BEFORE THE BOARD OF INQUIRY

IN THE MATTER of the Resource Management Act 1991
AND
IN THE MATTER of the Tukituki Catchment Proposal

STATEMENT OF EVIDENCE OF
Olivier Michel Nicolas AUSSEIL
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1. INTRODUCTION

1.1 My name is Olivier Michel Nicolas Ausseil.

1.2 I hold a PhD of Environmental Biosciences, Chemistry and Health from the University of Provence, France. I also hold a Master of Science Degree of Agronomical Engineering from the National Higher Agronomical School of Montpellier, France, and a DEA (equivalent Masters Degree) in Freshwater Environmental Sciences from the University of Montpellier 2, France.

1.3 I am currently employed as Principal Scientist - Water Quality by Aquanet Consulting Limited, a consultancy I formed in 2007.

1.4 I have over 11 years experience in New Zealand as a scientist working in local government and as a private consultant working for Regional Councils and Local Authorities, central government and government agencies, and the private sector. Prior to that, I worked as a Research Engineer between 1998 and 2001 for the French Atomic Energy Commissariat during my PhD studies.

1.5 Prior to forming Aquanet Consulting Ltd, I was employed by the Regional Planning Group of Horizons Regional Council (Horizons) from July 2002 to June 2007, where I held the positions of Project Scientist, Environmental Scientist - Water Quality and Senior Scientist - Water Quality.

1.6 My responsibilities at Horizons included leading the water quality and aquatic biodiversity monitoring and research programme and providing technical support to policy development. I was the primary author of three technical reports underpinning the river values framework and water quality standards in the notified version of the Proposed One Plan for the Region. I was also heavily involved in the development of the Water Management Zone and Sub-Zone framework included in the notified version of the Proposed One Plan. I was later engaged by the Department of Conservation to provide evidence to the Environment Court during the One Plan appeal hearings in 2012.

1.7 Since July 2007, I have been Principal Scientist at Aquanet Consulting Limited. In this position, I have been engaged by 10 different Regional, District or City Councils, the Ministry for the Environment, the Department of Conservation, Fish and Game New Zealand and a number of private companies to provide a variety of technical and scientific services in relation to water quality and aquatic ecology.
1.8 I am a certified Commissioner under the Ministry for the Environment “Making good decisions” programme. I was a Hearing Commissioner appointed by Horizons Regional Council to hear New Zealand Defence Force’s consent applications to discharge treated wastewater from the Waiouru wastewater treatment plant to the Waitangi Stream, in June 2011 and February 2012.

1.9 I have worked as a technical advisor on behalf of the consenting authority, the applicant and/or submitters on well over 100 resource consent applications, compliance assessments and/or prosecution cases for a wide range of activities. In July 2010, I ran a training workshop for Horizons staff on the technical assessment of resource consent applications for discharges to water.

1.10 My work routinely involves providing assessment of effects on water quality and/or aquatic ecology, recommending or assessing compliance with, resource consent conditions, and designing or implementing water quality/aquatic ecology monitoring programmes. I have designed and implemented a large number of monitoring programmes both at the scale of a specific activity and at a wider catchment or regional scale. As part of my previous role at Horizons Regional Council I redesigned the state of the environment water quality monitoring programme. I also undertook a detailed review of Environment Southland’s water quality monitoring programme in 2010 and of Environment Bay of Plenty’s in 2012.

1.11 I have recently completed a series of technical reports for Greater Wellington Regional Council recommending water quality and ecological limits for the protection of a range of river values throughout the Wellington Region in relation to a range of ecological (aquatic ecosystems), recreational (contact recreation, trout fishery and trout spawning) and water usage (livestock drinking water) management purposes. The series of reports include a report specifically detailing recommended in-stream nutrient limits in relation to the above stream and river management purposes. I was part of an expert panel providing recommendations to Greater Wellington Regional Council in relation to toxicant limits within aquatic ecosystems. I was also a peer-reviewer of Environment Canterbury’s 2009 technical report providing recommendations on water quality objectives and standards for the council’s Natural Resources Regional Plan¹.

1.12 I have authored or co-authored a number of catchment- or region-wide water quality reports focussing largely on in-stream nutrient concentrations, in-stream nutrient loads and catchment nutrient yields, and their effects on periphyton growth for Hawke’s Bay Regional Council on the Tukituki, Ngaruroro and Tutaekuri Rivers, for Environment Canterbury on the Hurunui catchment and recently for Pegasus Bay and for Greater Wellington Regional Council.

1.13 I was engaged by Environment Southland as mentor and peer-reviewer for their 2010 State of the Environment report, and wrote the section of this report relating to nutrient limitation. I also peer-reviewed a number of regional State of the Environment reports for Environment Canterbury (2010), Environment Southland (2010), West Coast Regional Council (2008), and Hawke’s Bay Regional Council (2009), as well as the 2009 Ministry for the Environment report on Clean Stream Accord water quality monitoring.

1.14 I was recently a peer-reviewer of an AgResearch report (to be published) to the Ministry for the Environment on water quality reference conditions and trigger values in New Zealand streams and rivers.

My role in the Tukituki Catchment Proposal

1.15 My involvement in the Tukituki catchment started in 2008 when I was commissioned by Hawke’s Bay Regional Council (HBRC) to prepare a technical report on the state and trends of water quality in the Tukituki catchment, based on water quality, river flow and aquatic ecology data collected up until 2008 by HBRC as part of their various State of the Environment monitoring programmes and by NIWA as part of the National River Water Quality Network (NRWQN). The report was finalised and presented to a group of Tukituki River stakeholders in December 2008.

1.16 In June 2011, I was engaged by HBRC as the Ruataniwha Water Storage Scheme (RWSS) Science Leader. I have continued in this role to this date, on behalf of HBRC, then on behalf of the Hawke’s Bay Regional Investment Company Limited. My role in the RWSS project has included coordinating the water quality, hydrology and aquatic ecology studies, as well as providing direct scientific advice to the project team. I also led the Environmental Flow

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Optimisation Study and was the primary author of the associated report (report K4).

1.17 My involvement with the Plan Change 6 (Change 6) started in mid-2012. My primary role was the provision of technical advice on the development of water quality limits and targets. I was, along with Dr Uytendaal, the author of the technical report making recommendations on water quality limits and targets for the Tukituki catchment now set out in Change 6. I was also a member of the expert panels convened for the “Managing nuisance growth using nutrient limits” and “Phormidium” technical workshops held in December 2012. The notes from these workshops are included as Appendices E and F respectively of the water quality limits technical report.

1.18 Although I contributed to all sections of the water quality limits technical report, I took principal responsibility for the sections that concern the following recommended limits:

(a) Microbiological water quality;

(b) Periphyton and nutrients;

(c) Water quality indicators: MCI, water clarity and deposited sediment;

(d) Ammonia and other toxicants;

(e) Water quality limits relating to point source discharges.

Purpose and scope of evidence

1.19 The purpose of my evidence is to provide evidence on matters relating to the water quality limits, targets and state indicators in Change 6 (as notified) and as proposed by submitters where they differ, as well as summarising the findings of the Environmental Flow Optimisation study, and providing comments on RWSS proposed consent conditions insofar as they relate to my field of expertise.

1.20 In my evidence I address the following matters in relation to Change 6:

(a) The spatial framework for water management in the Tukituki catchment;

(b) The limits setting framework;

3 Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1.
(c) Recommended water quality limits for point source discharges;

(d) Recommended water quality, limits targets and state indicators (other than nutrients) and;

(e) Periphyton and nutrient limits;

(f) A comparison with the One Plan water quality limits framework;

(g) Risks and benefits of different nutrient management options, including those sought by various submitters.

I provide comments on matters raised in submissions in relation to each of the above matters.

1.21 I address the following matters in relation to the RWSS:

(a) The environmental flow optimisation study;

(b) Approach to water quality and an assessment against the Change 6 provisions;

(c) Comments on matters raised in submissions.

Expert Code of Conduct

1.22 I have read the Code of Conduct for Expert Witnesses in section 5 of the Environment Court’s Practice Note (2011). I agree to comply with that Code of Conduct. Except where I state that I am relying upon the specified evidence of another person, my evidence in this statement is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions which I express.

2. SUMMARY AND CONCLUSIONS

2.1 Change 6 is based on a spatial water management framework composed of 5 water management Zones. For the middle catchment (Ruatanigha Plains), these Zones are the smallest geographical unit encompassing both surface- and groundwater catchments, and I do not recommend a water management framework based on surface sub-catchments for that area. In particular MAZLs for N should not be calculated on the basis of surface sub-catchments. I note
however that specific aspects (such as phosphorus) should, and are intended to, be managed at a surface sub-catchment scale.

2.2 Identification of additional values would not, in my opinion influence significantly the water quality limits framework in Change 6.

2.3 I have considered submissions on point-source discharge limits set in Policy TT3, and have made recommendations to amend some of these limits.

2.4 Excessive periphyton growth is a key water quality issue in the Tukituki Catchment, and reducing it is one of Change 6’s Freshwater Objectives. With this objective in mind, there are in my opinion clear and converging lines of scientific evidence that phosphorus (P) should be the management priority. If achieved, reductions in P inputs to the catchment are expected to result in a reduction in periphyton growth. However, complete elimination of excessive periphyton growth should not be anticipated in response to even dramatic reductions in nutrients. This is primarily due to the natural hydrology of the catchment, in particular the very long accrual periods in summer.

2.5 Managing both nitrogen (N) and P to control periphyton growth should in my view be the starting point when developing a nutrient management regime. I have recommended that the upper catchment (Zone 4) be managed in such way to maintain the risk of excessive periphyton growth at its current, low, level.

2.6 Managing only one nutrient (P in this instance) to manage periphyton growth incurs some risks. These risks for the middle and lower catchment have been assessed using a mix of monitoring data, expert conferencing and detailed modelling. In my opinion, the key conclusions are that (1) a reduction in dissolved inorganic nitrogen (DIN) is unlikely to provide significant benefits additional to those gained by reducing dissolved reactive phosphorus (DRP), unless DIN inputs to the system are reduced very substantially (2) conversely, an increase in DIN is not predicted to cause an increase in periphyton biomass in the catchment’s main rivers, and (3) I have not seen evidence that reaching the nitrogen levels required to provide material reductions in periphyton growth is technically feasible.

2.7 Options to manage the influx of nitrogen have been assessed by additional modelling undertaken by Dr Rutherford. It is predicted that nitrogen losses from land would need to be reduced to below their estimated 1900 level in order for
the in-stream DIN concentrations to approach concentrations at which some periphyton benefits could be expected in the lower river.

2.8 Failure to adequately control P inputs to streams and rivers represents the key risk associated with Change 6’s proposed nutrient management approach in the Tukituki catchment. This risk remains regardless of the management strategy adopted for nitrogen.

2.9 On this basis, I have not recommended any changes to the in-stream DIN or DRP limits proposed in Change 6.

2.10 I have considered submissions on the other proposed water quality indicators, limits and targets and have made a number of recommendations to amend them.

2.11 The implementation of the RWSS is likely to result in an increase in nitrogen inputs to the rivers. This is not predicted to result in increases in periphyton growth, and as long as nitrate concentrations remain below those at which they may cause significant toxic effects, should not result in adverse effects on river values.

2.12 The RWSS is being progressed on the basis of being at least “P-neutral” in each sub-catchment. I am not qualified to comment on whether this can, or will, be achieved, and these aspects are covered by other experts, but if this is achieved, then the RWSS is not expected to cause an increase in periphyton growth.

2.13 Four flushing flows per season are proposed as part of the RWSS, providing a means that would not otherwise exist of aiding in the reduction in periphyton growth.

2.14 I have considered the consent conditions proposed by the RWSS that relate to water quality monitoring, modelling and management, and have recommended that some be amended.

3. CHANGE 6 SPATIAL FRAMEWORK – WATER MANAGEMENT ZONES

3.1 The water management spatial framework proposed in Change 6 is composed of five water management zones (Zones). In her evidence Ms Codlin describes the water management zones framework adopted for Change 6, and provides
maps of the aquifer boundaries, the surface water catchment boundaries and the groundwater “catchments”. Mr Maxwell also addresses those matters.

3.2 I was part of the technical team considering the different options with regards to the spatial framework for water management in the Tukituki catchment.

3.3 The establishment of water quality and quantity frameworks generally involves the definition of spatial units within which the resource can be managed. Ideally these units should be consistent from a number of points of view, e.g. hydrologically, geologically, topographically, ecologically, and at the same time, integrate monitoring tools and locations that enable a robust characterisation of the water resource within the unit. Because these are management units, the transport/transfer of water and contaminants from one unit to another needs to be well understood, particularly when looking at the setting of limits and allocation (of water and/or contaminant) mechanisms. In practice, defining these units requires a degree of pragmatism.

