, which fail to show the significant water quality improvements over this shorter period. Furthermore, I observe, as do the Council's witnesses, that both state and trends are important for building a picture of water quality relevant to resource management planning. However, unlike the Council's witnesses, it is my opinion that trends convey more information to resource managers than a snapshot in time provided by state analysis.

The interpretation of national and regional datasets to summarise water quality state in the region.

16 Several of the Council's witnesses generalise that there is very poor water quality in the region. I observe that these views are based, to some degree, on inappropriate targets being used for defining poor water quality and also, to a biased representation of sites in the regional SOE network.

The application of a highly conservative model linking periphyton biomass with nutrient concentrations and its subsequent use in determination of target or 'ideal' nutrient loads.

17 This is perhaps the most contentious issue as my criticism of the modelling work of Dr Biggs and Dr Roygard struck at the heart of the arguments underlying the design of the POP. Dr Biggs and Dr Roygard observe that:

17.1 there are problems (i.e. unacceptable losses of values) caused by nuisance periphyton growths in the Region's rivers;

17.2 these problems are caused by elevated nutrient levels, particularly N;

17.3 the problems are getting worse because nutrient levels are trending up;

17.4 the vast majority of the N comes from non-point sources; and

17.5 intensifying agriculture, especially dairying, is the principal source, so should be targeted by the POP regulation.

18 In response, I note that:

18.1 there is little evidence from regional-scale monitoring of significant problems with algal growth except for some isolated locations;

18.2 the link between observed periphyton biomass and loss of values has not be properly quantified;

18.3 nutrient levels are not trending up;

18.4 dairy is only one of several significant contributors to nitrogen loads in the Region's rivers; and

18.5 despite having nearly three years of data from the Region's rivers I am not aware of any work by the Council to replace what is in my opinion, a flawed national periphyton model with a Region-specific model, despite this being a key purpose for the instigation of an extensive regional periphyton monitoring network (Ausseil & Clark 2007b).

Part C summary

19 In the Joint Technical Expert Statement of Dr Jon Roygard, Ms Kate McArthur and Ms Maree Clark (14 February 2012), water quality trends in the Region are summarised in Table 2 and paragraphs 22 – 25. At paragraph 25 they state "*Notably, nitrogen is meaningfully increasing at three sites on the upper, middle and lower Manawatu River*".

20 In my own analysis of recent trends (2001-2010), the same three sites show statistically significant and meaningful **decreasing** trends for nitrate-nitrogen. The Manawatu River at the Teacher's College site also shows significant and meaningful decreasing trends in total and ammoniacal forms of N and both dissolved and total Phosphorus. .

21 The supplementary statement from Roygard and Clark (24 February 2012) provides a detailed analysis of soluble inorganic nitrogen (*SIN)* and dissolved reactive phosphorus (*DRP)* load calculations at 17 river sites around the Region. The report supports land use scenarios that were presented by Roygard et al in their supplementary evidence of 14 February. The report covers the estimation of nutrient loads for 17 river sites. The methodology has been described in detail in previous reports and in a peer-review paper, although I note the most recent work deviates from the methodology used in the published work. Dr Roygard opines that the change in method was used to remove any bias that may occur due to variations in the sampling strategy for a site over time (see paragraphs 16-19 of his Supplementary Statement). However, Dr Roygard has not quantified the magnitude of changes in estimated

load that this method change causes. In my opinion, Roygard et al have produced a valuable body of work to estimate river nutrient loads, contributions from different sources and land use change scenarios. However, I am concerned that uncertainties and errors inherent in the data have not been explicitly recognised in the interpretation of the model scenarios. For example, the scenario results[4] are presented as single number estimates for change in loads. It would be valuable to have estimates of the uncertainty or variability associated with these estimates so we could judge their significance.

22 For the sake of balance it would also be informative to have some scenarios included that estimate reductions in average N loss per hectare as a result of improvements in farm practice. For example, the methodology recommended by Gerard Willis for Fonterra will result in reductions as farmers in the upper quartile reduce N-loss. It also seems unrealistic to have "do nothing" scenarios as this does not fit with dairy industry initiatives to increase nutrient use efficiency on farm, which are recognised by Fonterra witnesses as likely to provide further reductions beyond those achieved through the current POP regulation.

23 It is worth noting the % changes (Table 8 in Roygard et al Joint Technical Expert Statement (14 February 2012)) across all sites and scenarios ranges from 0 to -41% with most scenarios leading to changes of less than 10% at most sites. The range of natural variability in estimated loads reported by Roygard et al (2012) is +/- 31-54%. It appears that many of the changes predicted by Dr Roygard may not be measurable in reality due to high levels of natural variability.

24 In my evidence for the Council level hearing I highlighted concerns with the lack of periphyton data for the Region's rivers. The Council has rectified this and there is now a substantial body of periphyton data (see Table 5 in Statement of Roygard, McArthur and Clark). I have reviewed this data (as provided to me by Maree Clark) and used it to identify relationships between maximum periphyton biomass and average nutrient concentrations. I have also used the data to assess the relationship between periphyton biomass and a common measure of ecosystem health (Macroinvertebrate Community Index(*MCI*)).

25 I have undertaken a preliminary analysis of periphyton and nutrient relationships for sites in the Region and related these to the data used by Biggs (2000) to calculate the model that forms the basis of the MfE periphyton guidelines. It is clear from this analysis that maximum periphyton levels in the Region are lower than the national dataset. There is also little evidence of a relationship

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[4] Tables 40-41 in Roygard and Clark's Supplementary Statement.

between DRP concentrations and maximum periphyton biomass. There is a reasonable correlation between SIN and maximum biomass, but the slope of the relationship is much lower than Biggs (2000). This suggests that SIN targets defined to protect against nuisance levels of periphyton can be set at a much higher level than previously indicated (i.e. increased levels of SIN in the Region's rivers will not necessarily lead to the levels of nuisance growth predicted from the Biggs (2000) model).

26 Based on this preliminary analysis of periphyton-nutrient relationships I would conclude that the original model used by Dr Biggs, and subsequently used for load modelling purposes by Dr Roygard is inappropriate for use in the Region's rivers, because it is highly conservative and does not reflect measured nutrient-periphyton relationships in the Region.

27 The Lake Horowhenua Review report authored by Dr Max Gibbs (June 2011) (attachment 1 to Roygard et al. dated 24 February 2012) provides a summary of the current knowledge of the state of Lake Horowhenua and options for improving water quality to meet community objectives for the Lake. There is clear evidence of degraded values in the Lake. It is also clear that there are multiple contributing factors to the current degraded state of the lake, including historical sewage effluent and more recent N and P contributions from the horticulture, dairy and sheep and beef industries. For this catchment, it would seem appropriate that improving management of the Lake and its catchment be a priority for Horizons. However, it would not simply be a case of controlling dairy farms to address the problem. I discuss this point in more detail in Section C of my evidence.

PART A - THE PROCESS OF DEVELOPING A WATER MANAGEMENT FRAMEWORK

28 The POP uses a sequence of steps to link desired outcomes in waterways to land use practices in the Region. I have summarised these as seven steps and use this as a framework for my evidence:

28.1 Define priority management zones;

28.2 Define the values that the community wants protected/enhanced in each zone;

28.3 Define water quality standards that protect/enhance the value (or set of values) within different waterbodies;

28.4 Estimate the gap between current water quality and the standards defined above;

28.5 Estimate the potential causes and relative contributions that different activities make to the gaps in water quality;

28.6 Define policies and objectives that will drive changes to reduce the gap; and

28.7 Carry out SOE monitoring to enable progress reporting against standards.

29 My evidence covers 6 of the 7 steps. Defining policy and objectives (Step 6) is dealt with by other Fonterra witnesses. I do, however, comment on the benefits that implementation of BMPs on-farm has for water quality in the context of the planning regimes proposed by Mr Willis and Ms Barton for the Council.

Step 1: Water Management Zones

30 The Council has defined 43 WMZs and 124 sub-zones[5] to provide for integrated management of the Region's water resources at a manageable spatial scale[6]. The zones are catchment or part-catchment based and encompass the waterways within the zones, and the surrounding land area. I note that the decisions version of POP highlights 24 Water Management Subzones in seven catchment as target areas.

31 A range of criteria were applied to derive the WMZs[7]. These included National Water Conservation Orders, Local Water Conservation Notices, ecosystem types, geology, hydrology, resource pressures, location of monitoring sites and the length and availability of monitoring data (both flow and water quality).

32 I support the subdivision of the Region into smaller management units and also support the approach taken by the Council in defining WMZs. The catchment is the basic unit for managing water resources, but large river catchments (e.g. Manawatu River) are characterised by high levels of spatial diversity in climatic, geological, and hydrological patterns. The River Environment Classification[8], which underpins the definition of the WMZs, is recognised as the best-available tool for managing water resources within this spatial diversity. In my opinion, the WMZs are appropriate and provide opportunities to focus action (e.g. mitigation or remediation) in priority areas, rather than having to attack a poorly-defined regional-scale issue. For example, identifying and prioritising particular sub-catchments within the Manawatu River catchment above the gorge has been valuable in

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5 POP Schedule AB.

6 POP Policy 6.4.1.

7 McArthur et al. (2007).

8 Snelder et al. (2002).

focusing the efforts of the DairyLink project (discussed in detail in the evidence of Sean Newland).

33 However, I do not consider the water quality patterns for WMZs as shown in Figure 6.1 of Chapter 6 of the NV POP (version dated 31 August 2009) to be appropriate or necessarily reflective of actual patterns. I have reproduced this figure in **Appendix 1** of my evidence. This approach is inappropriate, because it requires extrapolation from a single monitoring station (which itself is only a limited sample of the actual conditions) to characterise the water quality for an entire sub-catchment. This will inevitably lead to exaggeration of water quality issues because water quality tends to decrease down a river. Monitoring data from a single site on a river does provide information on what is happening upstream, but it cannot be used to describe water quality at all points upstream. When reported to the public (e.g. the Council's 2005 SOE report) it may drive perception of widespread water quality problems, when the actual issue may be caused by a single point source discharge.

34 I recommend a more scientifically robust approach, involving interpolation between sampling sites to provide a picture of longitudinal variation in water quality (e.g. see Environment Waikato approach to reporting longitudinal patterns along Waikato River; www.ew.govt.nz/EnvironmentalInformation). This would highlight issues with particular river systems and remove the bias produced when characterising water quality in upstream parts of the catchment for which there is no data.

35 An alternative approach is presented by NIWA in a recent report for the MfE that models water quality in all rivers reaches across New Zealand (Unwin et al. 2010). Using this approach it is possible to characterise water quality state in river reaches based on modelled relationships. In my opinion, this approach will be a valuable tool for SOE reporting at a regional scale, because it removes the bias resulting from non-random selection of sampling sites.

Step 2: Values

36 I support the intent of the water values framework, which is to define, where possible, at the policy level, the values of each water body. I also support the aim of this approach, which is to avoid debates about these on a consent-by-consent basis. Defined values provide a valuable mechanism to co-ordinate management of water bodies.

37 I also support the underlying philosophy of the values framework[9] that:

9 Ausseil & Clark (2007a).

37.1 The pool of values that have been identified to be associated with a given waterbody should constitute the management objective for this waterbody (i.e. one value by itself should not become the overruling management objective for a waterbody);

37.2 Activities should be managed in a way that avoids, remedies or mitigates adverse effects on any of the waterbody's values; and

37.3 There may be cases where all waterbody values may not be able to be protected or reinstated fully, because of the social or economic cost incurred. In this case, the values framework can provide the basis for debate and decision making.

38 Assigning specific values is an appropriate way to manage waterways. Once community expectations for waterways are defined, then the appropriate water quality standards can be put in place to protect or enhance those values. It is important that in setting values the full costs/benefits of individual or suites of values are recognised by communities. The inevitable trade-offs also need to be considered by the community. The recently released National Policy Statement on Freshwater Management provides clear guidance on the important role of the community, facilitated by regional councils, in this value balancing process (MfE 2011[10]).

39 The POP (Table 6.2) identifies a total of 22 different values, applying to all or parts of the Region's rivers and lakes and their margins. The values are classed into four groups:

39.1 ***Ecosystem Values*** - includes six individual values recognising the intrinsic value of freshwater and coastal ecosystems for the living communities and natural processes they sustain. The life-supporting capacity value is a key value used for setting water quality standards;

39.2 ***Recreational and Cultural Values*** - includes eight individual values, associated with the spiritual and cultural values and the recreational (i.e., non-consumptive or non-commercial) use of the waterbodies;

39.3 ***Water Use Values*** - refers to the value of abstracted surface water in supporting the regional communities

10 MfE (2011) pg. 8 "The national values are not prioritised. At a national level it is not possible to prioritise individual activities and values, given the range of local circumstances and considerations that might apply. It is for regional communities, facilitated by regional councils, to consider values and priorities locally and determine how to respond to those values at a local level in implementing the policies of the NPSFM".

(e.g. community water supply) and economy (i.e. irrigation). It includes four individual values; and

39.4 ***Social and Economic Values*** - includes four individual values identifying that rivers and their margins provide services and uses that support and protect the regional communities and assets. For example, rivers have a natural capacity to assimilate nutrients, sediments and organic matter. For this reason, rivers are often used as receiving environments for treated wastes from municipal, industrial and agricultural activities. Within the POP this value is termed the capacity to assimilate pollution (*CAP*). However, the CAP value is defined in reference to the ability of the river to assimilate pollution, rather than a value relating to the cleaning, dilution and disposal of waste, which may or may not be in excess of the river's capacity to assimilate that pollution.

40 For each value a management objective has been defined (POP Table 6.2) and recommendations made on where in the Region the values should apply (POP Schedule AB).

41 It has been recognised[11],[12] that the potential for some of these values to conflict is reasonably high. For example, the "Water Use Values" and "Social and Economic Values" are directly associated with activities that can threaten other values (e.g. Ecosystem Values). Indeed, many values are mutually exclusive (e.g. natural state and trout fishery). For example, the CAP value will often impact on various social and ecosystem values (e.g. discharges of treated wastewater may render a waterway unsuitable for recreation until the point downstream where in-stream assimilation and natural attenuation has reduced contaminant levels below recreation standards). The ability to manage trade-offs between conflicting values is at the heart of the RMA and its associated instruments.

42 Within the current POP values framework, it is not clear how the inevitable trade-offs between conflicting values have been addressed. Contrary to the underlying philosophy, the POP has taken a sub-set of defined values, assigned water quality numerics to protect those values, and identified methods to control land use. There has been no discussion of whether the water quality numerics (set for a sub-set of community values) are appropriate for application to waterways managed for the full set of defined values.

43 I consider it important that this is recognised. This is even though I understand that Fonterra is not challenging the numerics in these

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[11] Evidence in chief of Dr Jonathon Roygard, (section 42a report) section 3.4.1.

[12] Ausseil & Clark (2007a).

proceedings and that the parties have agreed that the plan objectives and policies should seek to advance the achievement of those numerics. In my view, consideration of the full range of values, particularly community values, becomes all the more important when devising the rules and methods to give effect to the POP's objectives and policies. This comment applies equally to the next section of my evidence.

Step 3: Water Quality Numerics

44 In the evidence I presented at the Council hearing, I raised a number of concerns about the standards proposed in Schedule D of the NV POP. I considered that a number of the standards were overly conservative, with even reference sites unable to meet them. In addition I criticised the use of a highly conservative model to determine appropriate nutrient targets to meet periphyton targets.

45 With the change to definition of water quality "numerics", the recognition of more appropriate reference conditions for some (but not all) sites of naturally elevated nutrients, and the collection of a significant dataset for the Region linking nutrient concentrations to periphyton biomass many of these concerns can be addressed. However, the issue of what the appropriate levels of SIN and DRP should be in the Region's rivers is not resolved. There are still situations where nutrient "numerics" for particular sites are set at unachievable levels. For example, the Manawatu River at Weber Rd is unable to meet the target load even if the whole catchment was in native forest (see Appendix 3).

46 Water quality numerics in the manner currently proposed in Schedule D of the DV of POP provide a useful baseline for measuring progress towards defined management objectives (i.e. WMZ values), and an objective basis for identifying sites that may not be meeting water quality goals. As such, they will provide greater certainty than qualitative or narrative standards.

47 However there are limitations to using certain numerics for other purposes (such as targets to be reached). Water quality numerics (such as those in Schedule D) can be defined based on "effects-based" criteria (i.e. set at a level known to reduce risks of significant adverse effects on values) or based on "reference conditions" (i.e. levels are set to reflect the natural conditions). Effects-based numerics should generally be more permissive than those based on natural state conditions, since effects-based standards will allow for changes in natural conditions so long as the magnitude of change does not exceed thresholds for significant or unacceptable adverse effects.

48 I record that I still have significant concerns that certain water quality numerics proposed in the POP appear to be more stringent than even a reference condition approach might allow. The

development of nutrient numerics has also been impaired by the use of a model that may be inappropriate for many of the Region's rivers. The best example of an unachievable targets can be found in the recent work of Dr Roygard – six of 17 catchments could not meet the target SIN load even if their entire catchments were in native forest (Appendix 3).

49 The weighting towards ecosystem values in developing the numerics also needs to be recognised. The water quality numerics were developed to provide for values assigned to individual WMZs. Numerical standards were developed for seven of the 22 proposed water body values. These were: Life-Supporting Capacity, Contact Recreation, Aesthetic, Trout Fishery, Trout Spawning, Shellfish Gathering and Livestock Drinking Water. However, the "Life Supporting Capacity Value" in particular is seen as requiring the most stringent standards, and has been used in the POP as a de facto value on which to base water quality standards for the protection of aquatic ecosystems[13].

50 Controlling periphyton growth through improved nutrient management is the aim of the nutrient standards in the POP. The numerics that most directly affect dairying in the Region are those in relation to controlling periphyton growth. The Council asked a panel of expert scientists the question "*what are the appropriate mechanisms to control periphyton growth?*" The following general comments[14] were made:

50.1 Both N and P need to be managed, because of the interconnectivity of water bodies (where different nutrients might be limiting in the same stream network);

50.2 A high background concentration of a 'non-limiting' nutrient can contribute to periphyton blooms if control of the 'limiting' nutrient fails;

50.3 Year-round control of N and P is needed because periphyton growth and vigour are determined by the preceding nutrient conditions and the upstream presence of residual colony-forming periphyton material;

50.4 Not all rivers and streams will require nutrient management to reduce periphyton proliferation (e.g. rivers with soft substrates). However, contaminant management is still required in most soft-bottomed river systems, to reduce nutrient pools within sediments and provide for downstream reaches with hard substrates or estuarine/coastal waters; and

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13 Evidence of Ms Kathryn McArthur, section 5.2.

14 Wilcock et al (2007).

50.5 Controls on nutrient levels in water bodies should apply at all flows, with the exception of flood flows where these are defined as flows greater than the flow that is three times the median flow.

51 These comments are based on sound science, but reflect broad generalisations around the control of periphyton growth and are designed to provide conservative statements that might apply throughout New Zealand. The comments also contradict more pragmatic advice within the MfE Periphyton Guidelines (2000). For example, Wilcock et al (2007) recommend that both N and P need to be managed, which is true and appropriate when information on the limiting nutrient is unavailable. However, on page 12 of the Guidelines it states "*In using the soluble inorganic nutrient guidelines for developing consent conditions, it is important to recognise that the specific nutrient limiting periphyton growth needs to be identified and consent conditions set in terms of that single nutrient. It is usually unnecessary to specify conditions in terms of both nitrogen and phosphorus.*"

52 The Periphyton Guidelines highlight[15] the need to manage public expectations around the control of periphyton. It is important that public expectations of what is achievable are realistic. The example given in the Guidelines is where people might want to have a stream managed for recreational fishing, and for this to happen, it might be necessary to eliminate blooms of filamentous algae during summer. However, if the catchment includes a significant proportion of Tertiary marine siltstones which are rich in nutrients, then filamentous periphyton growths are a natural product of the catchment conditions and effective control is not likely to be achievable.

53 Within the Region 52% of stream reaches drain areas of soft sedimentary rock types, including Tertiary siltstones[16]. Therefore, because of these natural sources of nutrients (particularly P) there are likely to be stream reaches within the Region where controlling periphyton growth through on-farm nutrient management will be ineffective.

54 The Council has implemented an extensive periphyton monitoring programme as part of its revised SOE monitoring network[17]. This network has generated the information necessary to identify realistic expectations with respect to periphyton growth in rivers and options for managing those areas where the biomass is unacceptably high owing to human influences. With this data it should be possible to identify where problems with nuisance periphyton growth occurs.

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15 Biggs (2000), pg. 19.

16 Ausseil & Clark (2007b).

17 Kilroy et al (2008).

55 However, the analyses provided by Council witnesses to date (Table 5 in Roygard, McArthur & Clark; 14 February 2012) indicates that nuisance periphyton occurrences are sporadic and patchy, with regional average exceedences of periphyton numerics on only 6% of sampling occasions. I also note that the three worst sites for algal biomass exceedences are all downstream of sewage treatment plant discharges (Makotuku downstream of Sewage Treatment Plant (STP); Waitangi downstream of Waiouru STP and Manawatu downstream of PNCC STP). Samples taken upstream from these sites show significantly lower algal biomass, indicating a high likelihood that the algal biomass exceedences are caused by these discharges. For example, mean periphyton biomass in Waitangi Stream increases from 29.5 mg Chla/m2 upstream of the Waiouru STP (maximum = 95) to 86.7 mg Chla/m2 downstream of the STP (maximum = 275).

56 I consider that the nutrient numerics in the POP that apply to some rivers in the Region are overly-conservative and the use of these numerics has led to some perverse outcomes. For example, based on comparative N-loss rates from different land use classes (supplementary statement by Roygard and Clark) I show in (Appendix 3) that target loads in some rivers can't be met even if the entire catchment was returned to native forest.

57 As noted earlier, the primary driver for defining the nutrient numerics was life supporting capacity[18]: "*integration of several Ecosystem values under one set of water quality standards means that the Life-Supporting Capacity standards were key to the protection of native aquatic ecosystems for each individual sub-zone*". However, the Periphyton Guidelines[19] caution against this: "*The nutrient guidelines for the maintenance of benthic biodiversity are very restrictive …The nutrient guidelines are there to assist in achieving an instream management objective. It is important not to get bound up in minor breaches of the recommended nutrient levels, but to focus on whether the instream management objective is being achieved (ie, focus on outcomes rather than inputs as measures of success).*"

58 The outcome being sought by the Council is the protection of native aquatic ecosystems in different sub-zones. At the time I presented my evidence at the Council hearing I proposed that there was limited information to link periphyton biomass to ecosystem health in the Region. Over the last three years the Council has collected data that allows the correlation between periphyton biomass and invertebrate community health to be explored. I have carried out some preliminary analysis of this data (Figure 1) and it suggests that while a "clean water state" (i.e. MCI>120) tends to be observed

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18 McArthur (pg. 78. 218).

19 Biggs (2000) pg. 104.

at low levels of maximum periphyton biomass, the target level for many of the Region's more modified rivers (i.e. MCI>100) can be maintained at maximum periphyton biomass of 200 mg Chl*a*/m^2. Furthermore, the shape of the relationship indicates that a curvilinear model is a better fit (R^2 = 0.53) than a linear model (R^2 = 0.39). This suggests that MCI decreases are reduced once periphyton biomass exceeds around 100 mg/m^2 (i.e. there is a point of inflexion in Fig. 1 at 100 mg/m^2).

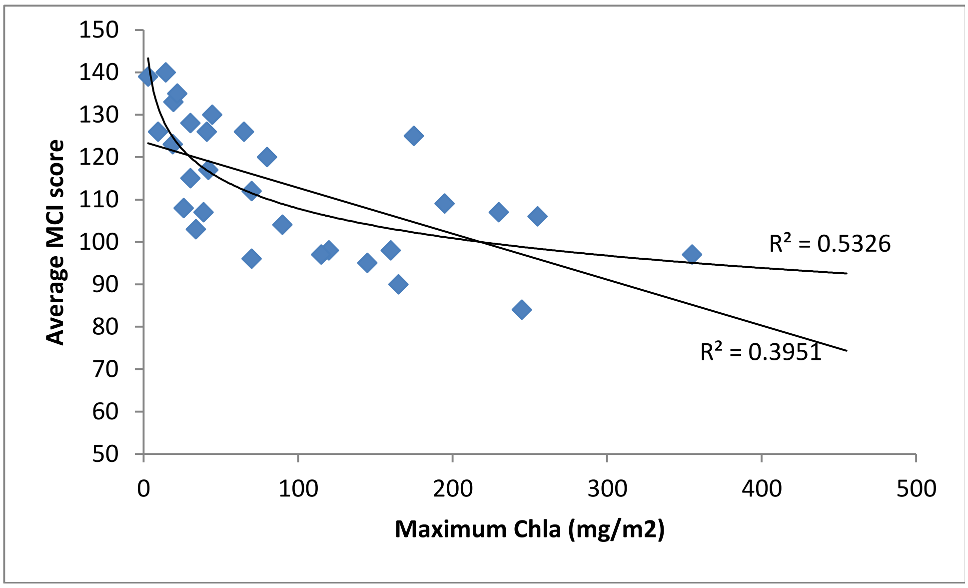


Figure 1. Relationship between maximum algal biomass and invertebrate community health measured as MCI. MCI data obtained from Table 4 of Roygard, McArthur and Clark (14 February 2012) and periphyton data provided by Maree Clark.

59 The report by Wilcock et al (2007) concludes that, *"periphyton growth and vigour is determined by antecedent water quality. For this reason, year-round control of both N and P is important." (Executive Summary page iv)*.

60 This conclusion is contrary to the Periphyton Guidelines[20] which suggest periphyton control for aesthetics/recreation should only be applied over the summer months (1 Nov – 30 April). The Council has not yet presented information on seasonal patterns in periphyton biomass across the Region's rivers, but the data presented in Table 5 of the Joint Statement of Roygard, McArthur and Clark[21] indicate the data exists to do so. When seasonal periphyton patterns have been established it may be possible to target nutrient control to specific times of the year. For example, through application of point source discharges to land during summer, when plant uptake of nutrients is maximised. The

[20] Biggs (2000) pg. 10.

[21] Dated 14 February 2012.

importance of understanding the seasonality of periphyton growth is highlighted by Dr Biggs in his evidence[22]:

> "*The timing of proliferations is less likely to be influenced by nutrient regimes than by the seasonal characteristics of the flow regimes.*"

61 The Council carried out an assessment of nutrient data in the Upper Manawatu River to assess the potential limiting nutrient in rivers[23]. The approach used to determine potential N versus P limitation assumes that "*the proposed One Plan nutrient standards will adequately limit the growth of periphyton in rivers*…" This approach ignores conventional approaches to assessing nutrient limitation using available monitoring data[24].

62 Using the same NIWA data as Roygard and McArthur (2008) from seven river sites in the region for the period covering 1989-2008, I calculated mean monthly SIN:DRP ratios (i.e. amounts of soluble inorganic nitrogen relative to dissolved reactive phosphorus). Across the seven sites, the average annual SIN:DRP ratio varied from 20 to 80. There was also significant variation between months (average of the seven sites), with the ratio varying from 19 (February) to 71 (September).

63 Based on the criteria used by McDowell et al. (2009) to assess potential nutrient limitation in New Zealand rivers (i.e. SIN:DRP > 15 implies P-limitation), all seven river sites could be considered, on average, to be primarily P-limited in all months of the year. The approach taken by Roygard and McArthur (2008) tends to over-estimate the importance of nitrogen versus phosphorus in limiting periphyton growth.

64 The Council has not yet provided direct evidence of the relationship between nutrient concentrations and periphyton biomass. Throughout the development of the POP they have relied on a regression model[25] to link observed and predicted nutrient concentrations to periphyton biomass. The Council now holds a dataset that can be used to develop regionally appropriate relationships between nutrient concentrations and periphyton biomass, but I am not aware of the Council having undertaken analysis of this data. I have accessed this data to provide a preliminary analysis of these patterns. I point out that the analysis I have carried is indicative only, as I have not sought access to flow

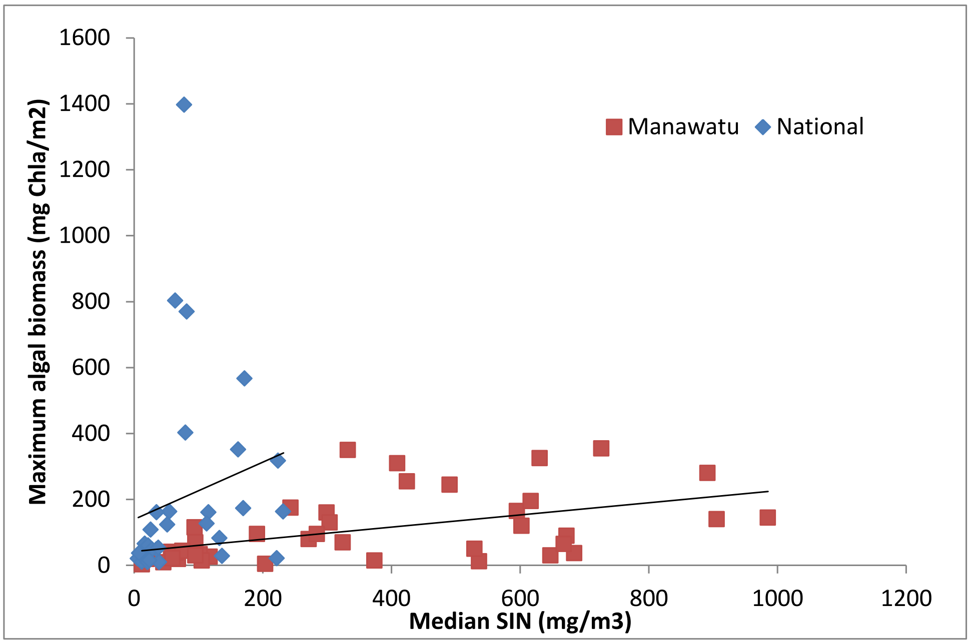
[22] pg 18; point 47

[23] Roygard and McArthur (2008) – Section 3.4.1.