3.4 A number of different options were considered in Change 6, including whole catchment, groundwater zones and surface sub-catchments. In relation to the Ruataniwha Plains, the key consideration guiding the decision that there should be two zones was the significance of the groundwater-surface water interaction in that part of the catchment. Essentially in this part of the catchment, surface water (and contaminants primarily transported by surface water, such as sediment, phosphorus and \textit{E. coli}) follows different pathways than groundwater (and nitrate). In my opinion, a spatial management framework that fails to recognise the nature of those basic hydrological and hydrogeological processes would not be appropriate for the Ruataniwha Plains.

3.5 Some submitters\textsuperscript{4} have requested that a different spatial framework, made of 17 smaller (than the water management zones proposed in Change 6) sub-catchments be utilised. The smaller geographical units proposed in those submissions follow surface water sub-catchments. In the upper and middle catchment, the three water management zones (4, 2 and 3) would be replaced by 9 sub-catchments (or 11 if the upper catchments of the Waipawa and Tukituki were separated out as suggested by Hawke’s Bay and Eastern Fish and Game Councils (Fish and Game\textsuperscript{5})). Zone 5 (Papanui catchment) would

\textsuperscript{4} Including Hawkes Bay Fish and Game Council & Eastern Fish and Game Council (#242), Ngāti Kahungunu Iwi Incorporated (#359).
\textsuperscript{5} (#242)
remain unchanged, and the lower catchment (Zone 1) would be replaced by 6 sub-catchments. I note in passing that some submitters\(^6\) have requested the definition of specific water quality limits for Lake Hatuma, which, if that was the case, might require the definition of an additional zone or sub-zone.

3.6 As explained above, the difficulty with the submitter’s sub-catchment proposition is that different contaminants follow different pathways. In areas of minimal groundwater presence, or of very limited groundwater/surface water interaction, such as in Zones 1 (lower Tukituki corridor) and 4 (Upper catchment), a spatial framework based solely on surface water sub-catchments could in my opinion be appropriate. On this basis I am neutral on whether subdividing Zones 1 and 4 into smaller units following surface sub-catchments would provide a more or less appropriate spatial framework, although I discuss these aspects further in relation to the definition of river values and water quality limits (Section 4).

3.7 However, in areas of significant groundwater/surface water interaction, I do not recommend adopting a spatial water management framework composed of surface sub-catchments because they would not, in my opinion, be appropriate when dealing with groundwater processes such as deep groundwater takes and contaminants such as nitrate-nitrogen that migrate along groundwater pathways before contributing to surface water contaminant levels.

3.8 In the case of nitrate nitrogen, the key issue will be that nitrate-nitrogen measured in-stream in a given surface sub-catchment will not necessarily be generated on land that is located within that same surface sub-catchment. If in-stream nitrate-nitrogen limits were found to exceed, or be close to exceeding, the in-stream concentration limits, then mitigation or remediation actions, such as control on nitrogen losses from land use, would have to be exerted over the groundwater catchment (not the surface water catchment) upstream of the point exceeding the limit. Given the location and extent of the groundwater catchments, this would concern a land area that would cover only parts of one or several surface sub-catchments. In other words the management actions would have to be applied across, rather than within, the surface sub-catchment spatial management framework units, which would defeat the purpose of having a sub-catchment spatial management framework in the first place. This means

\(^6\) Including Ngāti Kahungunu Iwi Incorporated (#359), Hawkes Bay Fish and Game Council & Eastern Fish and Game Council (#242)
in particular that MAZLs for nitrogen should not, in my opinion, be calculated, or used, on the basis of surface sub-catchments in Zones 2 and 3. On this point, I do not agree with submitters who have suggested that they should.

3.9 Notwithstanding the above, I note that some aspects of water quality, such as phosphorus inputs, are best managed (and are intended to be managed in Change 6) at a sub-catchment scale.

3.10 In conclusion:

(a) I am neutral with regards to subdividing Water Management Zones 1 and 4 into smaller surface catchments;

(b) I do not recommend subdividing water management Zones 2 and 3 into smaller units based on surface sub-catchments, as this would likely confuse or complicate the management of water quality and quantity in that area;

(c) I do not recommend calculating or applying MAZLs for nitrogen on the basis of surface sub-catchments.

4. FROM RIVER VALUES TO WATER QUALITY LIMITS

4.1 The definition of water quality limits in Change 6 followed a very simple process:

(a) Identification of the river values applicable to all or parts of the catchment, and where each of the above values apply;

(b) Identification of water quality parameters relevant to the above values;

(c) Definition of numerical or narrative “limits” that provide an appropriate degree of protection to each value.

4.2 This process is the same as the one I applied in my work for the Horizons One Plan, and in the series of technical reports I recently completed for Greater Wellington Regional Council.

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7 Maximum Allowable Zone Load, as defined in POL TT4(2).
8 Including Hawkes Bay Fish and Game Council & Eastern Fish and Game Council (#242), Ngāti Kahungunu Iwi Incorporated (#359).
4.3 The identification and definition of river values across the Tukituki catchment is discussed in the evidence of Mr Sharp. Some submitters have submitted that additional river values should be identified.

4.4 As I did not undertake the original values identification work for Change 6, I cannot comment on the merits or relevance of identifying additional values as sought by the above submitters. I can, however, comment on how adding these values might be accommodated in, or might influence, the proposed Change 6 water quality limits framework.

4.5 Some submitters have submitted that a set of values similar in many respects to that defined in the Horizons One Plan be used. I am very familiar with the values/limits framework of the One Plan, having led its development, and can comment on how these values were incorporated into the water quality limits framework, or into the One Plan at large.

4.6 In the case of the One Plan, a total of 23 values were originally identified, classed into four groups (Ecosystem, Recreational/cultural, Consumptive Use, and Social/Economic). Only a sub-set of 5 out of the 23 values were actually translated into surface freshwater numerical water quality limits. Specific numerical water quality limits were not identified in relation to the other values (e.g. Sites of Significance-Aquatic, Native Fish Spawning, Irrigation, Aesthetics, etc…) because either (1) the water quality requirements of these values were adequately covered by those of the other values, or (2) water quality limits were not considered necessary to protect these values. Ultimately, these other values were not used to define freshwater numerical water quality limits, but were translated into different policies/rules applicable to matters other than water quality limits (for example activities in the beds of rivers).

4.7 The set of values I used to develop the original set of water quality limits for the One Plan is very similar to the values identified in Change 6 that have led to the Change 6 water quality limits. The same water quality determinands have been considered, and although sometimes different water quality limits have

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9 Including Ngāti Kahungunu Iwi Incorporated (#359), Hawkes Bay Fish and Game Council & Eastern Fish and Game Council (#242)
10 Including Ngāti Kahungunu Iwi Incorporated (#359), Hawkes Bay Fish and Game Council & Eastern Fish and Game Council (#242)
11 These were: Life-Supporting Capacity, Contact Recreation, Trout Fishery, Trout Spawning and Stockwater.
12 These were: Aquatic Ecosystem, Contact Recreation Trout Habitat, Native Fish Habitat and Trout Spawning Habitat.
been set, these are, in my opinion, due to differences in catchment characteristics and advances in knowledge rather than differences in the identification of river values.

4.8 In conclusion, a more detailed values assessment such as that proposed by some submitters would not, in my opinion, influence significantly the water quality limits framework in Change 6.

5. WATER QUALITY LIMITS IN RELATION TO POINT SOURCE DISCHARGES (POL TT3)

5.1 The water quality limits technical report includes recommendations for water quality limits that may be applied to point-source discharges. These limits, and the technical reasons for recommending them, are presented in Section 5.12 of the water quality limits report. In Change 6, they have been incorporated into POL TT3. They include:

(a) A maximum degree of reduction in Quantitative Macroinvertebrate Community Index of 20%, as a threshold beyond which significant adverse effects on aquatic life may occur;

(b) A maximum daily average Soluble five-day carbonaceous Biochemical Oxygen Demand (ScBOD\textsubscript{5}) concentration of 2 mg/L, at flows less than the median flow, as a means of controlling the growth of nuisance heterotrophic growth (“sewage fungus”);

(c) A maximum average Particulate Organic Matter concentration of 5 mg/L at flows less than the median flow, to avoid significant adverse effects on aquatic life associated with the deposition of settleable organic matter on river beds;

(d) A maximum total ammonia-nitrogen concentration of 4.3 mg/L (at pH =8.0 and temperature = 20°C), to avoid acute toxic effects of ammonia. This limit is proposed to apply as an absolute maximum, applicable to any sample taken at any time beyond the zone of reasonable mixing. This limit is applied in addition to the chronic toxicity limit defined in Table 5.9.1;

(e) Maximum water clarity changes of 20% and 30% as thresholds beyond which, changes in water clarity may respectively become detectable
(20% change) and conspicuous (30% change). These are recommended to apply at river flows below median flow.

5.2 A number of submitters have suggested different limits for point source discharges. I will comment on these submissions in relation to each limit, but first I will comment on the applicability of the POL TT3 point-source discharge limits in relation to other water quality limits defined in the Change 6 Tables 5.9.1.A and 5.9.1.B, as this point was raised by some submitters\(^\text{13}\). In my view, the POLTT3 limits should be applied in addition to, not in replacement of, water quality limits and targets set in Tables 5.9.1.A and 5.9.1.B. when considering resource consent applications for point-source discharges.

5.3 Some submitters\(^\text{14}\) have suggested a more stringent limit relative to a change in QMCI, of no more than 10% reduction. Other submitters\(^\text{15}\) have questioned the 20% limit, on the basis of its apparently arbitrary nature.

5.4 All water limits incorporate elements of expert judgment, which can make them seem arbitrary in nature. More relevant are questions relating to whether the limits are measurable, relevant in terms of ecological effects and applicable – in short, whether they are fit for purpose.

5.5 QMCI scores are generally interpreted in the context of quality classes (Excellent, Good, Fair and Poor). A 20% change in QMCI will normally result in a change to a lower quality class, which arguably constitutes an ecologically significant adverse effect.

5.6 The 20% QMCI change limit was recommended for Change 6 on the basis that:

(a) It is generally ecologically significant; and

(b) It can be detected with an acceptable level of sampling effort; and

(c) It can be tested using relatively simple statistical methods\(^\text{16}\).

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\(^{13}\) Including Hawkes Bay Fish and Game Council & Eastern Fish and Game Council (#242), Environmental Defence Society Incorporated (#304)

\(^{14}\) Including Ngāti Kahungunu Iwi Incorporated (#359), Te Taiwhenua O Heretaunga (#67), Hort NZ & others (#384)

\(^{15}\) Dairy NZ (#17 & #378)

5.7 In contrast, a 10% change in QMCI would, in my opinion, be much less likely to be reliably detected without considerable sampling effort (i.e. increased number of replicate samples), and it is debatable whether it constitutes an ecologically significant change.

5.8 In the context of the Horizons One Plan, a 20% QMCI change limit was originally developed during the Council level hearing and supported by work undertaken by Dr John Stark (referred to above). It was subsequently debated and agreed upon in caucusing by water quality experts (in which I participated) during the Environment Court Hearing process. I have recently made similar recommendations in relation to QMCI change to Greater Wellington Regional Council.

5.9 Consequently, I do not recommend any change to the POL TT3 limit for QMCI.

5.10 Ammonia is present in water under two dissolved forms: unionised ammonia (NH$_3$) and ionised ammonia, or ammonium (NH$_4^+$). The chemical equilibrium between these two forms is driven by water pH, and to a lesser extent, temperature. The higher the pH and temperature, the higher the proportion of un-ionised ammonia. Both forms are toxic, but unionised ammonia is much more toxic. So for a given concentration of total ammonia, its toxicity will increase with pH and temperature. For this reason I am of the opinion that ammonia toxicity limits should be dependent on the pH and temperature of the receiving water body.

5.11 The approach taken in Change 6 is to define acute toxicity threshold concentrations at different combinations of pH and temperature, as contained in Schedule XXIII. POL TT3(d) referred to the corresponding concentration at pH=8 and temperature =20°C (4.3 mg/L) and referred to Schedule XXIII for concentrations at other combinations of values depending on water pH and temperature.

5.12 HBRC have made a submission seeking an amendment to POLTT3(d), to remove the 4.3 mg/L concentration and refer directly to Schedule XXIII. This change in my view does not change the limit in itself, but clarifies its intent, which is not to rely on a unique value, but rather a set of pH- and temperature-dependent values. I support that amendment.

\[17 \#35\]
5.13 Some submitters are seeking different total ammonia-nitrogen concentration limits:

(a) Ngati Kahungunu Iwi Incorporated (NKII)\textsuperscript{18} seeks a limit of 2.2 mg/L;

(b) Te Taiwhenua O Heretaunga\textsuperscript{19} seeks a limit of 2.0 mg/L;

(c) Fish and Game\textsuperscript{20} seeks a limit of 1.7 mg/L in water bodies with sensitive values and 2.1 mg/L in other water bodies.

5.14 These submissions raise two questions, which I will address in turn:

(a) How different are these numbers from those in Change 6 POL TT3?

(b) Is it preferable to rely on a single number or multiple pH and temperature dependent numerical thresholds?