[24] McDowell et al. (2009).

[25] Biggs (2000).

data or other details that might be required to carry out a full analysis. See **Figure 2**.



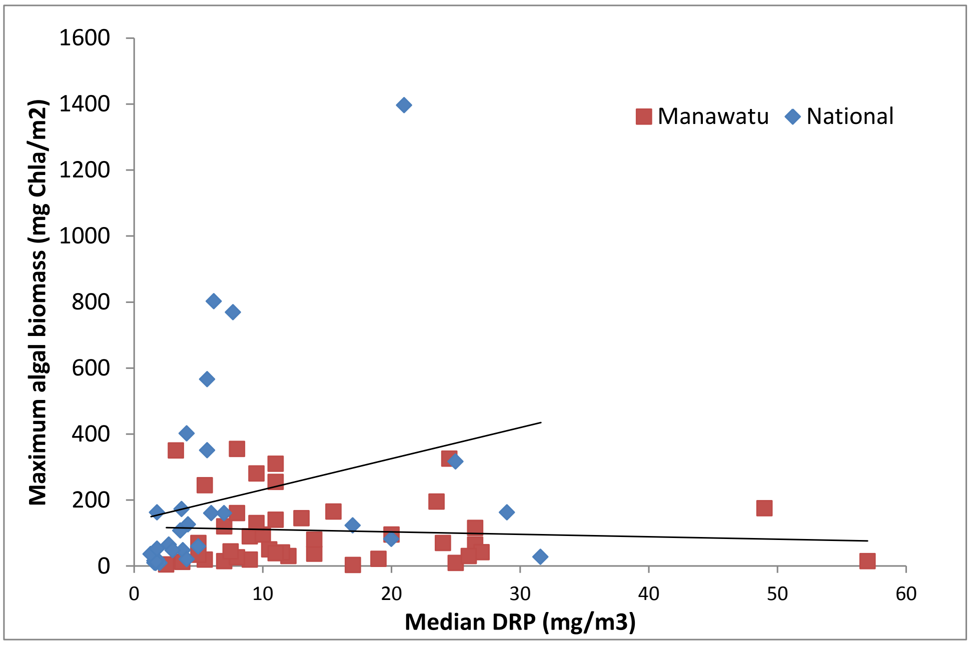


Figure 2. Data on maximum monthly Chlorophyll *a* biomass and median monthly nutrient concentrations (DRP and SIN) for 42 Manawatu-Wanganui sites (SIN (=Ammoniacal N + Total oxidised N) and DRP data obtained from Table 21 of Joint Statement of Roygard et al.). Maximum monthly Chla biomass was calculated from data supplied by Maree Clark on 20 February 2012. I have overlain data obtained from Table 1 in Biggs (2000) to illustrate differences in the data used in the national model and the regional dataset.(Note that Biggs (2000) used mean monthly nutrient values, rather than medians).

65 Table 11 in the section 42A Report of Ms McArthur for Horizons proposed a number of changes to the POP Schedule D Water Quality Standards (now numerics) for river and streams. Key changes relate to the observed exceedance of nutrient standards in some streams draining native forest. The change recommended is that the following be added to the existing numeric standards for both SIN and DRP "*or naturally occurring concentration in streams flowing from forested headwaters, whichever is the greater*".

66 In my Council hearing evidence, I agreed with these changes because they removed inappropriate "effects-based" standards and replaced them with more appropriate "reference-based" standards. The changes were based on expert opinion. The expert evidence of Dr Biggs states:[26]

> "*A small number of streams flowing from forested headwater catchments exceed the nutrient concentrations standards in the POP.*[27] *To allow for these circumstances, I recommend a proviso be added to the nutrient standards that sets the standard as either: 1) the numerical value for the water management sub-zone as set out in table D.17, or 2) the naturally occurring nutrient concentration in streams flowing from forested headwaters, whichever is the greater of the two. This will ensure that streams with naturally elevated nutrient concentrations, with no potential for land use related enrichment, are not considered to be 'noncomplying' with the standards in the POP.*"

67 Insertion of this proviso immediately varies the relevant numerics from being effects-based to reference-based. However, this matter highlights further issues with the numerics. The presence of naturally elevated nutrient levels in a number of catchments suggests that the effects-based approach may be overly conservative. It further suggests that the effect-based standards may not be transferable within the Region. Further, where

[26] Page 17, point 45.

[27] *Ausseil and Clark, (2007b) Table 27.*

headwater streams breach the nutrient standards due to underlying geology, then all downstream sites should also be given similar considerations. That is, if a forested headwater stream had DRP levels of 17-mg/m^3 it is inappropriate to make all downstream sites meet the DRP standards of 10 or 15 mg/m^3.

68 As highlighted by Dr Biggs in his evidence[28], the modelling approach used to define nutrient numerics for each water management sub-zone has a number of limitations:

> "*First, some areas of the Region have hydrological conditions that do not fit the calibration dataset for the model (in particular, the Central Plateau). Second, the current model does not account for effects of invertebrate herbivores or abrasion by suspended sediment on periphyton biomass. Third,* ***the periphyton biomass data currently held by Horizons is insufficient for testing the calibration of the model for the Region****. My professional opinion was used to fill some gaps associated with these limitations.*"

69 The Ausseil & Clark (2007b) report states:

> "*Whilst a useful tool, the New Zealand Periphyton Guidelines' model was found to generally be very environmentally conservative. The model also does not work on all river types. It is suggested a risk-based model linking the likely occurrence and duration of high periphyton biomass event to nutrient concentration in the water would be a very useful tool.*"

70 In original evidence I supported the recommendation of Ausseil & Clark (2007b) as this regional information was expected to provide far greater certainty in determining linkages between nutrient loads, periphyton growth patterns, and the desired outcome (i.e. Life-supporting Capacity).

71 Dr Biggs states in his Section 42A Report[29]:

> "*The cumulative effects of uncertainty in the POP water quality approach raise the risk that compliance with nutrient loading limits and numerical standards will not achieve the management objectives…we need to use the best science to inform decisions, but allow for subsequent 'finetuning' if all issues and responses haven't been adequately allowed for in the predictions or assessments. Indeed, it is important that there is opportunity for adaptive management (i.e. use results from and feedback about water quality management*

[28] Biggs pg 21, point 52.

[29] pg. 5, point 14.

under the POP to adjust one or more components of the Plan)."

72 I share the concern of Dr Biggs with regards to compounding uncertainties and agree that an adaptive management approach based on focussed action in priority WMZs is entirely appropriate.

Step 4A: Water Quality State

73 Based on my knowledge of the Region's rivers and knowledge gained from Council witness reports[30] I suggest there are four main issues that are likely to constrain the Life Supporting Capacity, recreational, aesthetic and water use values across the Region's waterways:

73.1 Levels of sediment, both suspended (affecting recreation, aesthetic and ecosystem values) and deposited (affecting ecosystem values);

73.2 Physicochemical characteristics that can compromise the life supporting capacity of waterways (e.g. high temperatures, low dissolved oxygen, low/high pH, ammonia);

73.3 Bacterial and/or faecal contamination, which can compromise the water's recreational quality, or suitability for human and/or stock drinking water; and

73.4 Nutrient enrichment, which can cause excessive growth of periphyton and aquatic plants and can compromise recreational, water use and ecosystem values.

74 Table 27 in Ausseil & Clark (2007) provides a valuable summary of water quality state in the Region. The table provides information on 11 key water quality indicators at sites representing up to 77 water management subzones. Where data is available, comparisons are made between recommended water quality numerics and measured values at a site. A site fails when measured values do not meet the numeric. Of the seventy-seven subzones represented in Table 27 only 2 meet all measured numerics.

75 The Upper Mangatainoka complies with all 9 indicators measured at the site. The Upper Whakapapa complies with both clarity and annual periphyton biomass indicators (although only on 2/3 sampling occasions). Three other sites (Upper Mangahao, Upper Mangawhero and Upper Ohau) are close to complying with all indicators. For example, Upper Mangahao almost meets the pH standard and just meets the temperature and clarity standards. The Upper Mangawhero has monthly mean DRP concentrations more than double the appropriate standard (15 vs 6 mg/m^3), but it is

[30] Ausseil & Clark (2007b).

given a pass because it is a "natural state waterway". Nine of the 26 sites considered to comply with the DRP standard (6 mg/m^3) actually have monthly mean concentrations greater than the recommended standard. They are given a pass because the elevated DRP levels reflect natural conditions (ie, they are reference sites).

76 Changes to the proposed DRP numeric to account for the exceedance of the numerics at reference sites effectively shift the DRP numeric from effects-based to reference -based, but it only applies to natural state sites. This creates some inequities. For example, mean monthly DRP concentrations at the Upper Mangawhero site are 15 mg/m^3, while the average concentration at the Lower Mangawhero site is 17 mg/m^3. Both sites exceed the recommended standard, but the Upper Mangawhero is deemed to pass due to it being a natural site, whereas the Lower Mangawhero is deemed to fail because it does not meet the numeric standard. Appropriate reference condition standards should be applied to all WMZ sub-zones.

77 Across the eleven indicators for which there is sufficient data there are variable levels of compliance with standards (see **Figure 3** below). Levels of compliance (based on measured concentrations) are greatest for the Ammonia standard (compliance at 68 of 70 sites) and lowest for SIN (15 of 70 sites compliant), clarity (18 of 70), and DRP (25 of 68).

78 I consider that the low levels of compliance across the monitored sub-zones, particularly for water clarity and nutrient concentrations indicates that the proposed "effects-based" numerics in the POP are too stringent and do not reflect the natural reference conditions found throughout the Region. How can a Region with 30% of the land area in native forest have only 3% of management subzones complying with "effects-based" numerics? How can predominantly natural reference sites[31], such as the Upper Tamaki and Middle Rangitikei, fail to comply with "effects-based" standards designed to protect specific values?

[31] Defined in Table 1, Appendix 1 of Ausseil & Clark (2007).

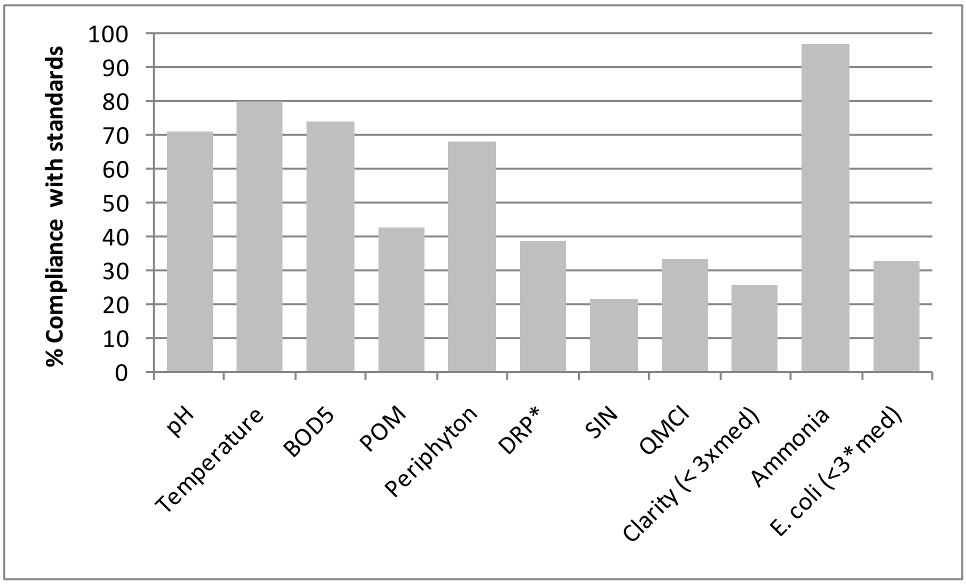


Figure 3. Percentage of monitored management subzones complying with recommended water quality standards for eleven indicators. Data taken from Table 27 in Ausseil & Clark (2007b).

79 I consider that the picture of water quality state provided by Ausseil & Clark (2007b) significantly overestimates water quality problems at the regional scale. Nonetheless, there are significant water quality issues within the Region and these issues will have direct impacts on waterway values.

80 In **Appendix 2**, I have presented data from Ausseil & Clark (2007b) for DRP and SIN across 69 sites. Overlain on the figures are the most permissive numerics provided under the Proposed One Plan (i.e. DRP = 15 mg/m^3; SIN = 444 mg/m^3). 32 sites (46%) exceed the most permissive DRP numeric and 21 sites (30%) exceed the most permissive SIN numeric. It is also clear from this analysis that there are some key sites within the Region where nutrient enrichment should be of particular concern. For example, five sites have mean monthly DRP concentrations greater than 100 mg/m^3 (i.e. 10x the mid-range nutrient standard of 10 mg/m^3). Five sites also have mean monthly SIN concentrations of greater than 1000 mg/m^3. These sites should be the immediate focus of the Council and wider community action.

81 The MfE presents water quality league tables for the country[32]. The data for these tables comes from NIWA's National River Water Quality Network (*NRWQN*). Seven of the 77 sites in the NRWQN are located in the Region. League tables have been developed for three suites of indicators (Nutrients, Water Quality for Recreational use, and Biological Indicators). Comparison of Manawatu-Wanganui

[32] http://www.mfe.govt.nz/environmental-reporting/freshwater/river/league-table/river-water-quality-league-tables.html.

rivers with other New Zealand rivers provides a means of determining where the key issues for the region might lie:

81.1 In relation to levels of nutrients, one site (Manawatu River @ Opiki Bridge) ranks in the most-enriched 10 sites in the country (rank = 72). Overall, the seven sites have an average rank of 48 out of 77.

81.2 In contrast, five of the seven sites rank in the worst 10 sites for recreational water quality (based on clarity and levels of faecal microbes). The average rank across the seven sites is 62 out of 76.

81.3 For biological rankings, the Manawatu and Rangitikei rank in the mid-range (average rank = 44 out of 77), with no sites in top or bottom 10, which suggests that despite nutrient enrichment, manifestation of effects on measures of ecosystem health are not readily observed.