5.15 The submissions do not provide any background technical explanation of, or justification for, any the numbers put forward. However, I am aware that the Horizons One Plan defines two acute toxicity limits of 1.7 mg/L in some management zones (generally upland areas) and 2.1 mg/L for all other waters for upland, which is similar to the numbers sought by Fish and Game. I was not part of the definition of these limits in the One Plan process, but I have reviewed the supplementary evidence of Dr Bob Wilcock to the Proposed One Plan council level hearing. This evidence suggests that the One Plan acute number of 2.1 mg/L was based on the application of the 1999 USEPA\textsuperscript{21} acute ammonia criterion, assuming a pH of 8.5. The 1.7 mg/L number was based on the application of an acute-to-chronic ratio of 5 to the One Plan’s lowest chronic ammonia limit (0.320 mg/L). The acute-to-chronic ratio was in turn taken from the ratio between the One Plan’s highest chronic ammonia figure of 0.400 mg/L and the 2.1 mg/L derived from the 1999 USEPA acute ammonia criterion.

5.16 The USEPA criteria for ammonia were revised in 2009. An important feature of the 2009 USEPA ammonia criteria is that it incorporates relatively recent data on freshwater bivalves, which are known to be particularly sensitive to ammonia toxicity. For this reason the 2009 USEPA defines (while the previous 1999 criteria did not) different criteria for waters containing and not containing ammonia.

\textsuperscript{18} #359
\textsuperscript{19} #67
\textsuperscript{20} #242
\textsuperscript{21} United States Environmental Protection Agency
freshwater mussels. Given the presence of freshwater *sphaerid* clams in at least parts of the Tukituki catchment, the acute ammonia toxicity limit in Change 6 (4.3 mg/l at pH 8.0) was based on the revised (2009) version of the USEPA acute criteria for waters containing freshwater mussels. At pH 8.5 and temperature 20°C, it corresponds to a total ammonia-N concentration of 1.66 mg/l, i.e. is comparable to, but comparatively slightly more conservative than, the most conservative number sought by Fish and Game for sensitive water bodies, and more conservative again than the various other limits sought by Te Taiwhenua o Heretaunga (2.0 mg/L), Fish and Game (2.1 mg/L) and NKII (2.2 mg/L). One has also to consider that pH regularly reaches 9 in the lower Tukituki River in summer, in which case the Change 6 limit becomes 0.68 mg/L, i.e. significantly more stringent than those sought by NKII and Fish and Game.

5.17 With regards to the question I pose in 5.14(b), I recommended a single number approach, calculated on the basis of a fixed pH and temperature, for the Horizons One Plan in 2007. I have since then worked extensively with this approach, and compared it with other approaches, in relation to point source discharges and general state of the environment reporting, and have come to the conclusion that a single number approach was a rather blunt tool, in that it is over-conservative at times (for example in winter) and under-conservative at other times (e.g. summer low flows when pH and temperature can be elevated). I have come to the conclusion that, at least at the policy level, a pH and temperature dependent approach is more robust and fairer, both to resource use activities and the environment.

5.18 In conclusion, I am of the opinion that the acute toxicity limit in POL TT3(d) is based on the most recent science available, and takes into account the presence of sensitive species in the catchment. I also believe that the reliance on a single-number limit is too blunt a tool, and recommend the adoption of TT3(d), with the amendments sought by HBRC’s submission.

5.19 Some submitters\(^{22}\) seek more stringent visual water clarity change limits:

(a) 5 to 10 % change instead of 20% in Zone 4 and the mainstems of the Tukituki and Waipawa Rivers;

(b) 15% instead of 30% in all other rivers.

\(^{22}\) Including Ngāti Kahungunu Iwi Incorporated (#359), Te Taiwhenua o Heretaunga (#67)
5.20 The intention of the visual water clarity limits I recommended for Change 6 is to provide a numerical “translation” of RMA Sections 70 and 107 that refer to discharges of contaminants into water not giving rise to “any conspicuous change in the colour or visual clarity” in the receiving waters. The 1994 Ministry for the Environment Water Quality Guidelines No. 2 provide guidance as to what degree of water clarity change constitutes a “conspicuous change”: That is a 20% change in waters where visual clarity is an important characteristic of the water body, and 33% to 50% in other waters. These guidelines are based on scientific work, including panel studies, which have shown that most people can detect a change of 30% in visual clarity.

5.21 A 20% change in water clarity is in my experience, a degree of change that would generally only just be able to be detected, or not detected at all, by visual observation of a river, and is in my opinion well below the statutory threshold of “conspicuous”. In my opinion, it is only a suitable limit to place on rivers that have high water clarity values, as recommended by the MfE guidelines. The recommended 30% change for other rivers is more environmentally conservative than the MfE guidelines for other waters, and is, in my opinion, well suited as a threshold for a “conspicuous” change.

5.22 I also note that similar limits were recommended for the Canterbury NRRP (2010), the Horizons One Plan, and I also have recently made similar recommendations to Greater Wellington Regional Council.

5.23 I am not aware of the technical justification for the 5%, 10% and 15% change in water clarity limits sought in submissions, but in my opinion, these limits do not correspond to a “conspicuous change in water clarity”. A 5% to 10% change would also be unlikely to be reliably detected using the most common method of measuring visual clarity in rivers in New Zealand, i.e. by measuring the horizontal sighting range of a black disc.

5.24 In conclusion I do not recommend any changes to the proposed water clarity change limits set in the proposed Change 6.

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6. **WATER QUALITY INDICATORS**

6.1 Change 6 as notified includes three water quality “indicators” in Table 5.9.1B (visual water clarity, Macroinvertebrate Community Index (MCI) and fine sediment cover). This is based on recommendations made by Dr Uytendaal and myself. The reason for calling these “indicators” was to recognise that they are important general descriptors of the state of the resource, but are, in my opinion, less suitable for use as enforceable “limits”, for the following reasons:

(a) They are, even in a natural state, influenced by a number of catchment-wide processes; or

(b) They are not directly associated with an amount of resource use (as opposed to, for example, nitrogen and phosphorus); or

(c) They are not robust or tested enough to be used as absolute limits. This is in my view, the case for deposited sediment

6.2 This does not mean that these determinands are not important, or less important than other determinands used in Table 5.9.1A and 5.9.1.B. On the contrary, I am of the opinion that these parameters should be carefully monitored and reported on, and used as reference points in Plan effectiveness monitoring and reporting, i.e. used to assess whether Change 6’s freshwater objectives (Objective TT1) are met or being progressed towards. I note that Dr Young has also commented on this point, and agree with his comments.

6.3 Some submitters\(^{25}\) seek the use of these three indicators as limits or standards. To a large extent, the decision of how exactly a numerical threshold is used in a regional plan is a policy decision; however, some technical considerations are relevant to that decision, and I comment on them in the paragraphs below.

6.4 The MCI is the most commonly used indicator of macroinvertebrate community health in large-scale monitoring and reporting in New Zealand, such as State of the Environment monitoring and reporting undertaken by councils. In view of the Change 6 freshwater objectives for the Tukituki River catchment, the MCI is, in my opinion, best suited as an overall indicator of stream “health” in relation to ecological, recreational and cultural values. The MCI can be influenced by a number of catchment-wide and site-specific processes that can compromise the

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\(^{25}\) Including Hawkes Bay Fish and Game Council & Eastern Fish and Game Council (#242), ), Hawke’s Bay Environmental Water Group (#32, 109)
applicability of a “nominal” MCI limit. For example, the MCI score in the lower Tukituki River is very likely influenced by high summer water temperatures. Given that there is, in my opinion, little that can be done to significantly influence water temperature in the lower Tukituki River, a “nominal” MCI limit would be difficult to enforce, or tie back to specific activities, or to an enforcement/management response. I also note that the use of the MCI as a state “indicator” is consistent with how it is used in the Horizons One Plan.

6.5 Similarly, water clarity in a river system is heavily influenced by a number of catchment-wide and site-specific processes, in particular the hydrology (e.g. water clarity declines naturally during high river flows) and geology (soft sedimentary (e.g. mudstone) catchments will naturally have lesser water clarity than hard sedimentary (e.g. greywacke) catchments). My experience of using “nominal” (as opposed to relative change) visual water clarity thresholds, is that they are very useful to describe the state of the resource (e.g. in SoE reporting), but much less useful in the resource consent process (both at the consenting and the compliance assessment stages). A limit based on a degree of relative change is, in my opinion, more applicable in the latter context.

6.6 Fish and Game seek the setting of deposited sediment limits in all streams and rivers of the catchment, varying from 10% in the upper catchment to 20 to 25% cover in the rest of the catchment. Deposited sediment cover describes the proportion of stream or river bed covered by fine (<2mm, i.e. sands and silts) sediment. The average % sediment cover is estimated based on visual observations, following protocols defined in a recent document, which identifies monitoring protocols and guidelines in relation to fine sediments. These guidelines identify sediment cover thresholds in relation to salmonid spawning (less than 10% cover is good, less than 20% cover is suitable). The Change 6 proposed indicators are based on the more environmentally conservative of these numbers (10%), applied to mainstem rivers with known trout spawning values. This number is also, in my opinion, adequately protective of recreational/aesthetic values of the lower Tukituki River. No other fine sediment cover guidelines are specifically identified in the guideline document. The scientific rationale for the numbers proposed by Fish and Game

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26 Nominal is used in this case to describe an absolute value (e.g. a MCI score of 120) as opposed to a “relative change” limit (e.g. a 20% change).
27 #242
is not detailed in the submission, but I am aware that similar numbers were incorporated in the Horizons One Plan. However, I suggest this rationale would need to be tested in the context of the Tukituki catchment. Importantly, similarly to MCI, the use of deposited sediment thresholds in the One Plan is specifically restricted to that of an indicator for state of the environment monitoring and reporting purposes. My view is that the degree of knowledge in relation to deposited sediments, their natural levels and their effects on aquatic ecosystems does not allow the setting of enforceable limits. In my opinion, setting deposited sediment thresholds as indicators is appropriate as it signals the need to monitor, and report on this determinand; however, given the state of knowledge, setting absolute limits would, in my view, be premature.

6.7 Te Taiaroa Hawke's Bay Environment Forum\textsuperscript{29} seek a maximum fine sediment cover of 5\% for trout spawning sites and 10\% for lower catchment site. As explained above, the maximum 10\% fine sediment cover I have recommended for Change 6 is the most stringent recommended by the guidelines, and a sediment cover below 10\% corresponds to a good state or better for trout spawning habitat. In my opinion, this is a suitable threshold to protect these values. Change 6 sets 10\% threshold for the whole of Zone 4, the main rivers and tributaries in Zones 2 and 3, and the lower Tukituki River. Smaller tributaries of the lower and middle catchment (zones 1, 2, 3 and 5) are predicted to have a naturally higher fine sediment content than for example, the main rivers that originate from the Ruahine Ranges, and expected to be dominated by fine sediment\textsuperscript{30} under natural conditions. For this reason, I do not recommend setting a numerical indicator for these smaller tributaries.

6.8 Dairy NZ\textsuperscript{31} seek clarification on how the median water clarity at flows below median will be calculated. In my opinion, it should be calculated using a sizeable dataset, to limit the influence of unavoidable short-term data variability on the estimate of the median. I recommend that it should be calculated on a rolling basis, using a dataset composed of the most recent 5 years of available data, filtered to exclude data points collected at river flows exceeding the

\textsuperscript{29} #66 & #375
\textsuperscript{30} Uytendaal and Ausseil (2013) Change 6 Folder 4, Tab 1, Appendix C, Page 152, Figure 28 for Freshwater Environments of New Zealand (FENZ) modelled predictions of soft (sand, silt, mud) and hard (gravel, cobble, boulder) substrate dominated streams. The modelling indicates that the tributary streams of Zones 1, 2, 3 and 5 are likely to be dominated by soft sediment under natural conditions.
\textsuperscript{31} #17 & #378
median flow, and amendments be made to the legend of Table 5.9.1.B to that effect.

6.9 Some submitters\textsuperscript{32} seek that water clarity indicators of 5-10 metres be applied. The submissions are expressed in general terms, so I assume they intend the numbers to directly replace those in the notified version of Change 6. Of the sites monitored in the Tukituki catchment, the Makaroro River at Burnt Bridge presents the highest water clarity, with a median of 4.4 metres at flows below median flow. Given that water quality at the Makaroro at Burnt Bridge can be considered as being representative of, or very close to, reference (i.e. with no or minimal impact from human activities) conditions, even a 5 metre clarity limit/indicator appears unrealistic for the rest of the catchment. With regards to 10 metre visual clarity, this was only measured around 5\% of the time at flows below median flows in the Makaroro at Burnt Bridge, very occasionally at the Mangaonuku Stream at Tikokino Rd site, and never at any other site in the catchment.

6.10 Fish and Game also seek water clarity limits that differ from Change 6 as notified. Fish and Game’s submission contains a modified version of Table 5.9.1.B, with a first column header of “Clarity m ≥”, which in the absence of a specific key or legend, I assume should be read “the water clarity is more than or equal to [number] metres”. I note that there does not appear to be any specification as to which statistic (e.g., median, or a given percentile) this limit is intended to be compared to. The column header does not contain any flow exclusion, whilst others do (e.g. \textit{E. coli} numbers in Fish and Game’s Table 5.9.1.A, and DIN and DRP limits in Table 5.9.1.B). I therefore assume that Fish and Game seek that the limits apply at all river flows. In my experience it would be extremely unusual to define water clarity indicators, targets or limits that apply at all river flows, as this simply would not recognise the natural variability of water clarity with river flows. The limits sought by Fish and Game (3.75 metres or 5 metres for most rivers and tributaries \textsuperscript{33}) are, in my opinion, unrealistic in the context of the catchment’s natural characteristics if the intention is to apply these limits at all river flows. For example, when considering data collected at all river flows, the current median water clarity site is 1.7m at the Makaroro at Burnt Bridge and Tukituki at SH50 sites, and 2.7m at the Waipawa at SH50 site.

\textsuperscript{32} Including Te Taiao Hawke’s Bay Environmental Forum (#66 & #375), Kelly T. (#45 & #381).

\textsuperscript{33} Apart from the Porangahau, Makara and Hawea sub-catchments where it is 1.6 metres
6.11 Some submitters seek that different MCI limits be applied. The process followed for the definition of the MCI indicator thresholds in Change 6 is set out in the water quality limits technical report. Essentially, an “indicator” score of 120, indicative of “Excellent” water quality, is recommended in all streams of Zone 4, as well as for all the mainstem rivers of Zones 2 and 3. An “indicator” minimum score of 100, indicative of “Good” water quality is recommended for smaller tributaries of Zones 2 and 3, owing to their soft sedimentary nature and their lesser trout habitat and trout spawning values. A score of 100 is also recommended for the lower Tukituki River, owing to the likely effects of elevated water temperatures on sensitive macroinvertebrate taxa, and the limited means by which water temperature can be influenced in that reach (refer to Section 7). Essentially a score of 120 was considered unrealistic for the lower Tukituki River, due to its natural characteristics.

6.12 Fish and Game seek a MCI score threshold of 100, instead of the score of 120 recommended in Change 6, for a number of “mainstem” rivers and streams of Zones 2 and 3, namely the Kahakahuri, Tukipo, Makaretu, Maharakeke and Porangahau streams/rivers. The Tukipo and Makaretu Rivers at SH50 currently exceed a MCI score of 100, and given their relatively high trout habitat and spawning values, I do not support lowering the MCI indicator from 120 to 100 in these rivers. Similarly, the Kahakahuri Stream has relatively high trout habitat and spawning values, and, in the absence of MCI data for this stream, I consider a score of 120 is a more appropriate indicator of a “desired” state than 100. However, the Porangahau and Maharakeke Streams have low trout values, and the Porangahau Stream currently presents mean MCI scores below 100. In this context, a MCI score of 100 possibly represents a more realistic “aspirational” state, and I agree with Fish and Game’s submission on this point.

6.13 Submitters seek a MCI score threshold of 120, instead of the score of 100 recommended in Change 6, for the lower Tukituki River. As explained in paragraph 6.11 above, I recommended a MCI score of 100 for the lower Tukituki River, on the basis of the likely effects of elevated water temperatures on sensitive macroinvertebrate taxa, and the limited means by which water temperature can be influenced in that reach. I note that a MCI score of 100 for the lower Tukituki River is consistent with the approach I took in my 2008 Tukituki River report, with the Horizons One Plan MCI state indicator for lowland

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34 Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Section 5.4, p23-26.
35 Including Fish and Game (#242), Te Taiao Hawke’s Bay Environmental Forum (#66 & #375),
rivers, and the recommendations I recently made to Greater Wellington regional Council.

6.14 In conclusion, having had regard to the submissions on these points;

(a) I do not recommend using water clarity, deposited sediments and MCI as absolute limits, and recommend using them as “indicators” of the state of the resource;

(b) I do not recommend any changes to the water clarity or deposited sediment indicators as in Change 6;

(c) I support the change sought by Fish and Game to lower the MCI indicator for the Maharakeke and Porangahau streams from 120 to 100.

7. WATER TEMPERATURE LIMITS

7.1 Table 5.9.1A in Change 6 contains a narrative limit in relation to water temperature: “The temperature of the water shall be suitable for sustaining the aquatic habitat”.

7.2 Fish and Game seek that “95th percentile of daily maximum temperature from 24 hour continuous monitoring shall be less than” 19 to 21°C across the whole catchment.

7.3 The HBRC water quality team recently provided me with the following data summaries, based on continuous temperature data recorded between November 2010 and May 2011. Year-round datasets are not available at this stage, apart for the Tukituki at Shagrock site. The following 95th percentiles of daily maximum temperatures were provided to me:

(a) Tukituki at SH50: 24.3°C;

(b) Tukipo at SH50: 23.2°C;

(c) Mangaonuku Stream: 20.3°C;

(d) Porangahau Stream: 23.6°C;

(e) Tukituki at Shagrock: 25.5°C;

(f) Tukituki at Shagrock (12 month dataset): 24.4°C;
7.4 At all these sites Fish and Game seek a water temperature limit of 19 °C.

7.5 I note that the Fish and Game submission does not specify over which period compliance with this proposed limit should be assessed—e.g. over any day, any month, any year? However, based on the above data summaries the limits sought by Fish and Game appear to be significantly lower (cooler) than water temperatures actually measured in most mainstem rivers over the late spring, summer and autumn seasons (and year-round in the case of the Tukituki at Shagrock).

7.6 Submitters\(^{36}\) seeks that temperature limits for aquatic ecosystems and or trout spawning be set.

7.7 During the process leading to making recommendations on water quality limits for Change 6, Dr Uytendaal and myself explored different options\(^{37}\). We specifically considered numerical water temperature limits or targets based on the temperature preferences or requirements of different aquatic species as an option. The key reason for not setting numerical water temperature limits or targets was that, in my opinion, the ability to meaningfully influence water temperature in the braided sections of the main rivers is very limited. In this context, I am of the opinion that the setting of absolute temperature limits or targets in the main rivers of the Tukituki catchment that are significantly lower than the current water temperature regime would serve no purpose as there are no available means by which limits could be enforced or targets achieved.

7.8 Fish and Game have also sought that a maximum water temperature change limit of 2°C be set at part of Policy TT3. The rationale given in the submission is as follows “A maximum change in temperature limit is appropriate to apply to point source discharges where discharges may be contaminated by heat. Increases in temperature may have an adverse effect on the values of the water body and on the fresh water objectives”. I agree with the Fish and Game submission that heat from a point-source discharge can have a significant adverse effect on aquatic life. This is particularly the case during summer when the ecosystems may be under stress from elevated water temperatures. Typically, these discharges result from water being used in cooling processes in thermal power stations, processing plants and the like. The reason for not recommending any specific water temperature change limits for Change 6 was

\(^{36}\) Including, Hawke’s Bay Environmental Water Group (#32, 109).

\(^{37}\) Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Section 5.1
that, to my knowledge, there are currently no such point-source discharges that may discharge heated water during summer in the catchment. I would expect that any new discharge would be assessed on site-specific characteristics and risks of effects, and therefore see little value in setting a generic limit. If such a limit was set however, I would recommend it specifically referred to a temperature increase instead of a change, and should only apply to summer periods.

8. **PERiphyTON LIMITS**

8.1 The periphyton cover and biomass limits in Change 6 are based on the New Zealand Periphyton Guidelines (NZPG)\(^{38}\) which identify maximum periphyton biomass and cover for the protection of aesthetic/recreation values and trout habitat and angling:

(a) A maximum biomass of 120 mg chl a/m\(^2\) for filamentous algae\(^{39}\);

(b) A maximum of 30% bed cover by filamentous algae more than 2 cm long; and

(c) A maximum cover of the visible river bed of 30% by long (> 2cm) filamentous algae and 60% by mat-forming cyanobacteria and diatoms.

8.2 The NZPG also define a maximum periphyton biomass of 50 mg chl a/m\(^2\) for the protection of aquatic biodiversity values. However it is important to note that this is a very low level of maximum biomass, and this guideline should, in my view, only be applied where high macroinvertebrate biodiversity can reasonably be expected, and even then, absolute compliance with this limit should not be expected\(^{40}\). A periphyton biomass of 120 mg/m\(^2\), recommended in the NZPG for the protection of trout habitat and angling, is in my opinion, adequate to protect a wide range of biodiversity values in slightly degraded systems. Based on this, I do not support submissions\(^{41}\) that seek the application of a 50 mg chlo a/m\(^2\) limit across the whole catchment.

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\(^{39}\) These are given as mass of the algal pigment chlorophyll a per square metre (i.e. chl a/m\(^2\)).


\(^{41}\) Including, Hawke’s Bay Environmental Water Group (#32, 109).
8.3 Consequently, Change 6 uses:

(a) a maximum periphyton biomass level of 50 mg chlo a/m² in the upper Tukituki Catchment (Zone 4) where biodiversity values are high;

(b) 120 mg chlo a/m² in the middle and lower catchment (Zones 1 to 3) where biodiversity values are somewhat lower;

(c) A maximum cover of the visible river bed of 30% by long (> 2cm) filamentous algae and 60% by cyanobacteria and diatom mats (>3 mm thick) across the whole catchment.

8.4 The Change 6 periphyton limits are very similar to those I recommended for the Horizons One Plan, and recently to Greater Wellington Regional Council.

8.5 Federated Farmers of New Zealand seek that the periphyton biomass and cover numbers be used as an indicator instead or a limit or a target. I accept that periphyton growth is influenced by a number of catchment-wide factors, and is not directly related to an amount of resource use, and so from that point of view it could be argued that, it could be used as an indicator of state against which Plan effectiveness is monitored. Ultimately, the decision to use these numbers as indicators or limits/targets is primarily a policy decision. I note however that, given (1) the significance of the periphyton issue in the Tukituki River, and (2) the explicit periphyton objectives set out in Objective TT1, and (3) the significant focus of Change 6 on nutrient management, clear, numerical periphyton limits and targets appear a sensible approach.

8.6 I note that the periphyton cover limit in paragraph 8.3(c) above is intended to provide protection to aesthetic, recreation and trout habitat/angling values and covers all mat-forming forms of algae, not just cyanobacteria, and are not intended to manage potential public health risks associated with potentially toxic cyanobacteria. These aspects are covered in the evidence of Dr Young and Ms Madarasz-Smith. Dr Young and Ms Madarasz-Smith recommend a maximum 95th percentile cover by cyanobacteria of 50%.

8.7 In its submission, Dairy NZ note that the NZPG in fact define two different chlorophyll a biomass guidelines, depending on whether the periphyton

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42 #20 & #354
43 #17 & #378
community is dominated by filamentous algae (120 mg chlo a/m²) or by mat-forming diatoms/cyanobacteria (200 mg chlo a/m²), which is correct.

8.8 The recommendation to use only one chlo a biomass threshold in Change 6 was based on the historical observation that abundant periphyton growths in the Tukituki River were generally dominated by filamentous algae. However, extensive monitoring carried out last summer by HBRC indicated that communities can, under drought conditions, be dominated by cyanobacteria over not insignificant reaches of river.

8.9 In this context, two different periphyton biomass limits could be incorporated in Change 6, to be applied depending on the make-up of the periphyton community at the time of sampling. However, periphyton composition thresholds would need to be defined to ensure that the correct limit is applied to each sample. To my knowledge, these thresholds have not been defined, tested or applied in a regional plan before.

8.10 Further, adopting two periphyton biomass limits would, in my opinion, create unnecessary complexity and confusion around the monitoring, reporting and assessment in relation to this limit. Given the strong general predominance of filamentous growths in the Tukituki River, both spatially and temporally, on balance, I recommend maintaining the periphyton biomass limits/targets as per the notified version of Change 6.

8.11 Some submitters seek that the maximum cover by cyanobacteria should be reduced from 60% to 50% in all Zones, apart from Zone 4, where Mr Kelly suggests it should be zero. For clarity, the limit recommended in 8.3(c) relates to aesthetic and recreational values, not to public health associated with toxic risks caused by cyanobacteria, and covers all mat-forming types of algae (including diatoms and cyanobacteria). Having considered Dr Young’s and Ms Madarasz-Smith’s recommendations, I am of the opinion that each recommended limit (i.e. the 60% mat-forming periphyton and the 50% cyanobacteria) covers different aspects and values, and I recommend that both limits be retained.

8.12 With regards to setting of the cyanobacteria or mat-forming algae cover limit at 0% in Zone 4, in my view it has to be borne in mind that different components of periphyton communities (including cyanobacteria and diatoms) are a natural

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44 Including Te Taiao HB Environmental Forum (#66 & #374), Mr Kelly T. (#45 & #381)
part of the river ecosystem, and can be relatively abundant even under natural conditions in unshaded streams and rivers during periods of stable flow. In my view a 0% cover limit is unrealistic and I do not recommend adopting it.