82 This information suggests that sediment and faecal contaminants in the Region's rivers should be of principal concern to both the Council and MfE.

Step 4B: Water Quality Trends

83 At the first instance hearing, the Chair of the Water hearing asked a series of questions (Minute #6) regarding the rule regime for non-point source pollution. I consider those questions to be a helpful reference point for discussing water quality trends in the current proceedings.

84 One of the questions was relevant to information on trends in water quality over time - **Question 5.2. Has that situation changed since the POP was notified?** The "situation" referred to is elevated nutrient levels in rivers. In my opinion, supported by analyses carried out by myself and NIWA water quality scientists, there has been a change in the situation since the POP was notified. The lack of deteriorating trends in key water quality parameters, and the presence of a number of improving trends (see below) suggests that the environmental imperative to control non-point source pollution in the Region has lessened since the POP was first notified.

85 Across the Region, and throughout New Zealand, some significant gains have been made over the last 20 years in addressing a number of issues in relation to water quality. For example, large amounts of organic pollution have been removed from water bodies through addressing point source discharges from industry and municipal wastes. The state of water quality in relation to a range of indicators of point source pollution has improved in many locations, due to this work. In addition, there is growing evidence

that improvements in farmer uptake of best practice in some monitored catchments has led to significant improvements in water quality (e.g. Wilcock et al 2009).

86 For the purposes of this evidence I updated the nutrient trend analysis I carried out for my original hearing evidence, using data from 5 river sites on the Manawatu and Rangitikei rivers. I have used two time periods. First, I have taken the approach of the Council's witnesses and used the entire period of record for the National River Water Quality Network (i.e. January 1989 – September 2011). I also used the period 2001-2010 (i.e. a 10-year dataset), which is consistent with the approach taken in my original hearing evidence. Note that these sites are part of NIWA's National River Water Quality Network and are the same sites described in the expert evidence of Dr Robert Davies Colley. Results of my analyses are given in **Table 1**.

87 Water quality data for the three Manawatu River locations and two Rangitikei sites were downloaded from the Water Quality Information System website (https://wqis.niwa.co.nz/wqis/index.do).

88 The received data were checked for cells coded as "missing" (replaced with blanks) and cells with values less than detection limits (replaced with value equal to half the detection limit). Data were imported into TimeTrends v.3 and analysed for trends using the Seasonal Kendall Trend Test. Both unadjusted and flow-adjusted (LOWESS; 30% span) data were analysed for trends, but I have reported only the unadjusted (raw) data trends.

89 Results (Table 1) show strong significant improving trends in unadjusted nutrient concentrations, especially nitrate, in the Manawatu River during the period 2001-2010. In contrast, the full period of record shows no significant trends for nitrate or SIN. These results are at odds with statements about long-term increasing trends for nitrate in the Manawatu River made by Roygard et al (14 February 2012)[33].

90 Overall, the recent trends suggest reducing nutrient levels in the Manawatu and Rangitikei Rivers over the last 10 years. The figures below highlight the improving trends. The Teacher' College site shows increasing trends (illustrated as LOWESS line fitted to the data) in nitrate and dissolved P from the late 1980s, peaking in 2000-2001 and then subsequently declining. These results must be taken into account when determining the most effective and efficient options for managing the river into the future.

[33] Para 25 (and table 2) of Joint Technical Expert Statement of Jo Roygard et al. (14 February 2012).

91 The choice of time period over which to analyse water quality trends can be somewhat arbitrary, but it can have a large effect on the outcome of analyses. For example, trend analysis may cover the full period of sampling records[34]. An alternative approach, and that recommended in MfE's Best Practice Guidelines for Analysis of Water Quality Data[35], is to visualise the data to determine what long-term patterns might be present. **Figure 5** shows data from 2001-2010 for Nitrate concentrations in the Manawatu River at the Teacher's College. A LOWESS line (smoother) has been added to highlight longer-term changes that underlie the natural seasonal variability. The pattern appears to be of a steady increasing trend through the nineties followed by a steady decreasing trend in the new century. I have chosen the period 2001-2010 to provide a 10-year window that incorporates the peak and decreasing trend in nitrate over time.

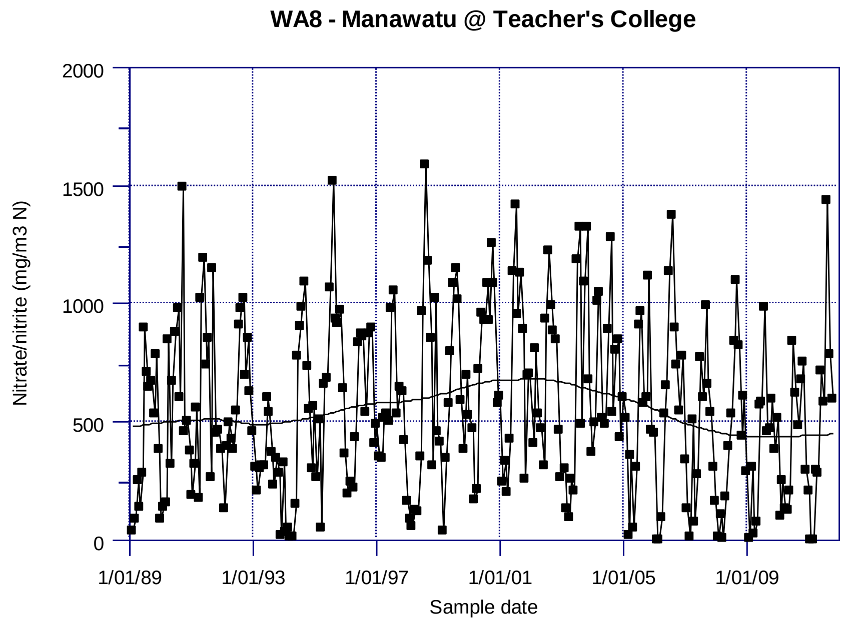


Figure 5. Time series (2001-2010) of Nitrate concentrations in the Manawatu River at Teachers College (Palmerston North). Data points are monthly samples. A LOWESS smoother (30% span) is overlain on the data to highlight long-term patterns. "WA8" is the site identifier used in NIWA's National River Water Quality Network (NRWQN).

92 The Council has commissioned several studies on water quality trends in the Region. The latest study by Ballantine & Davies-Colley (2009) identified that "*the longer term (19-yr) trend of worsening*

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34 For example Scarsbrook 2006.

35 Scarsbrook & McBride 2007.

water quality in the Manawatu has been slowing or even reversing … (i.e., water quality has been improving)."[36]

93 To my knowledge there has been no updated trend analysis carried out on behalf of the Council since the work of Ballantine & Davies-Colley (2009). It is my understanding that Table 2 of the Joint Technical Expert Statement (14 February 2012) presents a modified summary of the work of Ballantine & Davies-Colley (2009), rather than an updated analysis.

94 The Section 42A Report/evidence of Ms McArthur[37] states that:

> "*Long-term trend analysis of the seven national network sites in the Horizons' Region (1989–2007) showed increasing trends in total oxidised nitrogen (N0x-N) at a number of sites, particularly in the Manawatu catchment, and increasing dissolved reactive phosphorus for the Manawatu at Weber Road (NIWA site WA7). However the shorter term analysis of 2001–2008 data showed decreasing trends at some sites for N0x-N, E.coli and turbidity parameters, suggesting some water quality improvement in recent years.* "

95 My own analyses over a more recent 10-year period supports this statement, suggesting that there is strong evidence of improving water quality in some of the Region's major rivers. The cause of these changes is difficult to determine, but river water quality trends can often be associated with changing land use practices or climatic variability. The absence of trends in flow or temperature over the 2001-2010 period would suggest climatic variability is not a strong driver of the observed patterns.

96 Other potential reasons for the trends include that there has been a dramatic reduction in the number of point source discharges of animal waste to the Region's rivers. Between 1997 and 2009 the number of discharges to water decreased from 439 to 16[38]. During the same period, discharges to land increased by 193 consents. The observed water quality improvements would be consistent with expected water quality improvements following such changes. Over a similar time period (1998-2007) dairy cow numbers in the Region increased by around 16%[39], suggesting some land use intensification, but without declining water quality trends.

97 From the above analysis I conclude that nutrient levels in the Manawatu and Rangitikei Rivers are either stable or have been

36 Quoted in Dr Roygard's evidence (Box 30; pg. 105).

37 Pg. 60; point 151.

38 Box 25, pg. 93; Dr Jon Roygard evidence.

39 Expert evidence of Mr Matthew Newman.

improving over the past decade. This suggests that the imperative for region-wide controls on diffuse nutrient inputs to streams has reduced.

98 I am not suggesting that **no** controls be placed on diffuse nutrient inputs, because the levels of nutrients in some waterways are significantly elevated and will require action over time to bring them down further. What I am suggesting is that decreasing trends in nutrient levels indicate that current controls and management actions are working. This indicates that the scenario modelling and conclusions reached by Roygard et al in their Joint Technical Expert Statement (14 February 2012) are not supported by observed trends. On page 30 of their statement they conclude that to "*do nothing will not maintain or enhance water quality*". They also conclude "*Of the single number limit approaches continued degradation of water quality can be expected if loss limits were set above 24kg N/ha/yr the Upper Manawatu and 27kg N/ha/yr in the Mangatainoka*."

99 Given that nitrate has trended down over the last 10 years in the Manawatu River during a period of some growth in dairying it seems that the scenarios and interpretations made by Roygard et al, are inappropriate. Driving continuing improvements on farm would be appear valuable to ensure the recent gains are maintained and enhanced, however setting limits on all farms may be less effective than focussing on those who have the greatest potential gains.

Table 1. *Water quality trends (Relative Seasonal Kendall Slope Estimate expressed as percentage of raw data median) for two time periods (full period of record Jan 1989 – Sep 2011; last 10 years Jan 2001 – Dec 2010). Values highlighted in yellow are statistically significant (P<0.05) and those in red are also considered "meaningful" (i.e. >1% of median per annum).Trends presented are for unadjusted (i.e. not flow-adjusted) data.*

Full period (Jan 89 - Sep 11)	Nitrate/nitrite (mg/m3 N)	SIN	Total nitrogen (mg/m3 N)	Dissolved reactive phosphorus (mg/m3 P)	Total phosphorus (mg/m3 P)
Rangitikei @ Mangaweka	-1.35	-1.49	-0.69	0.00	0.00
Rangitikei @ Kakariki	-0.12	-0.43	0.00	0.00	0.00
Manawatu @ Weber Rd	0.55	0.28	0.74	2.11	0.85
Manawatu @ Teacher's College	-0.44	-0.82	-0.37	0.00	-0.62
Manawatu @ Opiki	-0.23	-0.31	-0.21	-4.81	-3.41

Last 10 years (Jan 01 - Dec 10)	Nitrate/nitrite (mg/m3 N)	SIN	Total nitrogen (mg/m3 N)	Dissolved reactive phosphorus (mg/m3 P)	Total phosphorus (mg/m3 P)
Rangitikei @ Mangaweka	-4.39	-3.17	-4.13	-3.50	-1.79
Rangitikei @ Kakariki	-0.52	-0.72	-2.03	-3.40	-1.25
Manawatu @ Weber Rd	-3.08	-3.19	-2.05	-2.50	-1.00
Manawatu @ Teacher's College	-6.43	-6.58	-4.76	-4.40	-2.70
Manawatu @ Opiki	-6.52	-5.67	-4.19	-7.58	-7.31

Step 5: Relative Contributions of Contaminants from Point Sources and Non-Point Sources

100 Where water quality is not meeting a specified standard, it is important to identify the relative sources that contribute to the problem.

101 Within the Region, 1,377 discharges to land consents and 340 discharge to water consents were identified by the Council in analysis from information collated in January 2009[40]. Dairy farming made up the majority of the 1,377 discharges to land (ie. 68% of consents). Of the 340 consented discharges to water, the majority of them are stormwater (30%) and temporary discharges, mostly in relation to construction (18%)[38]. The other major categories in terms of number of consents are other industry (14%), community effluent discharges (11%) and hydroelectricity (10%)[38].

102 There has been a significant reduction in the number of farm dairy effluent (*FDE*) discharges to water[38]. Numbers from January 2009[40] show 15 consents for discharges of FDE were to water and 942 were to land.

103 Region-scale analysis by the Council[41] has shown land use is predominately sheep and/or beef farming (51%) followed by native cover (31%) and exotic cover e.g. forestry (7.5%). Dairy farming is the fourth biggest land use type by area at 6.7%[42]. 78% of the Region's dairy farming is on Class I to IV land and 22% is on areas greater than Class IV (**Figure 6**).

104 The recent load calculation and scenario modelling exercise presented by Roygard and Clark provides a valuable assessment of the relative contributions of different land use types to the N-loads of a selection of the Region's rivers (refer to Table 39 in Roygard and Clark's Statement). Given the high proportion of sheep/beef farming in the Region (51%) it is not surprising that across the 17 sub-catchments analysed dairy contributions to N-loads never exceeds 36%, whereas sheep and/or beef account for up to 89% of the estimated N-load. This raises the question of how strict controls on dairy (contributing a third of N-loads) can produce significant reductions in river loads when other, more significant contributors are not controlled.

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40 Section 42a evidence of Dr Jonathon Roygard (section 6.4).

41 Table 8 in Section 42a evidence of Dr Jonathon Roygard (pg. 98).

42 Paragraph 27.

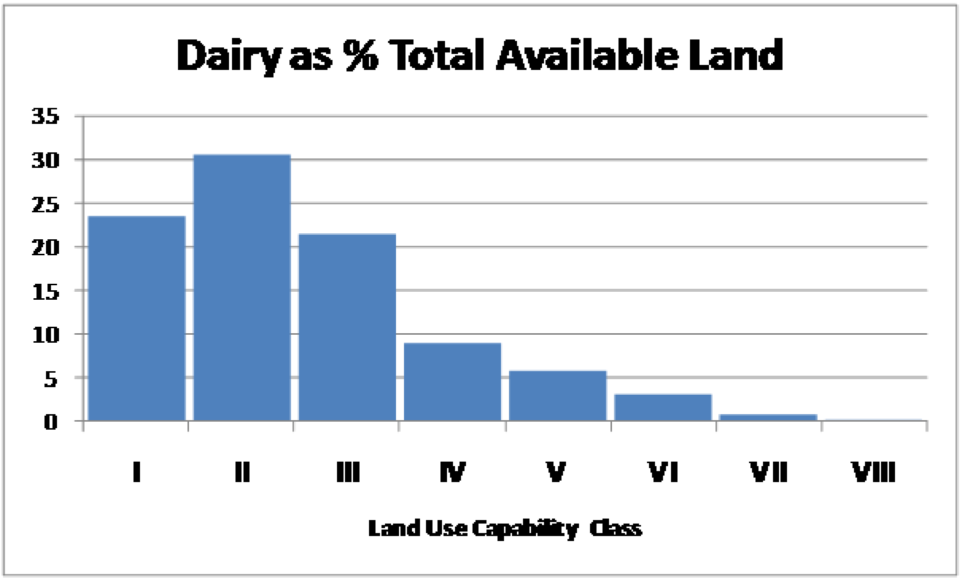

Figure 6. Distribution of dairying by Land use Capability Class. Data reproduced from Table 8 in the Section 42a report of Dr Jonathon Roygard.