8.13 In Change 6 the above limits are associated with an accrual period of 30 days. This is intended to recognise that the Tukituki River is characterised by very long accrual periods during which extensive periphyton growths can be expected even at low nutrient concentrations. The corollary to this is, as I concluded in my 2008 report, that even drastic reductions in nutrient concentrations in the Tukituki River are unlikely to totally prevent algal proliferations. This is primarily due to the natural characteristics of the catchment and its climate, particularly the extended periods of low flows that the Hawke’s Bay is known for. A reduction in nutrient concentrations is more likely to result in reduced algal growth rates and peak biomass, i.e. how fast and how often high algal biomass will occur, and how large the algal biomass and cover will be.

8.14 Fish and Game have submitted that compliance with the proposed periphyton biomass and cover limits be assessed against the 95th percentile of monthly measurements. I agree that it would be useful for the Plan to specify how compliance with these proposed limits will be assessed, and I also note that the length of the data record used for this assessment should be specified. As explained in paragraph 8.2, I am of the opinion that the periphyton biomass limit recommended for Zone 4 is purposely very stringent and absolute compliance should not be expected, and have previously recommended (in paragraph 8.2) that an 80% compliance level is appropriate. I concur with Fish and Game on the assessment of compliance at the 95th percentile level for the other limits. I also recommend that the assessment be conducted using a rolling 5-year dataset.

8.15 In summary, I recommend that:

(a) That the numerical periphyton biomass and cover limits/targets as proposed in Change 6 be maintained;

(b) That an additional numerical limit of 50% cover by cyanobacteria be added, as recommended by Dr Young;

45 Accrual period means the period of time between two river freshes, during which periphyton biomass may accrue.
46 #242
(c) That the Key to Table 5.9.1.B read:

(i) For the periphyton biomass limit/target in zone 4 (i.e. column “a” in Table 5.9.1.B): “Maximum 80th percentile algal biomass (mg Chlorophyll a/m²). The 80th percentile algal biomass shall be calculated as the 80th percentile of monthly monitoring results obtained within an accrual period of 30 days over a period of 5 consecutive years”;

(ii) For the periphyton biomass limit/target in all other zones (i.e. column “a” in Table 5.9.1.B): “Maximum 95th percentile algal biomass (mg Chlorophyll a/m²). The 95th percentile algal biomass shall be calculated as the 95th percentile of monthly monitoring results obtained within an accrual period of 30 days over a period of 5 consecutive years”;

(iii) For the filamentous algae cover limit/target in all zones (i.e. column “b” in Table 5.9.1.B): “Maximum 95th percentile cover of visible river bed by periphyton as filamentous algae more than 2 cm long. The 95th percentile algal cover shall be calculated as the 95th percentile of monthly monitoring results obtained within an accrual period of 30 days over a period of 5 consecutive years”

(iv) For the mat-forming algae cover limit/target in all zones (i.e. column “c” in Table 5.9.1.B): “Maximum 95th percentile cover of visible river bed by periphyton as diatom or cyanobacteria mats more than 0.3cm thick. The 95th percentile algal biomass shall be calculated as the 95th percentile of monthly monitoring results obtained within an accrual period of 30 days over a period of 5 consecutive years”

9. MANAGEMENT OF PERIPHYTON

9.1 Excessive periphyton growths are, and have been for quite some time, common in the middle and lower Tukituki River and in some of its tributaries. Examination of historical data\textsuperscript{47} shows that excessive periphyton growths were already common in the lower Tukituki River at least 24 years ago, when the data records start. Change 6 Objective TT1(c) sets an objective of “fewer

occurrences of excessive periphyton growths that adversely affect recreational use and amenity”.

9.2 As explained in the water quality limits report\(^{48}\), periphyton growth is influenced by a numbers of factors, including river flows, light availability, water temperature and available nutrients, so in theory at least, the growth of periphyton can be controlled or reduced by acting on one or more of these factors. In the case of the Tukituki catchment:

(a) River flows cannot be manipulated at present (although this point is expanded on in the second part of my evidence that deals with the proposed flow releases from the RWSS dam);

(b) Shading is efficient at controlling the growth of periphyton and macrophytes, but only in streams no wider than approximately 10 metres;

(c) Whilst shading could provide significant temperature benefits to smaller streams, the means of controlling temperature in the mainstems of the larger rivers, in particular the lower Tukituki are very limited, as I explain in Section 7.

(d) Nutrient management is therefore the only means currently available by which periphyton growth can be reduced in the main rivers of the Tukituki catchment.

9.3 I am of the opinion that management of nutrients in the Tukituki should be able to achieve a reduction in the frequency and duration of excessive periphyton growth, but, as explained in paragraph 8.13 above, even extremely stringent nutrient management would not result in a disappearance of excessive periphyton growths at times of low or stable river flows. This is due to the natural characteristics of the Tukituki River, in particular its wide, shallow semi-braided channel, and its hydrological regime characterised by very extended periods of low flows.

9.4 The work I conducted in 2008 during the preparation of my 2008 Tukituki water quality report included the analysis of all the water quality data that were available at the time, including in particular an analysis of nutrient concentrations and ratios at different sites in the catchment and under different conditions.

\(^{48}\) Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Section 5.4, p23-26
flow conditions, as well as the relative contribution of different sources to the nutrient loads carried by the Tukituki River. This work led me to the conclusion that: “if a management objective is to reduce the frequency and duration of algal blooms, managing DRP inputs to the system is an obvious priority target”.

9.5 Subsequent work I have carried out in the last two years, examination of additional data and analysis carried out by HBRC and NIWA, and detailed discussions with my colleagues Drs Uytendaal, Rutherford, Young and Wilcock have confirmed my view that there are clear and convergent lines of evidence indicating that phosphorus is the nutrient most likely to directly influence periphyton growth in the vast majority of the Tukituki catchment. What this means is that a reduction in phosphorus inputs into that part of the system is likely to directly result in a reduction in periphyton growth, and for this reason should be considered the first priority for nutrient management in the Tukituki catchment.

9.6 That is not to say that nitrogen should not be managed as well, and the risks and benefits of the different nutrient management approaches are discussed below as well as in Dr Wilcock’s evidence.

9.7 In my view, and based on my earlier work and more recent work carried out by HBRC and NIWA, the following general conclusions apply to the management priorities for phosphorus:

(a) The wastewater treatment plants (WWTPs) from Waipukurau and Waipawa are a significant and continuous source of biologically available phosphorus to the lower Tukituki River, particularly during periods of low flows. These are required by consent conditions to significantly reduce their phosphorus content by September 2014. Modelling has indicated that compliance with these consent requirements will lead to material reductions in periphyton growths in the Waipawa and Tukituki Rivers downstream of the points of discharge;

(b) With regards to non-point-source discharges, a number of sub-catchments have been identified as contributing a disproportionally (compared with their size) high amount of phosphorus to the Tukituki

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49 It is my understanding that upgrades of the Waipawa WWTP have recently been commissioned, as presented in evidence by Mr Maxwell.

50 RWSS Folder 4, Tab4, Report M4.
River. These have been identified as “priority” sub-catchments, to which specific Change 6 provisions apply (POL TT5 (1) (d) and (e));

(c) There is a need to, within these sub-catchments, identify and prioritise critical source areas for management and mitigation. Details of the proposed phosphorus management approach and its rationale are presented in Mr Heath’s and Dr McDowell’s evidence;

9.8 I now come back to questions and issues relating to the management of nitrogen to control the growth of periphyton, which are at the heart of a number of submissions received on Change 6. Having clearly established (1) that periphyton growth is excessive in the Tukituki River and (2) that phosphorus should be reduced as a priority in the Tukituki catchment does not necessarily mean that nitrogen should not be managed as well to aid in the reduction of periphyton growth. It is indeed necessary to explore what benefits might be provided by such an approach and, conversely, the risks of not doing so.

9.9 In that regard, the general science position is clear that managing both nutrients is a more environmentally conservative approach, and that not doing so, i.e. managing only one nutrient incurs a number of risks. These risks have been specifically identified and assessed during two expert workshops, and are further discussed in detail in the water quality limits report51.

(a) Risk 1: The spatial and temporal variability of nutrient limitation within a catchment means that addition of a nutrient may elicit periphyton growth in some parts of the catchment, but not others;

(b) Risk 2: Reactivity of the system to one nutrient if the other one is present in excess. This means that if one nutrient (e.g. DIN) is supplied in excess of algae growth requirements, then the system is likely to be much more reactive to increased inputs of the other nutrient (e.g. DRP);

(c) Risk 3: The risk to downstream environments, including estuarine and coastal environment. These risks are addressed in the evidence of Dr Wilcok and Dr Cornelisen;

51 Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Section 5.6, p35 to 43, and Appendix E and Appendix F
(d) **Risk 4:** This relates to the risks to other aspects of water quality posed by land use, such as inputs of sediments, faecal contamination or nitrate toxicity;

(e) **Risk 5:** Changes in nutrient concentrations and ratios may lead to changes in species composition within the periphyton community, including a potential change to communities more favourable to cyanobacteria. Evaluating this risk was the subject of a specific one-day expert workshop, and is addressed in detail in Dr Young’s evidence.

9.10 In my opinion, management options aiming at managing both nutrients should always be considered, and should indeed be the default position. The water quality limits report presents in detail the thought process that led to the recommendations made by myself and Dr Uytendaal, which I summarise below.

9.11 **In the upper catchment,** periphyton growth is currently generally low, although some moderate levels of growths have been measured after very extended periods of low flows in the Tukituki and Waipawa Rivers at SH50. These are to be expected, regardless of nutrient levels. In my opinion, the risk of excessive periphyton growth is currently low in the upper catchment and, as measured at the aforementioned SH50 monitoring sites, is not inconsistent with maintaining the high biodiversity values that can be expected in that upland part of the catchment. Given the current nutrient co-limitation status of this part of the catchment, and current levels of periphyton growth in the upper catchment, an increase in one or the other nutrients would result in the increase in the risk of excessive nutrient growths, if inputs of the other nutrient occurred (risk 2 above). In view of the upper catchment’s expected high biodiversity value I have recommended a precautionary approach of maintaining nutrients at the current levels, as measured at the SH50 sites\(^{52}\). The DRP and DIN concentration limits set out in Change 6 for Zone 4 reflect this approach.

9.12 **In the mainstem of the Tukituki and Waipawa Rivers (within Zones 1, 2 and 3).** Nutrient management strategies for the lower Tukituki River were the subject of a specific expert workshop, the outcome of which are summarised in Dr Wilcock’s evidence. Dr Wilcock also describes in some detail the state of knowledge with regards to the lower Tukituki River. Key conclusions were that (1) a reduction in DIN is unlikely to provide significant benefits additional to those gained by reducing DRP, unless DIN inputs to the system are reduced...

\(^{52}\) Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Section 5.6.5, p35.
very substantially (2) conversely, an increase in DIN will probably not result in an increase in periphyton biomass provided DRP is maintained below appropriate target concentrations. I note that the conclusions that were drawn during the expert panel workshop are based on extensive monitoring, conceptualisation and modelling effort. In my view attempting to reduce DIN inputs to the catchment’s rivers and streams is very unlikely to be an effective method for reducing, or contributing to reducing excessive periphyton growths in the lower Tukituki or Waipawa rivers. Another relevant point is that, regardless of the strategy opted for in relation to nitrogen, the long lag times in the transport of nitrogen via groundwater\textsuperscript{53} mean that the control of periphyton in the Tukituki will have to rely on other mechanisms than reducing N inputs for a significant period of time. The key risk of this strategy not succeeding in terms of periphyton outcomes would be that phosphorus reduction efforts prove unsuccessful.

9.13 The potential risks and benefits of reducing nitrogen inputs to reduce periphyton growth in other mainstems of the middle catchment (Zones 2 and 3) are assessed in the water quality limits report\textsuperscript{54}. Managing DRP concentrations as a means of controlling periphyton growth is also the strategy most likely to succeed in “mainstem” tributaries of Zones 2 and 3.

9.14 The substrates of smaller tributaries of Zones 1, 2 and 3 are likely to be dominated by fine sediment, making them generally unsuitable for periphyton growth. I have recommended that a DRP limit or target of 0.015 mg/L should apply to these streams, primarily as a means of controlling their input of DRP into larger streams.

9.15 In the Papanui Stream (Zone 5), attempting to reduce dissolved nutrient concentrations (either or both DRP and DIN) is unlikely to be effective at controlling the nuisance growths of macrophytes currently occurring in that stream. Instead, I have recommended\textsuperscript{55} that riparian management should be considered as a first priority in order to improve the currently much degraded life-supporting capacity values of the Papanui Stream.

9.16 One might question the reasons why these conclusions for the Tukituki catchment differ from those that were reached in relation to the Horizons One

\textsuperscript{53} RWSS Folder 4, Tab4, Report M3, p28
\textsuperscript{54} Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Section 5.6.6.6, p39-40
\textsuperscript{55} Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Section 5.6.6.7, p40-41
Plan, particularly given that some of the experts, including Dr Wilcock and myself, advised, and presented evidence to, both processes. In his evidence Dr Wilcock provides his views on this matter, which I have reviewed and agree with. I will comment further on these aspects. To me, the key reasons that have led me to the conclusions I have reached are:

(a) The natural characteristics of the Tukituki River, in particular the significance of the groundwater inputs in the lower half of the Ruataniwha Plains, which during periods of low flows constitute the bulk of the water flowing in the middle/lower Tukituki and Waipawa Rivers and a number of its tributaries (here I am referring particularly to the “spring-fed” tributaries and “gaining’ river reaches in the south-eastern end of the Ruataniwha Basin\(^56\)). This groundwater provides a constant influx of nitrogen during periods of low flows, largely in excess of plant growth requirements;

(b) Detailed investigation, research and modelling work specific to the Tukituki enabled a robust assessment of the risks (as set out above in paragraph 9.9) associated with focusing on P management and, conversely, the potential benefits of N management to control periphyton. In particular, it enabled the quantitative or semi-quantitative assessment of the risks and benefits of different N and P management options. Options to manage the influx of nitrogen down to a point where it might assist in the control of periphyton growth (beyond what can be achieved by way of phosphorus management) have been assessed and those that appear realistic are not likely to result in material differences in the control of periphyton growth;

(c) In contrast, the Horizons One Plan approach was a region-wide approach which had to account for a much greater diversity of catchment characteristics, including catchments where there was a presumption of catchment-wide co-limitation or N limitation (e.g. the Rangitikei River). At the time the One Plan water quality limits were developed (in 2005-2007), information and data were much more limited than it is now for the Tukituki. Further, the risk of nitrate toxicity to aquatic life was not widely recognised in New Zealand at the time, whilst managing nitrogen to avoid nitrate toxicity is now more widely

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\(^56\) Refer to Exhibit IDM1 of Mr Maxwell’s evidence
recognised objective. For the One Plan, the risk to downstream environments, including lakes and estuaries was identified but not assessed in detail in each catchment. The assessment of temporal and spatial variability of periphyton controlling factors was hindered by the paucity of data available at the time (for example, no nutrient diffusing substrate data were available at the time, and periphyton data were limited to once-per-year measurements at a limited number of sites). In particular, the data were considered largely insufficient to develop region or catchment specific nutrient/periphyton models, and the potential periphyton benefits and land-use requirements of different options were not able to be quantified. The absence of such models in particular precluded the robust assessment of the risks set out above, and the scientific understanding was not able to inform decision-making beyond the existence of these risks.

9.17 Just so my position is clear, I am not recommending against a nutrient management strategy aiming at reducing nitrogen concentrations or loads in the Tukituki. Such strategy could not result in adverse in-stream environmental effects, and I have therefore no technical or scientific grounds on which to oppose it. However, on the balance of the data and information I have seen, and the understanding I have formed of how the Tukituki River system functions and is likely to react to different management options, I have come to the conclusion that a management strategy aiming at reducing nitrogen concentrations as a tool to reduce periphyton growth in the Tukituki is unlikely to deliver any material improvements unless nitrogen concentrations are very significantly reduced compared to their current levels. I have commented on numerous occasions in the past that nutrient management alone is unlikely to result in more than a reduction (i.e. not an elimination) of excessive periphyton growth in the Tukituki River. This means that even if a drastic reduction of DIN inputs to the Tukituki River was achieved, any additional (to those obtained by reducing P) benefits that may be gained by pursuing a significant decrease in DIN concentration would probably be limited. Reducing nitrogen to levels where it can materially affect periphyton growth would in turn require a significant change in land use in the Tukituki catchment (as I expand on in Section 12). I am not able to comment on whether or not this would be a desirable outcome, but the basis for my not recommending in-stream DIN limits for the control of periphyton growth in the water quality limits technical report I produced with Dr Uytendaal was that, I had not seen any evidence that reaching the nitrogen
levels required to provide material reductions in periphyton growth was technically feasible, or could reasonably be expected to occur in practice.

10. **SUBMISSIONS ON WORDING OF NUTRIENT LIMITS**

10.1 Fish and Game have sought that the DIN and DRP limits be expressed as the 95th percentile concentration\(^\text{57}\). In contrast, the Change 6 DRP and DIN limits are expressed as annual average concentrations. I also note that NKII’s submission seeks that DIN and DRP limits be expressed as maximum concentrations\(^\text{58}\), although the submission appears self-contradictory on this point, as it also seeks that the same numbers be expressed as annual average concentrations\(^\text{59}\). I am not in a position to comment further on the merits of this submission, as I am unsure of the relief sought. I note however, that the discussion that follows in paragraphs 10.2 to 10.4 would also apply to setting nutrient limits based on maximum concentrations. I also note that, in response to submissions, I discuss a range of numbers that are similar to those sought by NKII should these be taken as annual average concentrations.

10.2 In my view, the way any water quality limit is developed should take into account the mechanisms of effects of the water quality determinand in question. The way DRP and DIN limits are expressed in Change 6 essentially recognises that it is the longer term nutrient status of a river that tends to dictate periphyton growth, instead of short-term variations. For instance, isolated high concentrations of dissolved nutrients are unlikely to cause significant growth by themselves if the general background concentrations (better represented by median or average concentrations) are low. Whilst 95th percentiles and maxima are commonly used to express water quality limits in relation to determinands that may have a short-term effect (e.g. acute ammonia toxicity as used in Change 6 POL TT3), average concentrations are generally used when the long-term concentrations tend to determine the effect.

10.3 The way each water quality limit is developed should also guide how compliance is assessed against that limit. For instance, the DIN and DRP limits proposed for Zone 4 were based on the annual average of actual observations, with the aim of maintaining DIN and DRP at or below their current concentrations within that zone. In this situation, it would be self-contradictory to

\(^{57}\) #242

\(^{58}\) Ngāti Kahungunu Iwi Incorporated (#359), p 30-31.

\(^{59}\) Ngāti Kahungunu Iwi Incorporated (#359), p 29.
assess compliance at any other level than the annual average of observations. If limits were to be defined as 95th percentile concentrations (which I do not recommend), then, in my view, limits for Zone 4 should also be based on the 95th percentile concentration of actual observations.

10.4 No scientific rationale was provided in Fish and Game’s submission for the definition of nutrient limits based on 95th percentile concentrations. I suggested to HBRC that it enquire whether, in the case of that submitter at least, the submission seeking 95th percentile limits on DIN was an error, and also how the DRP limit in that submission should be read. The response from Fish and Game was that it was intended and not in error, and that the DRP limit should also be read as a 95th percentile concentration. In my view, and based on my experience with defining nutrient water quality limits, using annual average concentrations to define nutrient limits to control periphyton growth is a more appropriate approach than using 95th percentile or maximum concentrations for the reasons I explain in paragraph 10.2. I also note that nutrient limits based on annual average concentrations have been set in the Horizons One Plan and the Hurunui and Waiau River Regional Plan, and I have recently made similar recommendations to Greater Wellington Regional Council.

11. SUBMISSIONS ON DRP LIMITS

11.1 A number of submitters seek DRP water quality limits that differ from those set in Change 6:

(a) A 95th percentile DRP concentrations of 0.006 mg/L in the upper part of the catchment (equivalent to Zone 4),

(b) An annual average concentration limit of 0.010 mg/L for all or most of the catchment downstream of Zone 4, apart for the Papanui stream catchment, where a target of 0.015 mg/L is sought by some;

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60 Email response from Ms Corina Jordan (Wellington Fish and Game) to Ian Maxwell, 16 August 2013.
61 As amended by Decision of the Commissioners, March 2013.
63 Including Fish and Game (#242).
64 Including Te Taiao HB Environment Forum (#66 & #374), Kelly (#45 & #381), Ngāti Kahungunu Iwi Incorporated (#359), Te Taiwhenua O Heretaunga (#67).
65 Including Te Taiwhenua O Heretaunga (#67).
(c) Other submitters\textsuperscript{66} seek that a 0.015 mg/L DRP concentration be applied to mainstems of Zones 1, 2 and 3.

11.2 For context, the Change 6 proposed DRP limit for Zone 4 is an annual average concentration of 0.004 mg/L at river flows below three times the median flow.

11.3 The current measured DRP concentrations at Makaroro River at Burnt Bridge at river flows below three times the median flow are as follows:

(a) Annual average concentration: 0.003 mg/L;
(b) 95th percentile concentration: 0.008 mg/L.

11.4 The DRP concentrations at Tukituki at SH50 and Waipawa at SH50 at river flows below three times the median flow are respectively as follows:

(a) Annual average concentration: 0.004 mg/L at both sites;
(b) 95th percentile concentration: 0.008 mg/L and 0.009 mg/L;

11.5 The DRP limits sought by Fish and Game for Zone 4 are lower than those measured at the Makaroro at Burnt Bridge site, and so appear unrealistic in the context of natural or near-natural conditions in the catchment. Further, they would require a reduction in DRP concentration at all three sites, whilst there is no evidence of a significant adverse effect at the moment, and thus appear unnecessary.

11.6 For the rest of the catchment, Change 6 sets DRP limits/targets of 0.010 mg/L in the Tukituki and Waipawa Rivers in Zones 1, 2 and 3, and in all mainstem tributaries, which is consistent with the submissions referred to in paragraph 11.1(b). However Change 6 sets a limit/target of 0.015 in the Papanui Stream, the south-eastern tributaries of Zone 1 and in all smaller tributaries of Zones 2 and 3. Te Taiao HB Environment Forum and Mr T. Kelly, make the comment that 0.010 mg/L across the whole catchment would better achieve the improvements sought in Change 6. Whilst I agree with this as a statement of fact, one also needs to consider that (1) DRP targets were set in these streams primarily to control/reduce inputs to mainstems (2) most of these streams do not provide suitable habitat for excessive periphyton growths (3) where periphyton growths may occur, in my view, 0.015 mg/L provides adequate control of

\textsuperscript{66} Including Federated farmers of New Zealand (#354).
periphyton growth in lowland streams and (4) no or little water quality data are available for most of these streams and (5) where data are available (e.g. Papanui Stream, Mangatarata Stream) the 0.015 mg/L target is often largely exceeded and is probably a more realistic target in the short to medium term.

11.7 Federated Farmers seek that a 0.015 mg/L DRP concentration limit/target be adopted as the limit for Zone 1, 2 and 3 mainstem. The submission suggests the argument that the proposed Change 6 DRP limit/target of 0.010 mg/L is similar to the ANZECC trigger value for lowland rivers. The numbers are indeed the same, but the ANZECC triggers values were not used to derive the Change 6 number. Importantly I note that the annual average DRP concentration is currently between 0.010 and 0.015 mg/L at a number of key lower Waipawa and Tukituki rivers sites where periphyton growth is, in my opinion, currently excessive with regards to adequately protecting key river values. Setting a limit of 0.015 mg/L would allow an increase in DRP concentrations at these sites, instead of requiring a reduction (as the 0.010 mg/L target does). Given the conclusions I draw with regards to phosphorus being the key driver of periphyton growths in the mainstem rivers, an increase in DRP at these sites would likely result in a direct increase in the risk of excessive periphyton growths. Conversely, not requiring a reduction in DRP concentrations in the lower Waipawa and Tukituki Rivers would not be consistent with Change 6's objective of reducing the occurrences of excessive periphyton growths. I therefore cannot support this submission on this point.

12. SUBMISSIONS ON DIN LIMITS

12.1 A number of submitters seek the setting of water quality limits for DIN, in order to control periphyton growth, as summarised in paragraphs 12.2 to 12.6 below. Given the range and diversity of suggested in-stream and land loss limits, additional modelling of a range of scenarios was undertaken in order to provide the Board of Inquiry with information on the potential benefits (in terms of periphyton growth) and constraints (in terms of N losses from land use) of different N management options. This modelling was undertaken by Dr Rutherford and is presented in his evidence. I will refer to results presented in Dr Rutherford’s evidence. I will also comment on the in-stream DIN limits sought by the different parties in relation to the current state and “reference” (i.e. natural or near-natural) state of DIN concentrations in the catchment. The

67 #20 & #354
data statistics I refer to in the following paragraphs are those presented in Appendix G of the water quality limits technical report.

12.2 Some submitters\(^\text{68}\) seek the application of the following DIN water quality limits:

(a) 0.167 mg/L in the upper catchment; and

(b) 0.444 mg/L in the middle and lower catchment.

These submissions did not specifically seek a change in the wording of the limit, and I have thus assumed that these limits were expressed as annual average concentrations at flows below three times the median flow.

12.3 Some submitters\(^\text{69}\) seek the application of the following DIN water quality limits:

(a) 0.070 mg/L in the upper catchment; and

(b) 0.444 mg/L in the middle and lower catchment.