105 Estimating the relative contribution of point sources and non-point sources to nutrient loads in waterways can be extremely difficult. Calculations by the Council of point source inputs rely on available information for point sources in the catchment. It assumes that the Council knows of all significant (individual or cumulative) point sources inputs and has reliable information on discharge characteristics for these sources across a range of flow conditions. One major potential source of uncertainty is around the number of on-site wastewater systems spread throughout the Region. As highlighted by Dr Jonathon Roygard in his Section 42A evidence "*The numbers of consents for this activity represent the fraction of these systems that have applied for consent*". It is unknown what contribution these systems make to nutrient loads and I note that on-site wastewater systems are not mentioned under point sources or non-point sources in the analysis of nutrient loads and sources (Roygard & Clark). This is a significant gap in understanding of sources contributing to nutrient loads in the Region's rivers and I suggest that the Council needs to explicitly account for losses from on-site wastewater systems.

106 Having calculated the relative contributions from the point sources, the Council has estimated contribution of non-point sources by removing the point source estimates from the total measured loads. In my opinion, this is likely to overestimate the contribution of non-point source loads and underestimate point source contributions.

107 What is also missing from the analysis is consideration of the natural background loads within the river systems. For example, what would the natural, background nitrogen losses be from the lands now being used for intensive agriculture? There is now the data

available to identify the nutrient loads that might be expected from native vegetation cover (see **Appendix 3**).

108 I have previously noted concerns about the method used by the Council to calculate nutrient loads in the Manawatu River. The method (flow-stratified approach[43]) was developed specifically for the POP and produces significantly different estimates to those produced using standard techniques (i.e. averaging approach)[44]. However, I note that the method has been presented in a peer-reviewed journal and some modifications to the method have subsequently be made for the load calculation and scenario modelling work presented by Roygard & Clark (24 February 2012). There has been no comparison made of the loads using the previous and current methodologies. It would be useful for the Council to highlight these differences.

109 In his evidence[45], Dr Barry Biggs summarises work to model the maximum monthly periphyton biomass under several nutrient loading scenarios in the Manawatu and Mangatainoka catchments. The model uses measured SIN and DRP concentrations to predict periphyton biomass. It also uses the model to predict periphyton biomass based on reduced nutrient levels, which in turn are based on estimated nutrient loads based on nutrient standards.

110 All of these steps introduce uncertainty into the model predictions. In my opinion, this uncertainty requires caution to be exercised when interpreting the numbers. In his summary of evidence, Dr Biggs concludes "*The model predictions indicate that a shift in SIN and DRP from current state to the Standard load limits **would** be accompanied by 30 to 75% reductions in maximum monthly periphyton biomass*". In my opinion this statement fails to acknowledge the uncertainty inherent in these model predictions and may lead to unrealistic expectations about the benefits that might accrue from improved nutrient management.

Step 6: Assigning N-loss Values to Land

111 The POP proposes that existing dairy uses in particular WMZs, will require resource consents to continue to operate and discharge contaminants into the environment. The resource consent seeks to control outputs (i.e. nutrient loss from a farm).

112 Reducing the losses of nutrients and other contaminants (e.g. sediment) from farms is a key element of the Strategy for New Zealand Dairy Farming[46]. I am aware of a range of methods which have been employed by farmers, communities, the dairy industry, and councils, to control N-loss and protect water quality. I

43 Roygard & McArthur (2008).

44 Section 42A report of Dr Jonathon Roygard Appendix 2, Table 14.

45 Expert witness evidence of Dr Barry Biggs, pgs 26-27.

46 www.dairynz.co.nz.

am not aware of any empirical evidence that has linked measured farm-scale reductions of soil profile N-leaching loss to measured water quality benefits at the catchment scale, although a range of models are available to address different components of this question (e.g. OVERSEER, CLUES). In contrast, there is direct evidence that fencing and planting of riparian zones has catchment-scale benefits for water quality in New Zealand streams[47].

113 Fencing and planting of riparian zones is a key component of the Dairying & Clean Streams Accord. Most recently, the benefits of improvements in riparian management have been highlighted for a small South Taranaki stream – part of the Best Practice Dairy Catchments programme[48]. The Waiokura Stream improvements in stream water quality (i.e. significant reductions in concentrations of phosphorus, sediment and faecal bacteria) were attributed to adoption of on-farm best environmental practices, including fewer farm dairy effluent discharges and riparian management involving permanent livestock exclusion from stream banks and riparian planting to mitigate runoff from pasture.

114 A key management outcome being sought through the POP is "*The waterbody and its bed supports healthy aquatic life/ecosystems*" (POP Table 6.2 Life Supporting Capacity Management Objective). While periphyton is a vital component of healthy aquatic ecosystems, excessive growth of periphyton can alter the conditions within a waterway, making it temporarily unsuitable for some other aquatic life.

115 A number of factors interact to produce levels of periphyton biomass that can adversely affect other species. These potential limiting factors include light, temperature, grazing pressure, nutrient concentrations and, most importantly, flow conditions. All else being equal, it should be possible to control periphyton biomass by reducing the availability of nitrogen and phosphorus, but only if the reductions exceed the levels at which nutrient availability limits growth.

116 Often either N or P is the primary limited nutrient. For example, a recent analysis of over 1000 monitored river sites around New Zealand indicated that P was likely to be the primary limiting nutrient at 75% of sites[49]. The study also concluded that focussing mitigation on P losses rather than N losses might result in more rapid reductions in periphyton growth. As highlighted by the Waiokura study[41], riparian management is an effective means of reducing sediment and P losses to waterways.

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48 Wilcock et al. 2009.

49 McDowell et al. (2009).

117 I understand that the evidence of Sean Newland, Terry Parminter, Dr Stewart Ledgard and Gerard Willis discuss other concerns with the POP approach, and suggest alternatives.

Step 7: State of the Environment Monitoring

118 The Council's SOE monitoring programme is the primary water quality monitoring programme in the Region, although this effort is supported by NIWA monitoring at a further seven sites. The design of a SOE monitoring programme needs to ensure that the resulting data provides a good representation of the water quality in the Region, otherwise the resulting interpretation may be biased. To minimise the potential biases in sampling programme design it is considered good practice to ensure the location of sites is representative of existing land use conditions in the region and the frequency, timing, and methodologies of sampling are defined and stable.

119 In my view, the Council has inappropriately characterised the water quality of an entire catchment based on sampling from a single site at the catchment outlet (see **Appendix 2** and paragraph 33 above). As noted earlier, Horizons is extrapolating upstream water quality based on a single sample point and monthly sampling. I consider it would be more appropriate to say "*water quality leaving the catchment is poor; we know what is happening in the catchment; we will address specific activities in specific parts of the catchment to fix the problem*". Assumptions that the results from a single monitoring site apply to all sections of the catchment upstream of that point are not valid.

120 I question the representativeness of the SOE network that Horizons has put in place to monitor the WMZs. Across the Region 31% of the land area is in native landcover[50]. Therefore, to provide an unbiased estimate of water quality state, nearly a third of sites should be in catchments dominated by native cover. This is not the case:[51] "*The selection of SoE sites has focused on areas of pressure.*"

121 In my Council-level evidence I suggested it would be useful for the Council Officers to describe the spread of SOE sites across the Region and estimate the representativeness of the sites. This has never been done, to my knowledge. If there is significant bias in the spread of sites (e.g. greater proportion of sites in agricultural catchments than the regional land cover patterns would suggest), how does this affect the definition of WMZs and descriptions of water quality state and trends at the Regional scale?

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50 Ausseil & Clark (2007b)

51 Section 42A report of Dr Roygard on behalf of the Council, paragraph 253, page. 137.

122 Further information has been published by NIWA that supports my view of the SOE network under representing water quality in the region. Unwin et al (2010) modelled water quality patterns across every river reach in New Zealand. By comparing patterns for measured versus predicted it is possible to identify areas where a choice of measurement sites may bias the overall picture. The example below is for water clarity (**Figure 7**).

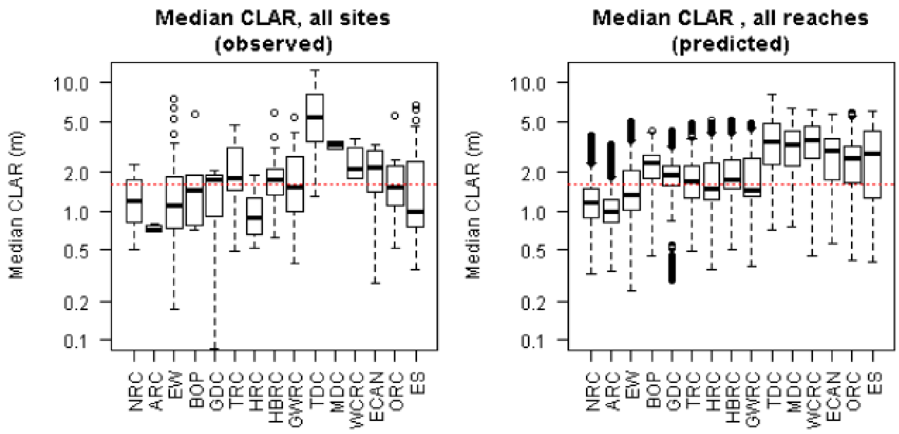

Figure 7. Water clarity box plots showing variation in observed and predicted values across 15 regions. The bold line across the box is the median value. The red line relates to the ANZECC guideline for upland streams. Reproduced from Unwin et al. (2010).

123 For observed data, the Council's sites show a median clarity of less than 1 m. In contrast, model predictions suggest a median clarity of greater than 1.5 m. This suggests that the Council's data under-estimates water clarity on a regional scale when compared with a model applied to all reaches across the Region.

124 Ausseil & Clark[52] provide some key recommendations on upgrades to the information that the SOE network might provide Horizons. Included in these recommendations are two that are directly relevant to arguments about the validity of the Council's approach to setting nutrient standards for the control of nuisance periphyton growths. First, Ausseil & Clark[53] recommend the addition of reference sites to cover a number of river classes in the region:[54] "*Reference site data is paramount to better understand the natural characteristics of each class of water.*" Secondly, they state that the "current" periphyton monitoring is largely insufficient to capture estimates of maximum annual periphyton biomass: "*An increased periphyton monitoring programme is strongly recommended.*"

[52] 2007b.

[53] 2007b.

[54] Section 9.1, Pg. 160.

Finally, a region-specific nutrient-periphyton model is suggested. This would be based on the data from the improved periphyton monitoring network. A review of the proposed nutrient standards might be required once the model is developed and validated.

PART B – RESPONSE TO MATTERS RAISED IN SUPPLEMENTARY EVIDENCE AND IN THE END OF HEARING REPORT

Response to Matters Raised in Dr Biggs' Evidence

125 Table 2 of Dr Biggs' supplementary evidence comments on a number of matters raised in my evidence in chief presented at the Council level hearing on POP (*Council-level EIC*). I continue to support the position I took in my Council level EIC and have largely replicated the paragraphs that Dr Biggs commented on earlier in this statement. For clarity I refer to the paragraphs from my Council level EIC and to the same paragraphs in this statement.

126 Dr Biggs stated that he disagreed with paragraph 23 of my Council EIC (paragraphs 46-48 above). It appears that Dr Biggs may have misunderstood paragraph 23 of my Council level EIC, as I agree that it would not be appropriate to disregard the whole POP approach to setting water quality numerics because a limited number of situations do not fit the framework. My point was that appropriate 'reference condition' standards should be applied in situations where inequities between reference condition and "effects based" standards exist. This is further explained in paragraph 40 of my EIC (paragraph 76 above).

127 In Table 2 of Dr Biggs' supplementary evidence, he states that he disagrees with my paragraph 29 (paragraphs 52-53 above). The point I made was that there is a need to manage public expectations about the ability to control periphyton blooms. Nutrient-rich siltstones leach significantly higher levels of nutrients than some other rock types and this will set constraints on the level of algae control able to be effected in these catchments. This is not explicitly dealt with in the periphyton numerics in the POP.

128 Dr Biggs' explanation of his reason for disagreeing with my paragraph 30 (paragraphs 56-57 above) suggests that he has misunderstood my evidence. I have not asserted that "*the primary driver for the MFE guidelines was protection of life supporting capacity".* My evidence was that the Council officers had stated in evidence and during the Council-level hearings that many of the numerics were set to provide for life-supporting capacity. I stand by my original statement that there was limited data to link periphyton biomass to ecosystem health in the Region at the time of developing those numerics.

129 The relationship shown in **Figure 1** of this statement of evidence shows that there is a strong association between maximum algal biomass and invertebrate community health. The relationship appears consistent with the Periphyton guidelines for protection of a clean water state (i.e. MCI >120), but a moderate community health (i.e. MCI >100) appear to be sustained at periphyton levels higher than the numeric applied in the current version of POP (i.e. max Chla <120 mg/m2).

130 When presenting his evidence at the Council, Dr Biggs commented on the "toxicity" of periphyton to invertebrate groups. In my view, this is incorrect. The negative correlation that often exists between periphyton biomass and invertebrate community health is driven by a complex set of often interrelated factors (e.g. summer temperature, levels of fine sediment, life cycles, successional changes and impacts of introduced predators such as trout). Indeed, there is published evidence of positive and negative correlations between periphyton biomass and invertebrate abundance and diversity, so to characterise the relationship between invertebrates and their periphyton food source as "toxic" is incorrect.

131 Dr Biggs' responses to paragraphs 32, 34, 37, 40 and 63 (paragraphs 62, 66, 72, 77 and 102 above) of my Council level EIC are primarily differences of opinion. I understand that Dr Biggs does not disagree with my assessments, but only with the recommendations which flow from those assessments, including what those assessments mean for the validity of numerics.

132 Dr Biggs disagrees with paragraph 36 of my Council level EIC, in which I state that detailed information on nutrient and periphyton conditions across the Region's rivers is missing, and without it the imperative for strict regulatory controls on nitrogen leaching losses from intensive land use is weak. Detailed information on nutrient and periphyton relationships now exists, but has not yet been fully analysed. In **Figure 2**, I have plotted the relationships between SIN and DRP and maximum periphyton biomass for data available from Horizons[55] and overlay the data used by Dr Biggs to generate his model (Biggs 2000[56]). My point is that the model used by Dr Biggs may not be appropriate for use in the Region, because relationships between nutrient concentrations and periphyton biomass observed in the Region are very different from the dataset used to develop the original model.