Again, these submissions did not specifically seek a change in the wording of the limit, and I have thus again assumed that these limits were expressed as annual average concentrations at flows below three times the median flow.

12.4 Some submitters\(^\text{70}\) seek the application of the following DIN water quality limits:

(a) 0.110 mg/L as an annual average concentration in sensitive catchments, which include the upper Waipawa and Tukituki rivers down to SH50, parts of the middle Waipawa, Tukituki and Tukipo rivers, and the Kahakahuri Stream, and the area around Lake Hatuma and the Mangatarata Stream;

(b) 0.444 mg/L as an annual average concentration maximum concentration in the rest of the catchment.

12.5 I also note that similar limits are sought by NKII\(^\text{71}\) if these limits are assumed to be read as annual average concentrations (refer to paragraph 10.1).

12.6 Fish and Game’s submission\(^\text{72}\) contains two elements that are relevant, and can be used as the basis for scenario modelling:

\(^{68}\) Te Taiao HB Environment Forum (#66 & #374) and Kelly, T (#45 & #381).

\(^{69}\) Forest & Bird CHB (#23 & #234) and F&B Hastings/Havelock Nth (#24), Hawke’s Bay Environmental Water Group (#32, 109)

\(^{70}\) Including Te Taiwhenua O Heretaunga (#67)

\(^{71}\) #51 & #359
(a) Water quality limits, including:

(i) 95th percentile DIN concentrations of 0.060 mg/L for the upper Waipawa and upper Tukituki Rivers, as well as the Makaroro River (Zone 4);

(ii) 95th percentile DIN concentration of 0.167 mg/L in the Tukituki and Waipawa Rivers and tributaries (e.g. Kahakahuri and Mangaonuku Streams) at the bottom of Zones 2 and 3 and the top of Zone 1;

(iii) 95th percentile DIN concentration of 0.444 mg/L in the Lower Tukituki corridor and tributaries, as well as in the Papanui, and Porangahau Streams;

(b) LUC-based nitrogen loss limits applicable to land use across the whole catchment. Fish and Game’s submission is that “drop down numbers should be included to achieve freshwater limits and Freshwater objectives over 20 year timeframes. The mean annual zone load to achieve the limit, should be allocated by land use capability or an alternative methodology”.

12.7 Consequently, a scenario was modelled by Dr Rutherford on the basis of the LUC-based N loss limits sought by Fish and Game. As sought by Fish and Game, another scenario was modelled based on “drop down” numbers. N loss numbers were set at 30% of the initial numbers for LUC classes 1-6, with classes 7 and 8 remaining constant.

12.8 To provide an indication of the likely outcomes of a close to natural scenario, a “re-forested” scenario was run, which assumes that the whole catchment is planted in exotic or native forestry, with a flat N loss rate of 3kg/ha/yr across LUC classes 1-6.

12.9 In addition, Dr Rutherford also re-ran a range of scenarios, including two historical scenarios (1900 and 1950), the current situation, and a range of future scenarios, i.e. with or without the RWSS. I will refer to the outputs of this modelling as presented in Dr Rutherford’s evidence (Exhibits JCR)
12.10 **Upper catchment**

12.11 The Makaroro River at Burnt Bridge is the closest representation of a reference site in the Tukituki catchment. It has been monitored by NIWA as part of the National Rivers Water Quality Monitoring Network (NRWQN), and is considered a “baseline” site within this network. The majority of the catchment above that point is in native vegetation and planted forestry (83%), with the remainder in extensive sheep and beef farming. A point to note is that this is as good a representation as is available of pristine water quality conditions in the upper part of the catchment, but it is not likely to be representative of natural conditions in other parts of the catchment, particularly where concentrations of nutrients are likely to be naturally influenced by groundwater inputs. I will come back to this point in the section that addresses Zones 2 and 3. When considering data at flows below three times the median flow, DIN concentrations at Makaroro River at Burnt Bridge are as follows:

(a) Annual average concentration: 0.066 mg/L;
(b) 95th percentile concentration: 0.175 mg/L;
(c) Maximum concentration: 0.192 mg/L.

12.12 In my experience, these concentrations are within the expected range of reference DIN concentrations measured in other reference sites for rivers flowing from the Ruahine and Tararua Ranges. For example, work I undertook recently for Greater Wellington Regional Council identified reference DIN concentrations in the following ranges for rivers flowing from the Tararua/Rimutaka Ranges:

(a) Annual average concentration: 0.025 to 0.120 mg/L;
(b) 95th percentile concentration: 0.050 to 0.231 mg/L;
(c) Maximum concentration: 0.100 to 0.340 mg/L.

12.13 Comparison of these statistics show that the limits sought by Fish and Game for the upper Waipawa, Tukituki and Makaroro rivers (a 95th percentile concentration of 0.060 mg/L) are currently not met in the Makaroro at Burnt

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73 Two types of sites are monitored as part of the NRWQN: “baseline” and “impact".
Meeting these limits would require a 60% reduction of the 95th percentile concentration.

12.14 Given that (1) water quality in the Makaroro at Burnt Bridge is within the expected range of reference/natural conditions and (2) there is no evidence of excessive periphyton growth at that site that may justify requiring a reduction in in-stream nutrient levels at that site, I do not support the limits sought by Fish and Game for the upper Tukituki catchment, because they appear (1) unrealistic under even natural conditions and (2) not warranted in order to manage currently occurring in-stream adverse effects.

12.15 The Tukituki at SH50 and Waipawa at SH50 have been used as the key monitoring sites in relation to the upper catchment zone (Zone 4). Concentrations in DIN at these sites are as follows (Tukituki and Waipawa rivers respectively):

(a) Annual average concentration: 0.134 mg/L and 0.150 mg/L;
(b) 95th percentile concentration: 0.369 mg/L and 0.452 mg/L;
(c) Maximum concentration: 0.546 mg/L.

12.16 The annual average concentrations of DIN at these sites are marginally higher than the upper bound of measured reference concentrations reported in my paragraph 12.11(a) above. However, based on monitoring data, I consider that the level of periphyton growth at these sites is low enough to sustain the range of values identified by HBRC (as described in the evidence of Mr Sharp), in particular the high biodiversity values in Zone 4. Conversely, I consider that there is no evidence of excessive periphyton growth that might warrant requiring a reduction in nutrient concentrations in order to reduce periphyton growth at these sites. This was the basis for the in-stream DIN concentration limits set in Change 6 for Zone 4.

12.17 The limits sought by Forest and Bird CHB74 and Forest and Bird Hastings/Havelock North75 and the Hawke’s Bay Environmental Water Group76 for the upper catchment (0.070 mg/L) correspond approximately to the measured water quality in the Makaroro at Burnt Bridge, and could be used if specific limits had to be defined for this site. However, given the known range

74 #23 & #234
75 #24
76 #32 & 109
of concentrations measured or estimated at reference sites, one could expect some sites within the rest of Zone 4 might exceed those values under natural or close to natural conditions. Further, the application of those limits to the Waipawa and Tukituki Rivers at SH50, would require a significant (approximately 50%) reduction in annual average DIN concentration at these sites, which, as explained in paragraph 12.16 above, I do not think is necessary in order to address any adverse environmental effects currently occurring there.

12.18 The limit sought by Te Taiwhenua o Heretaunga (0.110 mg/L as an annual average concentration) would similarly require a reduction in DIN concentration in the Waipawa and Tukituki at SH50, which I do not support.

12.19 The limits sought by Te Tāiao HB Environment Forum and Mr T. Kelly are slightly higher than, but comparable to, those in Change 6 (0.167 mg/L vs 0.150 mg/L in Change 6), and could probably be applied without significant differences occurring in periphyton growth. However, the limits included in Change 6 are based on a careful examination of actual data, and are designed to maintain DIN concentrations at these sites, whilst I am unsure of the rationale behind the submitter’s revised values. If the objective is to maintain DIN concentrations within Zone 4, then my recommendation is to use the Change 6 limits as notified for that zone.

12.20 **Middle catchment (Zones 2 and 3)**

12.21 The following limits are sought by submitters within Zones 2 and 3:

(a) 95th percentile concentration of 0.167 mg/L for the Waipawa, Tukituki, Mangaonuku, Kahakahuri, Tukipo, Makaretu rivers;

(b) 95th percentile concentration of 0.444 mg/L for the Porangahau catchment;

(c) An annual average concentration of 0.110 mg/L in “sensitive catchments”, which include parts of the middle Waipawa, Tukituki and Tukipo rivers, and the Kahakahuri Stream;

(d) Annual average concentration of 0.44 or 0.444 mg/L across Zones 2 and 3.

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77 Fish and Game (#242)
78 Fish and Game (#242)
79 TToH (#67)
12.22 Based on the data summaries presented above, it is apparent that a 95th percentile DIN concentration of 0.167 mg/l is currently exceeded at the Makaroro at Burnt Bridge, and fall outside the expected range of “reference” conditions, even in the upper catchment, so in my view is an unrealistic suggestion anywhere in the Tukituki catchment.

12.23 TRIM modelling predicts that under a “re-forested” scenario, annual average concentrations at flows below three times median flow would be in the 0.106 to 0.392 mg/L range (with most sites in the 0.130-0.240 mg/L range) in streams and rivers located near the bottom of Zones 2 and 3 (Exhibit JCR 11). This is higher than the concentrations currently measured at the Makaroro at Burnt Bridge site, which supports my view (expressed in paragraph 12.11) that reference conditions in the rain-fed rivers of the upper catchment are not likely to be representative of reference conditions in the spring-fed streams of the middle catchment.

12.24 A limit based on a 95th percentile DIN concentration of 0.444 mg/L in the Porangahau Stream as sought by Fish and Game corresponds to an annual average concentration of approximately 0.178 mg/L. The modelling of historical scenarios predicts that this concentration was probably exceeded in 1900 (0.338 mg/L), but would be met in a “re-forested” scenario (0.154 mg/L).

12.25 Similarly, TRIM modelling indicates that the 0.110 mg/L annual average concentration limit sought by Te Taiwhenua O Heretaunga in parts of Zones 2 and 3 was probably exceeded in 1900 by a factor of 2 to 4.8 at all sites modelled in Zones 2 and 3 (Exhibit JCR12). Under a “re-forested” scenario, this concentration is expected to be met at one site, close to being met at a further 3 sites, but exceeded by a factor 1.7-3.6 at 3 other sites (Exhibit JCR 11).

12.26 With regards to the suggested annual average concentration of 0.444 mg/L sought by a number of submitters across Zones 2 and 3, modelling predicts that:

(a) In Zone 3, land loss limits approximately equivalent to the modelled “30% LUC” losses would be required in order to meet this concentration in some of spring-fed streams of Zone 3 (e.g. Maharakeke and

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80 F&B CHB Branch (#23 & #234), Te Taiao (#66 & #374), Kelly (#45 & #381), TToH (#67)
81 Based on an annual average concentration/95th percentile ratio of 40%, calculated based on monitoring data for the Porangahau, Tukipo and Makaretu rivers.
82 #67
Kahahakuri streams and the Makaretu River), but lower limits would be required to meet it in the Porangahau Stream;

(b) In Zone 2, the “initial” LUC-based limits are not predicted to result in a decrease (in fact an increase) in in-stream DIN concentrations, and lower land loss limits than the “initial” LUC-based limits sought by Fish and Game would be required to meet this concentration in the Waipawa River at SH2. Additional modelling would be required to confirm how much lower these land-loss limits would need to be. However, much lower land loss limits, probably slightly higher than the 30% LUC numbers, would be required to meet this concentration in the Mangaonuku Stream;

(c) This concentration is predicted to be met at all sites under a “re-forested” scenario.

12.27 One of the aims of the additional TRIM modelling was to investigate the point at which nitrogen concentrations of loads start providing a material control over periphyton growth. Dr Rutherford has concluded that, based on his modelling, nitrogen loss corresponding to the LUC-based limits sought by Fish and Game, or even a 70% “drop down” reduction would not materially alleviate nuisance periphyton growth in Zones 2 or 3.

12.28 **Lower catchment (Zone 1)**

12.29 The following limits are sought by submitters within Zones 2 and 3:

(a) 95th percentile concentration of 0.167 mg/L for the Waipawa and Tukituki rivers down to the point of their confluence;\(^83\);

(b) A 95th percentile concentration of 0.444 mg/L in the lower Tukituki River, as well as for the south-eastern tributary catchments (Hawe, Makara, Mangamahaki, etc.);\(^84\);

(c) An annual average concentration of 0.444 mg/L.\(^85\)

12.30 As per my paragraph 12.22, I am of the opinion that setting a maximum 95th percentile DIN concentration of 0.167 mg/L as a limit, as sought by Fish and

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\(^{83}\)Fish and Game (#242)

\(^{84}\)Fish and Game (#242)

\(^{85}\)Including Te Taiao HB Environment Forum (#66 & #374), Kelly (#45 & #381), Te Taiwhenua O Heretaunga (#67).
Game for the Waipawa River downstream of SH2 and the Tukituki River upstream and downstream of the Waipawa confluence, is an unrealistic proposition anywhere in the Tukituki catchment.