Response to Matters Raised in Dr Quinn's Evidence

133 Dr Quinn's supplementary evidence appeared to be focussed on addressing the comments made at paragraph 33 of my Council level EIC that *"Horizons has provided no direct evidence of the relationship between nutrient concentrations and periphyton biomass"* (paragraph 65 above)[57] Dr Quinn's response was to agree that the information was not provided, but to disagree that there is no relationship. However, I did not state that there is no relationship between periphyton biomass and nutrients. My comments were made to highlight that robust direct measurements

55 Ausseil and Clark 2007.

56 Note that the data from Biggs (2000) are mean monthly SIN and DRP. Whereas I have used median monthly SIN and DRP. I used the data referred to by Roygard et al and obtained it (as they did) from the Land & Water NZ website.

57 See paragraph 33 of my EIC.

were limited and instead Horizons was using a model that may, or may not, be appropriate for the purposes it was being used for.

134 There is weak evidence of a link between algal cover and nutrient concentrations based on the National River Water Quality Network (*NRNQN*).

135 Table 3 of Dr Quinn's supplementary evidence shows correlation coefficients for the relationship between DRP, DIN (=SIN) and percentage cover of filamentous algae. When using average data (the most statistically appropriate dataset), there are seven data points. Relationships are not statistically significant at $P<0.05$ (most commonly applied criteria – Dr Quinn applies a less commonly used and more relaxed criteria of $P<0.10$). This weak relationship only serves to highlight my concerns about using modelled links between nutrient concentrations and periphyton biomass as the underlying driver for proposed changes to management of nonpoint source contaminants in POP.

136 As noted above, **Figure 2** shows the relationships between periphyton biomass and nutrient concentrations in a selection of the Region's rivers based on the best available data. A linear regression of SIN on maximum periphyton biomass shows a significant relationship indicating that increasing levels of SIN result in elevated maximum periphyton biomass. However, the slope of the relationship is much lower than that presented by Biggs (2000). I also note that the relationship between median monthly DRP concentrations and maximum periphyton biomass was very weak.

Response to Matters Raised in Mr McBride's Evidence

137 I attended the Council hearing during the presentation of Mr McBride's evidence to the Panel. During that presentation, the Commissioners noted that merely because water quality trends are improving, does not mean the Council should do nothing. I agree with this statement and point out the significant body of work the dairy industry and Horizons are engaged in to ensure there is continual improvement in farmer practice (see the evidence of Sean Newland).

138 The thrust of my evidence is that there is less of an imperative for dramatic change in the management framework contained in the POP, because nutrient levels are trending down, likely as a result of practice change under a more permissive regime. I query the justification for a nutrient management approach which potentially affects farmers operating above LUC targets relatively harshly and is more costly, when:

138.1 the current management approach appears to be resulting in some improving water quality trends; and

138.2 where there is no evidence of dramatic deterioration in the Region's water quality.

139 The approach taken in the Fonterra version is that an effective but less costly approach to regulation of nutrients should be adopted to build on current gains.[58] I consider that the two-tiered planning structure for existing dairy farmers proposed by Mr Willis will lead to reductions in average N-loss from dairy farms through a requirement for improvements on the top quartile. Assuming that other contributors are also maintaining or reducing their contributions then continuing improvements in nutrient levels in the Region's rivers will follow.

Response to Matters Raised in Ms McArthur's Evidence

140 In Table 2 of her supplementary evidence, Ms McArthur comments on a number of matters raised in Part A of my evidence. Where those comments repeat matters also raised by the specialist Horizons witnesses responded to above, I have not repeated my response to them.

141 Figures 8-11 in to Ms McArthur's supplementary evidence show preliminary periphyton cover data for four sites (Manawatu at Weber Road, Manawatu at Hopelands, Manawatu downstream of the Pahiatua sewage treatment plant discharge, and Rangitikei at McKelvies). Ms McArthur uses this data as evidence of the need to manage N and P year round, as high periphyton cover can occur year round.

142 I consider it inappropriate to use the percentage cover measure for these purposes. Measure of periphyton biomass (chla mg m^{-2}) would be the more appropriate measure to use. I am also unsure as to why the four sites displayed have been chosen, or whether they were a random selection of the 48 monitored sites. Quinn and Raaphorst (2009) assessed periphyton percentage cover at 73 NRWQN sites over the period 1990-2006. For the Manawatu River at Weber Road, NIWA field staff recorded a maximum percentage periphyton cover of 80% (based on 150 observations). In contrast, in just nine observation events, the Council witnesses recorded two occasions when cover exceeded 80%. Visual assessment of periphyton cover can be influenced by a range of factors. As a result, visual assessment of periphyton cover is less reliable than quantitative measures of periphyton biomass.

143 In Table 2 of Ms McArthur's supplementary evidence, she disagrees with my statement that there is limited information linking periphyton biomass and ecosystem health. At the time of my original evidence the Council lacked quantitative periphyton data from a range of sites over different seasons, so was unable to link nutrient concentrations, periphyton biomass and measures of ecosystem health across the Region. In my view, the Council also needs to be very careful about assuming cause/effect relationships between nutrient concentrations and measures of macroinvertebrate

58 Less costly than that proposed by Ms Barton, but more costly than the relatively unregulated situation prior to the POP.

community health. Macroinvertebrates in streams flowing through agricultural catchments are faced with a wide range of often inter-correlated stressors (e.g. temperature, sediment, habitat destruction). Diagnosing the cause of any decline in ecosystem health (or what the relevant contribution of different stresses are) is difficult and is currently the focus of significant research in New Zealand to help understand the complex interactions of multiple stressors.

144 Ms McArthur disagrees with my statements in paragraphs 32 and 68 of my Council-level EIC (paragraphs 61-63 and 114-116 above, respectively) regarding nutrient limitations. In my view, where neither N nor P are limiting algal growth, it would make sense to focus management on the nutrient that is most easily controlled. This is often P, because it binds to sediment, which can be controlled through a range of well-recognised mitigation options (e.g. stock exclusion from waterways, stream fencing). If P loads to waterways are reduced, P may become limited. The additional benefit of this is increasing the N:P ratio, which can reduce the risk of favourable conditions for N-fixing cyanobacteria. In contrast, the focus of Rule 13.1 of the POP is N-control, with apparently less concern about P-control, particularly in intensively-farmed landscapes.

145 In Table 2 of Ms McArthur's supplementary evidence, she disagrees with paragraphs 46, 53 and 54 of my Council-level EIC (paragraphs 83-84, 96 and 97 above, respectively) and states:

> *It is fundamentally flawed to suggest relationships between decreasing nutrient trends at the site scale and land use change at the regional scale, particularly in the absence of a robust analysis to determine the causes of improving trends.*

146 I find this statement surprising given that this is exactly what Horizons is proposing to do in the POP. That is, through the POP rules and management regime, the Council proposes to reduce nutrient loads by control of land use at the regional scale.

Response to Matters Raised in Dr Roygard's Evidence

147 In Table 2 of his supplementary evidence, Dr Roygard comments on a number of matters raised my Council-level EIC.

148 Dr Roygard comments on my evidence that the number of reference sites for monitoring water management zones is insufficient.[59] My concern is not the *number* of sites monitored, but with how representative the picture of the Region's water quality is, based on those sites. If site choice is biased towards impacted sites, then the picture of water quality across the Region is also biased. For example, if Horizons had 30% of its waterways in native forest, but monitored a lesser percentage of such sites, then the network would

[59] Paragraph 72 of my Council-level EIC (paragraph 121-122 above).

not be regionally representative. Dr Roygard has not addressed my question contained within paragraph 72 of my Council-level EIC (paragraph 121-122 above).

149 In response to paragraph 7.4 of my Council-level EIC (paragraph 13.4 above). Dr Roygard states that combined information from both state and trends provides information for resource managers. I agree. However, when assessing the effectiveness of a particular management regime, in my view trends are more informative. The key point from my trend analysis is that there have been some improving trends and no deteriorating trends. In my view, this does not support the Council's argument that current management approaches are not working in the Region and that therefore the imposition of relatively strict controls of dairying to be achieved within specified time frames is required.

150 I am unsure which aspect of my paragraph 44.2 of my Council-level EIC (paragraph 81.2 above) Dr Roygard disagrees with in his Table. My evidence was and still is that water quality league tables released by the MfE suggested that sediment and faecal contaminants in the Region's rivers should be a principal concern. In my view, sediment and faecal contaminants have far greater impact on community values than nutrients. This assertion was reinforced by supplementary evidence presented by Ms McArthur (presentation to combined Water and Coastal Hearing panels on 11/12/09) in relation to levels of faecal indicator bacteria in coastal areas and their impacts on shellfish gathering.

Response to matters raised in the Supplementary Evidence of Dr Biggs for the End of Hearing Report

151 Dr Biggs suggests (page 7, paragraph 2) that "*under all the intensification scenarios, periphyton growth in the Manawatu River is likely to increase moderately to greatly, and reach biomass levels that are often considered to be* ***hyper-eutrophic****, aesthetically undesirable, and reduce the biodiversity of benthic invertebrate communities (with negative implications for fish, particularly trout). All the nutrient reduction scenarios will result in significantly lower periphyton maximum biomass and a reduced duration of high biomass events that exceed the periphyton guideline. Also, all scenarios are likely to be effective for increasing in-stream benthic invertebrate biodiversity, with the greatest gains being for adoption of the 'Ideal' loadings*."

152 Dr Biggs contends that increasing intensification in the Manawatu catchment will result in large increases in periphyton biomass, presumably as a result of increasing nutrient levels in the river. There are a number of assumptions behind these modelling scenarios that need to be challenged. First, that intensification will increase nutrient levels. Despite significant increases in dairying in the Manawatu catchment over the last decade, there is irrefutable evidence of decreasing trends in nitrate and phosphorus concentrations. Therefore the assumption that intensification will

necessarily lead to increased nutrient levels is not supported by evidence. Secondly, Dr Biggs' modelling uses relationships between nutrient concentrations and peak algal biomass that are highly conservative and at odds with observed relationships between periphyton biomass and nutrient concentrations (Figure 2). The term **hyper-eutrophic** as used by Dr Biggs is rather emotive in this context. Peak algal biomass measured at the Hopelands site is 355 mg Chla/m^2. Table 7 of the Periphyton guidelines suggests that, for New Zealand rivers, maximum algal biomass of 351 mg/m^2 is observed in mesotrophic sites (eutrophic sites have a biomass maximum of 1396 mg/m^2. This suggests that the river site with greatest periphyton biomass is only mesotrophic, not eutrophic and certainly not hyper-eutrophic.

153 Table 3 of Biggs statement is indicative of the concerns I have repeatedly raised on the modelling undertaken. For the Manawatu at Hopelands the current state nutrient loads leads to a predicted maximum Chla biomass of 1000 mg/m^2, yet the measured maximum biomass from the Council's monitoring over the last 3 years is 355 mg Chla/m^2. So based on available data the modelling of Dr Biggs is over-estimating peak algal biomass by a factor of three.

154 For the Current State condition Biggs predicts "*Based on the flow hydrographs for this river (and associated duration of base flows), and Biggs (2000b), biomass exceeding 200 mg/m^2 chlorophyll a could occur for 4-6 weeks per year in 3 out of 4 years under current conditions, occasionally reaching ~ 900 mg/m^2 chlorophyll a*".

155 **Figure 8** below shows the time series for the Manawatu River at Hopelands from December 2008 until November 2011 (34 sample dates over a three year period). Importantly, there was a prolonged period of elevated algal biomass in March-April 2010. It would be of value to have the Council witnesses describe river conditions during this period. For example, it would be useful to know the flow conditions preceding and during this period. The duration of low flow periods is an important determinant of maximum periphyton biomass. If there was a prolonged period of low flow between March and May 2010 we would have confidence that the periphyton biomass measured on single days in March and April are representative of maximum biomass at that site.

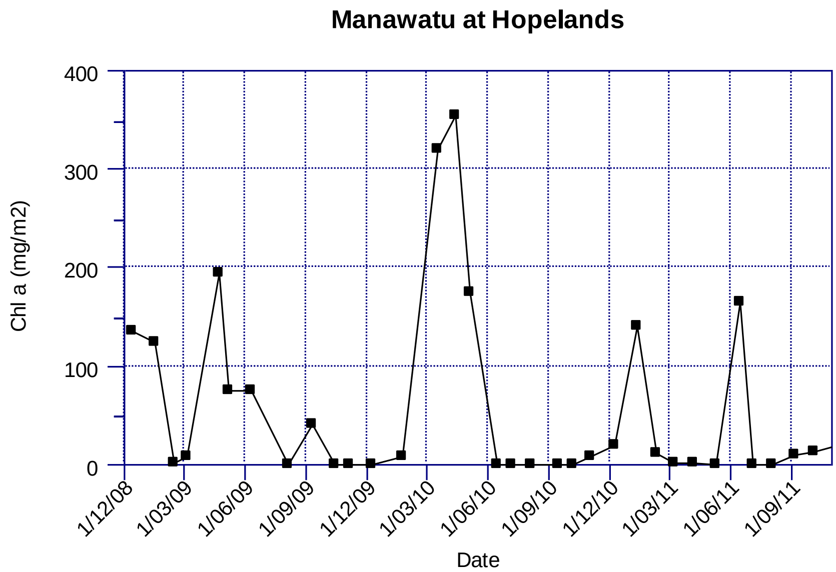

Figure 8. Time series of algal biomass for Manawatu River at Hopelands (data provided by Maree Clark).

156 Biggs suggests that under all intensification scenarios, periphyton biomass is likely to reach levels for prolonged periods in the Manawatu River at Hopelands that are indicative of eutrophic to hyper-eutrophic conditions, with periphyton mats dominated by filamentous green algae which are often considered aesthetically undesirable by the public, and which will significantly reduce the biodiversity of benthic invertebrate communities in the river, with negative implications for fish, particularly trout.

157 I disagree and provide two pieces of evidence. First the available data suggests that filamentous green algae seldom dominate the algal community at the Hopelands site. Secondly the assumption that increased periphyton biomass will result in reduced invertebrate community health. The values for the MCI at the Hopelands site averages 97, while the target for the site is 100. Given the spread of MCI values at Hopeland as presented in **Figure 4** of Roygard et al (14 February 2012) it appears that the average MCI level is not significantly different from the target.

158 In response to my drawing attention to the potential flaws in his modelling approach, Dr Biggs suggests that i) there is no reason to support non-transferability of science from elsewhere in New Zealand (i.e. the Biggs (2000) model used to develop national guidelines should be applicable to the Manawatu) and ii) Nothing has been presented by Dr Scarsbrook, or any other submitter, that would place the applicability of the current model in question.

159 To address Dr Biggs first point I would draw attention to the recommendations to the Council (subsequently adopted) that a regional model be developed to provide for a better understanding of the relationships between nutrients and periphyton (Ausseil &

Clark 2007b). In my opinion, the expense of developing a regional model is entirely justified by virtue of the increased regional specificity of knowledge it produces. Regional data will be more relevant than predictions based on a national model of questionable transferability. I am of the opinion that there is now a significant body of evidence based on regional data collected by the Council's staff to indicate that the modelled relationships between maximum Chla biomass and both SIN and DRP that have been presented by Dr Biggs lead to unrealistic predictions of periphyton biomass. The model used by Dr Biggs should be discarded and replaced with a regional model as per the recommendations of Kilroy, Biggs & Death (2008).

Response to matters raised in the end of Hearing Report prepared on behalf of the Council

160 Dr Roygard makes statements about state vs trends. I agree both are important, but we are dealing here with a resource management planning process. You are looking to achieve environmental outcomes over time. That is you are looking to drive a trend in water quality from current state to a desired state. I cannot see how effective and efficient policy can be an outcome of a process where recent improving trends in water quality are ignored.

161 Trends analyses for the Council Region were overviewed in the s42A Evidence of Dr Roygard, summarised in the s42A reports of Ms McArthur and Dr Davies-Colley, and mapped and further summarised in the Supplementary Evidence of Ms McArthur. Dr McBride (for the Council) and I also provided evidence on trends. A summary of the trends was provided by Dr Davies-Colley (as quoted by Dr Roygard in Box 30 of his s42A Evidence):

> *"There are few significant trends in water quality across the region. Trend analysis of 2001-2008 water quality data revealed no significant trends in DRP concentrations (either increasing or decreasing), 6 meaningful decreasing trends in SIN concentrations [note 1], 4 meaningful decreasing trends in E. coli [note 1] and 4 meaningful decreasing trends in turbidity [note 1]. These trends are in sharp contrast to the longer term trends (1989 to 2007) for the NRWQN sites where meaningful increases were observed for NOx-N at the 3 NRWQN sites on the Manawatu [note 1]. This suggests the longer term (19-yr) trend of worsening water quality in the Manawatu has been slowing or even reversing more recently (ie., water quality has been improving)."*

PART C – RESPONSE TO MATTERS ARISING FROM THE ADDITIONAL JOINT STATEMENT OF DR JON ROYGARD, KATE MCARTHUR AND MAREE CLARK LODGED BY HORIZONS ON 14 FEBRUARY 2012 AND SUPPLEMENTARY STATEMENT BY JON ROYGARD AND MAREE CLARK ON NUTRIENT LOAD SCENARIOS AND METHODOLOGY DATED 24TH FEBRUARY 2012

162 I have commented in various places above on the supplementary evidence that has been filed and add to those comments in this section.

163 In Table 1 of the 14 February 2012 Statement of Roygard et al. there is an updated comparison of water quality state in the region with national quartiles based on Land and Water New Zealand (*LAWNZ*) compiled data (www.landandwater.co.nz). Information in the table is used to again highlight a poor water quality state in the Region.

164 My interpretation of this table is that the Region's sites appear under-represented (i.e. values<25%) in the best 25% of sites. This supports my previously-stated opinion that the Council's SOE network is biased towards modified sites. Interestingly, visual clarity is the only indicator where the region is strongly over-represented in the worst 25% class. If the state of water quality in the Region was the same as the state of water quality nationally then every cell in Table 1 would equal 25%. Numbers greater than 25% suggest that the region is over-represented in that category, whereas percentages less than 25% suggest the Region is under-represented in that category.

165 In my original evidence I suggested that the Council's SOE dataset under-represented natural state sites and as a result the picture of water quality in the region is biased. Table 1 supports this view. Apart from clarity (linked to soft-rock geology in the Region) none of the indicators suggest the region is over represented in the worst 25% of sites.

166 NIWA has published a report modelling water quality patterns around New Zealand. This report shows differences between measured and predicted water quality. There are clear indications that water quality state in the Region is worse than predicted meaning that the measured state is biased.

167 In the evidence of Dr Jon Roygard water quality trends in the Region are summarised in Table 2 and paragraphs 22 – 25. In paragraph 25 he states "*Notably, nitrogen is meaningfully increasing at three sites on the upper, middle and lower Manawatu River*". This statement is not supported by independent analyses carried out by Ballantine & Davies-Colley (2009), or my own more recent analysis of trends for the periods 1989-2011 and 2001-2010. The

reason for these discrepancies appear to be linked to the time period analysed for trends.

168 The significant differences between my own trend analysis of the NRWQN sites (2001-2010) and those in Appendix 3 stem from differences in the time period of analysis. The trends referred to in Appendix 3 cover the period from 1989 to 2007 as used by Ballantine & Davies-Colley (2009). That is they have used the full data record available at the time of analysis. The approach I have taken is to look at both a defined period (last 10 years), and the full sample record. Use of a defined trend analysis period is the same approach I took in my Council level EIC. The trends for that earlier period 1999-2008 have been confirmed and strengthened looking at the later period 2001-2010.

169 It is of utmost importance to provide an accurate view on water quality trends, particularly with regard to nitrate, as "*it is the effects of N loss beyond the root zone of the plant on water quality that is at issue*" (Clare Barton paragraph 46). In my view, nitrate levels have decreased significantly in major rivers (i.e. Manawatu and Rangitikei) over the last decade. Therefore, the cost/benefit assessment of more strict controls (via N-loss limits for dairy farms) needs to be questioned.

170 I note that the protocols developed by NIWA for the periphyton monitoring programme recommended building a regional periphyton-nutrient model after at least 1 years data had been collected. Despite having almost three years data I am not aware of any attempts by the Council to model the relationships between nutrient levels and peak periphyton biomass. Understanding these relationships is central to assessing the appropriate regulatory response in the POP.

171 The Supplementary Statement from Roygard & Clark (24 February 2012) provides a detailed analysis of SIN and DRP load calculations at 17 river sites around the region. The report supports land use scenarios that were presented by Roygard et al in their Supplementary Evidence of 14 February.

172 The report covers the estimation of nutrient loads for 17 river sites. The methodology has been described in detail in previous reports and in a peer-review paper, although I note the most recent work deviates from the methodology used in the published work. Dr Roygard is of the view that the change in method was used to remove any bias that may occur due to variations in the sampling strategy for a site over time (see paragraphs 16-19 of his Supplementary Statement). However, Dr Roygard has not quantified the magnitude of changes in estimated load that this method change causes.

173 In my opinion, Roygard et al have produced a valuable body of work to estimate river nutrient loads, contributions from different sources

and land use change scenarios. However, I am concerned that uncertainties and errors inherent in the data have not been explicitly recognised in the interpretation of the model scenarios. For example, the scenario results (Tables 40-41 in Roygard and Clark's Supplementary Statement) are presented as single number estimates for change in loads. It would be valuable to have estimates of the uncertainty or variability associated with these estimates so we could judge their significance. In addition, the underlying assumptions as to loads appear to be in error given knowledge of recent improving trends in water quality. The model would need to be recalibrated to address apparent errors and the scenarios rerun.

174 For the sake of balance it would also be informative to have some scenarios included that estimate reductions in average N-loss per hectare as a result of improving farm practice. For example, improvements in effluent management, reflected in improving effluent compliance figures for the Region, will lead to reductions in N-loss. This occurs through changes in application rate and increases in effluent area.

175 Additionally, scenarios could have been built around increases in the efficiency of applied nutrients (e.g Urea). To have "do nothing" scenarios representing the status quo does not reflect the significant body of work being undertaken by farmers, industry and Horizons to improve practice on farm.

176 In addition, the alternative approaches suggested by other parties would need to be modelled. In particular Fonterra's Version as proposed by Mr Willis would need to be modelled in more detail. Key assumptions informing that scenario, based on mine and the evidence of Dr Ledgard, would be as follows:

176.1 That existing farms in the lower 75% range are likely to stay at or below their current N-loss given the requirement that they produce NMPS and implement other N-loss technologies and practices (e.g. stock exclusion). For balance, some scenarios which show N-loss increases in the lower 75% range should be modelled as well.

176.2 That those farmers in the top 25% range will be required to make N-loss reductions. It is acknowledged that there will be some uncertainty in this area, so assumptions as to losses would need to be agreed and a range scenarios modelled in any case.

176.3 11% conversion rates as proposed by Council witnesses would be assumed.

176.4 Overall, some N-loss reductions will be made in the future through ongoing industry initiatives. Accepting these will also be relatively difficult to predict, a range of scenarios and their likelihood could be tested.

177 It is worth noting the % changes (Table 8) across all sites and scenarios ranges from 0 to -41% with most scenarios leading to changes of less than 10% at most sites. The range of natural variability in estimated loads reported by Roygard et al (2012) is +/- 31-54%. It appears that many of the changes predicted by Dr Roygard may not be measurable in reality due to high levels of natural variability.

178 Table 6 of the Statement of Roygard et al. shows that measured SIN loads exceed target SIN loads at 15 of 17 sites. One of the sites where the measured load is greater than target is Tamaki at Reserve. This is a reference site, yet the measured load is 30% higher than target. This indicates that the target loads may be unachievable.

179 Six of the seventeen sites used by Roygard in the modelling study would fail to meet the target load even if the entire catchment was in native forest (Appendix 3). Assuming a loss factor of 2.4 N/ha/yr from native forest and using an attenuation factor of 0.5 there are six sites where the target load could not be achieved even if all the catchment was restored to native forest. For example, the Manawatu River at Weber Road would exceed the target load by 119% even if the entire upstream catchment reverted to bush. All three sites in the Rangitikei River could not meet target loads even if the entire catchment reverted to native bush.

180 From examination of the periphyton data, point source discharges can have a significant localised effect on periphyton biomass, e.g. Manawatu d/s of PNCC STP and Mangaitonoka d/s of Pahiatua STP show a higher biomass and more frequent exceedence of chl a target than the upstream sites. Therefore, despite point source discharges having a low relative contribution of nutrients at the catchment scale, they can and do make a significant contribution at the reach scale to exceedences of the POP targets.

181 Table 38-39 in Roygard and Clark summarise the relative contributions for the various land use types to measured loads. Across the seventeen sub-catchments, dairy contributes between 2 and 36% of the measured N load. In contrast, sheep and/or beef contribute between 18 and 89% of the measured load (note that sheep and/or beef contributes -11% in one catchment – recognised as an impossible outcome). Controls on dairy in these sub-catchments may lead to reductions in the contribution of dairy to the measured load, but if there are no controls on other contributors there may be no measurable effect on measured load.

182 In addition to the load estimation and scenario modelling report of Roygard and Clark, Horizons also submitted a technical report

summarising current and historical water quality in Lake Horowhenua (Gibbs 2011).

183 There are very significant water quality problems in Lake Horowhenua and it would be appropriate to target the Lake for management action. However, there is nothing presented in the report that would support the claim made by Dr Gibbs that increases in N concentrations in Arawhata Stream are "directly related to recent dairy intensification in the stream catchment" (Executive Summary, last paragraph, page 9). Throughout the report the authors implicate dairy intensification as a major issue for the health of the lagoon. This is not supported by any data other than an unquantified shift in land use between the late 1980s and the 2000s.

184 I have made some estimates of nutrient losses from different land uses in the lake catchment. This was based on numbers provided in Roygard & Clark's supplementary statement (24 February 2012) and are the same differential N-loss rates used above for calculations in Appendix 3.

185 Losses from dairy are around 28% of catchment losses of N, whereas cropping contributes 13%, horticulture 21% and sheep and/or beef 35%. Dairy has a much lower per hectare N-loss rate than cropping (50 kg N/ha/yr) or horticulture (80 kg N/ha/yr) so it is hard to see how dairy can be blamed for the increased levels of N getting to the lake if dairy has replaced horticulture as suggested by Dr Gibbs (page 34 "After groundwater, the single largest inflow to Lake Horowhenua is the Arawhata Stream which drains land traditionally used for horticulture and market gardens but more recently intensive dairy farming").

186 Rehabilitation of Lake Horowhenua will be an inter-generational process that began in the 1980s with removal of human sewage discharges. Improving management of nutrient losses from all land uses in the catchment will be required.

CONCLUSIONS

187 I support the subdivision of the Region into smaller management units and also support the approach taken by Horizons in defining WMZs. In my opinion, the WMZs are appropriate and provide opportunities to focus action (e.g. mitigation or remediation) in priority areas, and on priority issues, rather than having to attack a poorly-defined regional-scale issue.

188 I do not support the use of WMZs to describe regional water quality patterns as shown in Figure 6.1 of Chapter 6 of the POP (version dated 31 August 2009). This approach is entirely inappropriate, because it requires extrapolation from a single monitoring station (which itself is only a limited sample of the actual conditions) to

characterise the water quality for an entire sub-catchment. This will inevitably lead to exaggeration of water quality issues.

189 The POP water quality numerics (Schedule AB) cover an appropriate range of water quality parameters. I consider that the nutrient numerics in the POP that apply to rivers throughout the Region are overly-conservative and may be largely unachievable in many rivers. This view is supported by results of preliminary analysis of nutrient-periphyton relationships. The analysis indicates that target levels for SIN used as numerics in the DV POP are highly conservative when used to predict levels of maximum periphyton biomass.

190 The Council witnesses have presented no regional data showing relationships between nutrient concentrations, periphyton biomass and life supporting capacity. In order to link observed and predicted nutrient concentrations to periphyton biomass, the Council witnesses have relied on a national-scale regression model. This model has not been validated for the Council's rivers, and is recognised as being inappropriate for river types (i.e. catchments with high proportions of marine tertiary sediments) that make up around 50% of Manawatu-Wanganui Rivers.

191 I consider that the low levels of compliance across the monitored sub-zones, particularly for water clarity and nutrient concentrations indicates that the proposed "effects-based" numerics in the POP are too stringent and do not reflect the natural reference conditions found throughout the Region.

192 I consider that the picture of water quality state provided by the Council's witnesses significantly overestimates water quality problems at the regional scale. Nonetheless, there are significant water quality issues within the Region and these issues will have direct impacts on waterway values. Many of the Region's rivers have issues with elevated levels of nutrients, sediments, faecal contaminants and a range of other stressors. However, public perception of water quality is generally positive.

193 There has been a change in the situation since the POP was notified. Improving trends in key water quality parameters in the Manawatu River suggest that the environmental imperative to control non-point source pollution in the region has lessened since the POP was first notified.

194 The Council calculates the nutrient load attributable to non-point sources as the difference between measured load in the river and the load attributed to point sources. The information used to calculate point source contributions is incomplete and this will lead to over-estimation of the contribution from non-point sources. In addition, based on this methodology some catchments cannot meet the target loads even if the entire catchment reverted to native bush.

195 The Council has embarked on significant upgrades to its SOE monitoring programme. Development of a monthly periphyton monitoring programme at 48 sites fills a critical gap in current environmental knowledge, although the Council witnesses have not yet used this extensive dataset to draw linkages between periphyton biomass and nutrient concentrations. The issue of controlling periphyton growths is central to the POP, as the nutrient numerics, standard loads and on-farm nutrient leaching loss limits are all in place to control periphyton growth. These elements have all been put in place without reliable information on periphyton biomass patterns in the Region. There is evidence that periphyton biomass observed in the Region's rivers is far lower than was predicted by the national model applied to nutrient concentrations observed at river monitoring sites.

196 Uncertainties in links between instream outcomes and non-point source nutrient controls support an argument for an adaptive management process, whereby increases in scientific understanding (e.g. improved knowledge of causative factors for periphyton growth in the region) combined with adequate monitoring of both causative factors (nutrients) and outcomes (periphyton, MCI) can be used to refine nutrient numerics and revise on-farm nutrient output targets over time. However, the uncertainties always present in science should not be used to justify maintaining the status quo. Significant water quality issues in the Region underline the need to reduce point source and non-point source contaminant loads. This should be achieved through targeted action to ensure that all resource users are applying mitigation practices that will have demonstrable benefits for community values.

197 There are three keys areas where the evidence of Horizon's witnesses are at odds with my own evidence. First, the choice of time period for trend analysis is a major point of difference. I have used a recent 10 year period for trend analysis to highlight improving trends in the Manawatu River, whereas the Council officers look at trends over a much longer time frame. Secondly, differing interpretations of national and regional water quality datasets have led to differences in opinion of the extent of water quality problems in the region. Finally, the application of a highly conservative model linking periphyton biomass with nutrient concentrations and its subsequent use in determination of target or 'ideal' nutrient loads, is perhaps the most contentious issue.

Dr Michael Scarsbrook
14 March 2012

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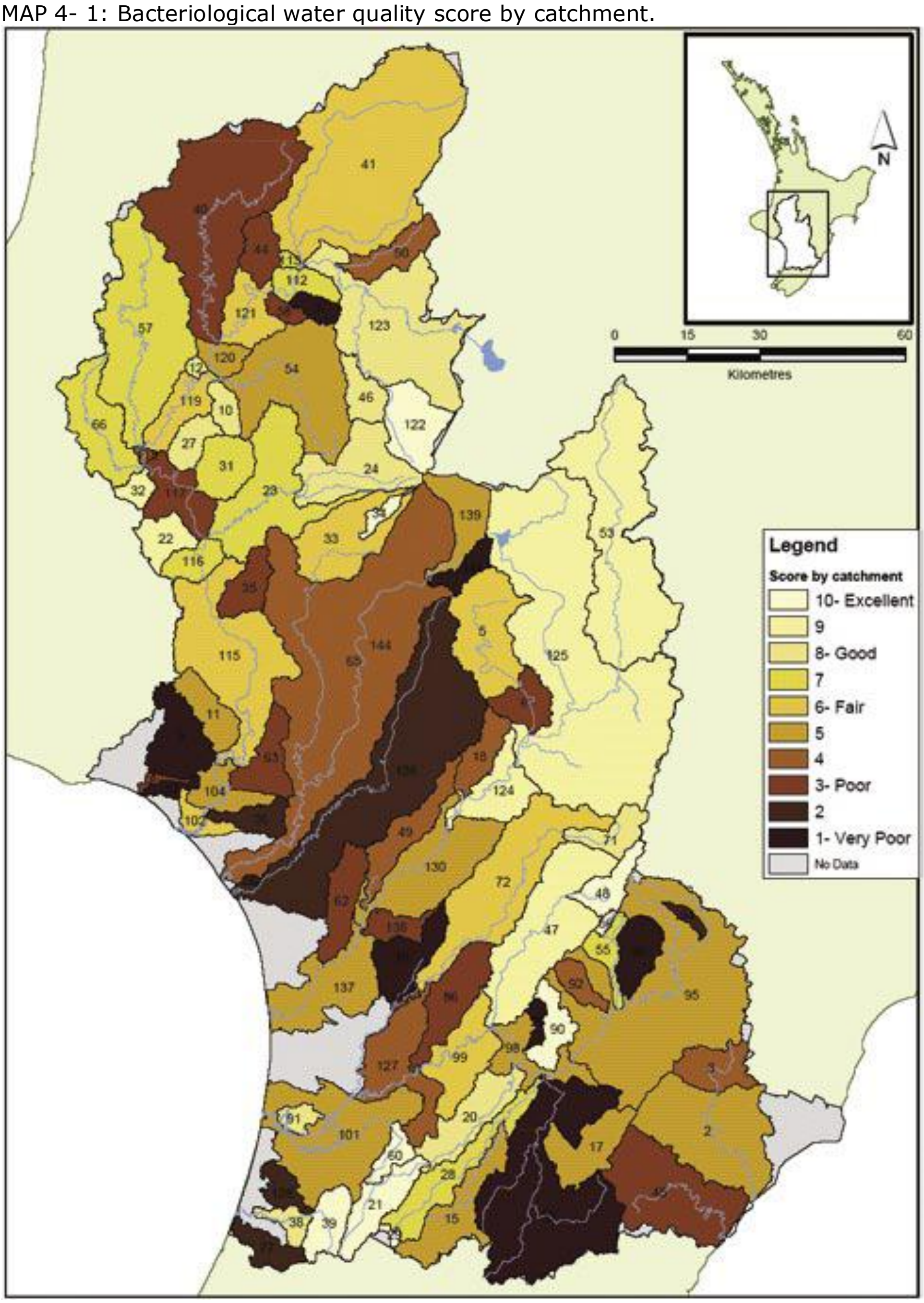
APPENDICES

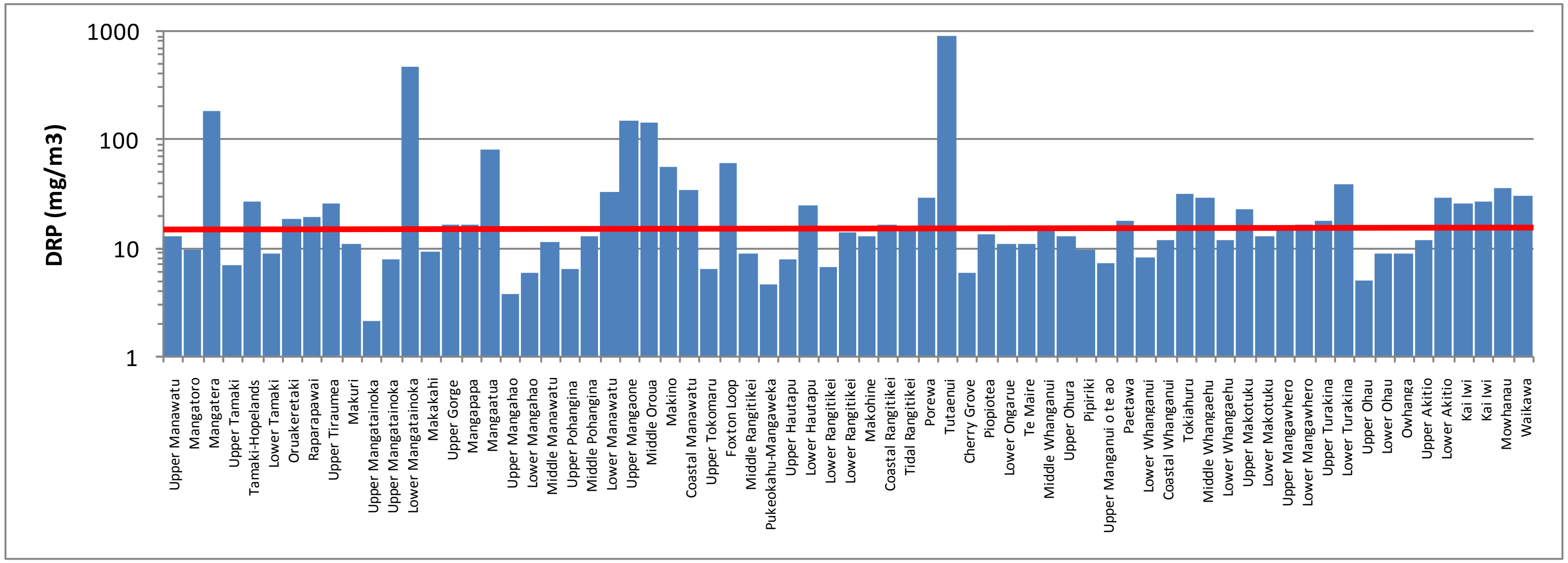
Appendix 1

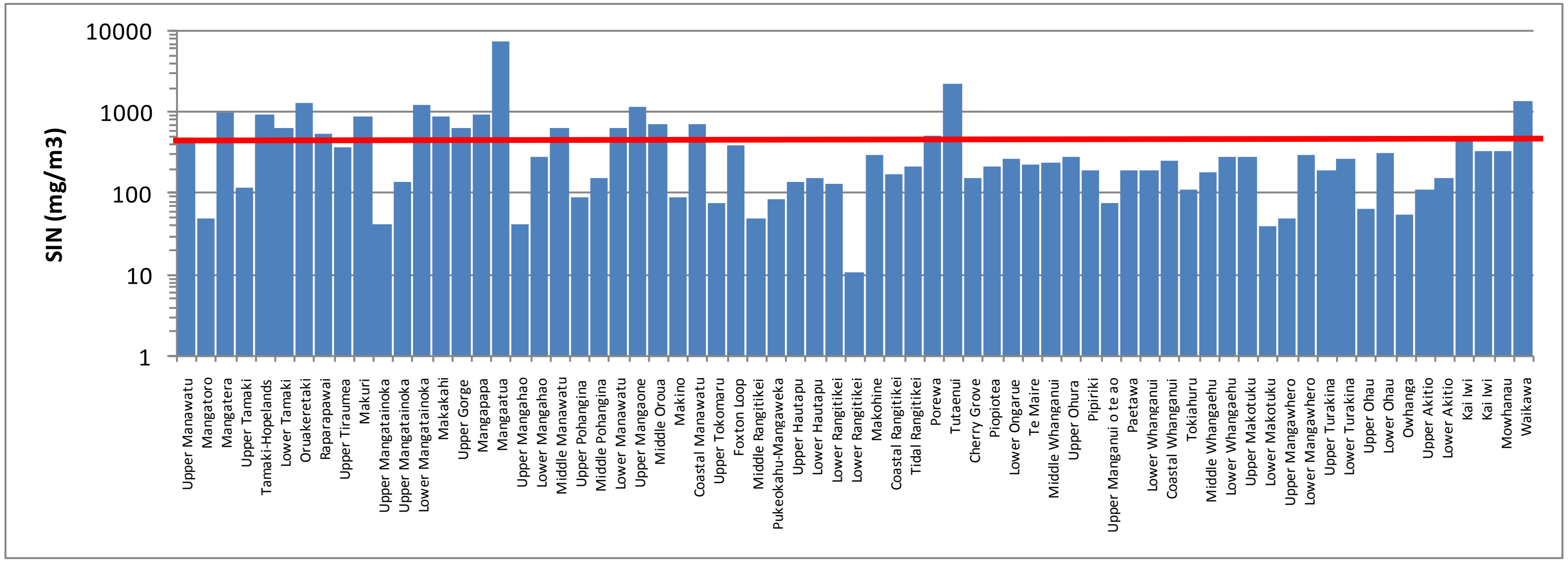
Reproduced from SOE Report Technical Report Four/Freshwater Quality (2005; pg. 56). A slightly modified Figure also appears on page 6-6 of the POP.

MAP 4- 1: Bacteriological water quality score by catchment.



Appendix 2: Mean Monthly concentrations (mg/m^3) of DRP and SIN at 69 river sites in Manawatu-Wanganui Region.




SIN (mg/m3)
10000
1000
100
10
1
Upper Manawatu
Mangatoro
Mangatera
Upper Tamaki
Tamaki-Hopelands
Lower Tamaki
Oruakeretaki
Raparapawai
Upper Tiraumea
Makuri
Upper Mangatainoka
Upper Mangatainoka
Lower Mangatainoka
Makakahi
Upper Gorge
Mangapapa
Mangaatua
Upper Mangahao
Lower Mangahao
Middle Manawatu
Upper Pohangina
Middle Pohangina
Lower Manawatu
Upper Mangaone
Middle Oroua
Makino
Coastal Manawatu
Upper Tokomaru
Foxton Loop
Middle Rangitikei
Pukeokahu-Mangaweka
Upper Hautapu
Lower Hautapu
Lower Rangitikei
Lower Rangitikei
Makohine
Coastal Rangitikei
Tidal Rangitikei
Porewa
Tutaenui
Cherry Grove
Piopiotea
Lower Ongarue
Te Maire
Middle Whanganui
Upper Ohura
Pipiriki
Upper Manganui o te ao
Paetawa
Lower Whanganui
Coastal Whanganui
Tokiahuru
Middle Whangaehu
Lower Whangaehu
Upper Makotuku
Lower Makotuku
Upper Mangawhero
Lower Mangawhero
Upper Turakina
Lower Turakina
Upper Ohau
Lower Ohau
Owhanga
Upper Akitio
Lower Akitio
Kai Iwi
Kai Iwi
Mowhanau
Waikawa

Appendix 3. Estimates of SIN loads relative to Target loads for catchments where native vegetation cover has been extended to cover 100% of the catchment.

Site	Target load (T SIN/yr)	Current native cover (ha)	% Target load from Native	Total catchment area (ha)	%Target load if all catchment in native
Manawatu Weber Rd	69.6	5285	9	68842	119
Manawatu Hopelands	364.3	12757	4	124345	41
Tiraumea Ngaturi	222.4	8248	4	74217	40
Mangatainoka Putara	3.2	1857	70	1867	70
Mangatainoka Larsons Rd	11.6	4510	47	6808	70
Makakahi Hamua	91.1	2763	4	16537	22
Mangatainoka SH2	264.3	8789	4	42809	19
Mangahao Balance	79.5	18204	27	27736	42
Manawatu Upper Gorge	1193.5	54455	5	319330	32
Manukau SH1	2	2382	143	2981	179
Waikawa Nth Manukau Rd	8.1	295	4	1480	22
Waikawa Huritini	10	2725	33	7286	87
Rangitikei Mangaweka	220	106644	58	268367	146
Rangitikei Onepuhi	230.1	110976	58	327504	171
Rangitikei McKelvies	248.3	112216	54	388816	188

Tamaki Reserve	1.6	1141	86	1156	87
Mangatoro Mangahei	18.8	1293	8	22795	146