12.31 The 95th percentile concentration limit of 0.444 mg/L sought by Fish and Game for the lower Tukituki River corresponds to an annual average concentration of approximately 0.190 mg/L.86

12.32 TRIM modelling indicates that N loss limits slightly lower than the 30% LUC numbers would be required to reach in-stream annual average concentrations similar to those sought by Fish and Game (Exhibit JCR 10). Mr Millner comments in his evidence on the potential land use implications of the “30% LUC” scenario.

12.33 The conclusions of the expert panel was that, given the current and future (after WWTP upgrade) DRP concentrations, a reduction of DIN concentrations to below 0.150 mg/L (expressed as an annual average concentration) was required in order to achieve a degree of co-limitation of periphyton growth in the lower Tukituki River. The limit proposed by Fish and Game is slightly higher than, but relatively similar to, this number, and I am of the opinion that applying it to the lower Tukituki River may at times provide some benefits in terms of periphyton growth. What is more difficult to say is how significant these benefits might be.

12.34 Based on TRIM modelling of the “0.3 LUC” scenario (which would be required in order to achieve the in-stream concentrations limits sought by Fish and Game in the lower Tukituki River), Dr Rutherford has concluded that material reductions in periphyton biomass would not occur in the lower Tukituki River under this scenario.

12.35 With regards to the suggested annual average concentration of 0.444 mg/L sought by a number of submitters in Zone 1, modelling predicts that:

(a) Fish and Game’s “initial” LUC scenario would not reduce DIN concentrations to this level;

(b) The 30% LUC and re-forested scenarios would reduce in-stream DIN concentrations to less than half of the concentration sought.

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86 Based on a 42% average to 95th percentile concentration ratio calculated for lower Tukituki River sites.
12.36 I do not have at the time of writing sufficient information to indicate the maximum N losses that could be allowed in the upper and middle catchment in order to meet the annual average DIN concentration of 0.444 mg/L sought by some submitters. I recommend that this point be investigated further by modelling of additional “intermediary” scenarios.

12.37 As discussed above, the conclusions of the expert panel was that a decrease in DIN concentration would probably have little effect on periphyton growth unless it is reduced to below 0.150 mg/L \(^{87}\) (expressed as annual average concentration), and I am of the opinion that an annual average concentration of 0.444 mg/L in the lower Tukituki corridor would probably not be sufficiently low to lead to material reductions in periphyton growth in the lower Tukituki River. This is supported by TRIM modelling which indicates that even lower DIN concentrations are not likely to provide significant control of periphyton growths (paragraph 12.34).

12.38 **Papanui Stream (Zone 5)**

12.39 As explained in paragraph 9.15, I am of the opinion that reducing DIN concentrations (for example to the 0.444 mg/L annual average concentration sought by some submitters) is unlikely to be effective at controlling the nuisance growths of macrophytes currently occurring in that stream, and I do not support submissions on this point.

13. **SUBMISSIONS ON WATER QUALITY LIMITS IN TABLE 5.9.1.A**

13.1 NKII\(^{88}\) seek the following *E. coli* concentration limits:

(a) 200 *E. coli*/100mL at river flows below the median flow;

(b) 500 *E. coli*/100mL at flows between the median flow and three times the median flow in the main stems, and the median flow and four times the median flow in tributaries.

No explanation of the rationale used to determine the 200 and 500 *E. coli*/100 mL numbers was provided in the submission.

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\(^{87}\) Uytendaal and Asseil, 2013- Change 6 Folder 4, Tab 1, Section 5.6, p.35 to 43, and Appendix E p.226

\(^{88}\) Ngāti Kahungunu Iwi Incorporated (#359)
13.2 The limits I recommended for Change 6 are 260 \textit{E. coli}/100mL at flows below median flow during the November-April main bathing season and 550 \textit{E. coli}/100mL the rest of the time. They are based on the application of the 2003 Ministry of Health/Ministry for the Environment microbiological water quality guidelines, which are themselves based on a statistical analysis of levels of health risk. These numbers are commonly used in New Zealand, and I am not aware of any recent research or guidelines that may suggest the limits be reduced to the numbers suggested by NKII. On this basis I do not support changing the Change 6 numbers as proposed.

13.3 Similarly I am unsure of the rationale for seeking different flow thresholds in mainstems (below 3 times median flow) and tributaries (below 4 times median flow), so cannot comment on its validity, but I note that there are currently no flow monitoring sites on any of the smaller tributaries that this exception would cover. On the basis that this limit would be very difficult to monitor against, let alone enforce in the absence of continuous flow data in smaller tributaries, I do not support the submission on this point.

13.4 Fish and Game’s\textsuperscript{89} and NKII’s\textsuperscript{90} submissions also seek that the lower \textit{E. coli} concentration limit should apply year-round at flows below median flow, as opposed to only during the bathing season as proposed in Change 6. The rationale for the \textit{E. coli} limits I recommended for Change 6 are as follows:

(a) \textit{E. coli} concentrations below 260/100mL fall in the MoH guidelines “green mode” indicating a low level of risk to recreational users. This limit was recommended to the period of the year when “primary contact”\textsuperscript{91} activities, such as swimming, are most likely to occur;

(b) \textit{E. coli} concentration between 260 and 550/100mL fall in the “amber mode”, which is indicative of a slightly more elevated, yet still acceptable, health risk for swimmers\textsuperscript{92}. This number was recommended as a limit for the period of the year when recreational activities were more likely to be dominated by “secondary”\textsuperscript{93} contact” activities such as

\textsuperscript{89} Ngāti Kahungunu Iwi Incorporated (#359)
\textsuperscript{90} The ANZECC Guidelines (2000) define “Primary Contact” activities as those in which the user comes into frequent direct contact with water, such as swimming and waterskiing.
\textsuperscript{91} for freshwaters the “acceptable” level of risk is 8 in every 1,000 bathers
\textsuperscript{92} The ANZECC Guidelines (2000) define “Secondary Contact” activities as those that generally have less-frequent body contact with the water, such as boating and fishing.
fishing, or “visual use”\textsuperscript{94}, instead of “primary contact” activities such as swimming. Concentrations below 550 \textit{E. coli}/100mL being indicative of an acceptable health risk for swimmers (i.e. primary contact), they are, in my opinion, adequately conservative for the period of the year when secondary contact recreational use of the river is likely to dominate recreational activities, and I do not recommend amending the limits as set out in Change 6.

13.5 Dairy NZ\textsuperscript{95} has raised the point of the methodology to be used to assess compliance with the proposed Change 6 limit. A submission by HBRC seeks that compliance be assessed against the 95\textsuperscript{th} percentile calculated using a minimum of 20 samples. I support this submission.

13.6 Some submitters\textsuperscript{96} seek that additional parameters such as heavy metals be included in Table 5.9.1.A. The ANZECC guidelines refer to a very large number of contaminants, including metals, organic micro-contaminants, etc. The intention of referring to the ANZECC guidelines in Table 5.9.1.A is to provide for the management of these “other toxicants” that have not individually been addressed in the Plan. I recommend no change in that regard.

13.7 Change 6 sets a default 95\% level of protection in relation to all other toxicants, based on the ANZECC Guidelines framework. Fish and Game seek that a higher level of protection (99\%) be set for all the surface sub-catchments, apart from the Hawea Stream and the Porangahau Stream, for all toxicants, including nitrate-nitrogen. Questions associated with nitrate-nitrogen toxicity are covered in evidence by Dr Hickey and Dr Uytendaal, and I will not comment further on these.

13.8 The Fish and Game submission raises two questions:

(a) Is a 99\% protection level appropriate for the rivers and streams under consideration?

(b) How should the recommended limit be applied?

\textsuperscript{94} The ANZECC Guidelines (2000) define “Visual Use” activities as those occurring in close proximity to the waterbody but that do not involve direct contact with the water, such as walking.

\textsuperscript{95} #17 & #378

\textsuperscript{96} Including Hawke’s Bay Environmental Water Group (#32, 109)
13.9 In response to the first question, the ANZECC guidelines recognise three categories of ecosystem condition, with a level of protection ascribed to each:

(a) “High conservation/ecological value systems: Effectively unmodified or other highly-valued ecosystems typically (but not always) occurring in national parks, conservation reserves or in remote and/or inaccessible locations”. For toxicants, “the highest protection level (99%) has been chosen as the default value for ecosystems with high conservation value”;

(b) “Slightly to moderately disturbed systems (95% species protection). Ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity”. For toxicants “in most cases the 95% protection level trigger values should apply to ecosystems that could be classified as slightly-moderately disturbed ecosystems”;

(c) “Highly disturbed systems (80-90% species protection). These are measurably degraded ecosystems of lower ecological value. Examples of highly disturbed systems would be some shipping ports and sections of harbours serving coastal cities, urban streams receiving road and stormwater runoff, or rural streams receiving runoff from intensive horticulture”.

13.10 Having considered Fish and Game submission on this point, I consider that a default 99% protection level for “other toxicants” appears suitable for the upper catchment (Zone 4) given the expected high biodiversity values in that part of the catchment, and I support Fish and Game submission on this point. I consider that a higher than 95% protection level (i.e. 99%) could be considered for the lower Tukituki given its high trout fishery value. However I understand from Mr Maxwell that the high trout fishery values are primarily associated with high angler use rather than high in-stream biodiversity /conservation values, and on this basis consider that the 95% protection level is adequate for the rest of the catchment for “other toxicants”.

13.11 In response to the second question (paragraph 13.8(b)), it is essential in my view to note that the numerical limits provided in Table 3.4.1 of the ANZECC (2000) Guidelines are “trigger values”, and are not intended to be used as

\[97\] ANZECC Guidelines (2000), pages 3.1-10 and 3.4-3
absolute water quality limits or standards. They “represent the best current estimates of the concentrations of chemicals that should have no significant adverse effects on the aquatic ecosystems” (ANZECC 2000, Section 3.4.3). The ANZECC (2000) guidelines provide a risk-based decision scheme for applying the guideline trigger values. The process is summarised in Figure 3.4.1, p 3.4-14 of the guidelines document and its application is discussed further by Dr Hickey. Basically the process recommends comparing the expected contaminant concentration with the default trigger guideline value. If the expected contaminant concentration is below the guideline, this indicates a low risk of significant adverse effects on the aquatic ecosystems. If the contaminant concentration exceeds the guideline, this indicates a potential risk, and the guideline trigger values should be reviewed in the light of site specific factors and/or a site-specific guideline should be calculated. If the site-specific guideline is still exceeded, the ANZECC framework recommends that either further investigation in the risk of effects (e.g. direct toxicity assessments) or remediation action be undertaken. These considerations are consistent with the recommendations I made recently to Greater Wellington Regional Council98.

13.12 The above considerations are the reasons why the wording of the “other toxicant” limits in Change 6 Table 5.9.1A does not refer to contaminant concentrations of trigger values; rather it sets a level of protection. Having considered this wording, I am of the opinion that it is adequate, but for clarity I recommend that the following be added, possibly as a footnote:

“This limit sets that the risk evaluation process set out in the ANZECC Guidelines will be followed on the basis of the specified protection level (99% or 95%). It does not mean that default trigger values defined in the ANZECC Guidelines will be used as limits”.

13.13 The submission by Dairy NZ99 also raises two areas of concerns in relation to the chronic ammonia toxicity limits defined in Change 6, Table 5.9.1.A, and seek the following relief:

(a) That the assumption that Sphaerids (freshwater clams) are prevalent in the Tukituki catchment be revised, and that the ammoniacal-nitrogen limits be set at the 95% protection level in all but soft-bottomed streams;

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98 Ausseil (2013). Recommended water quality limits for rivers and streams managed for aquatic ecosystem health in the Wellington Region, p41.
99 #17 & #378
That how “average” is determined for ammoniacal nitrogen limits be defined.

13.14 The rationale for the definition of the chronic total ammonia-N limits in Change 6 is set out in the water quality limits technical report\textsuperscript{100}. In summary:

(a) Sphaerids are known to occur in the Tukituki catchment;

(b) Their typical habitat (soft substrate) is typically not sampled when undertaking macroinvertebrate surveys, and their distribution and frequency in the catchment are unknown, apart from records in the Tukipo River and Porangahau Stream;

(c) Sphaerid habitat in hard-bottomed mainstem rivers such as the Tukituki or Waipawa Rivers is likely to be restricted. However, some “mainstem” streams, such as the Porangahau, Mangatarata and Papanui Streams are likely to provide suitable habitat for Sphaerids. Similarly, most smaller tributaries within the Ruataniwha Plains are likely to be naturally soft-bottomed and although not much is known about these streams, some are likely to provide potentially suitable habitat for Sphaerids;

(d) I am also not able to discount the presence of other freshwater bivalves, such as freshwater mussels, which based on toxicity data for related North-American species are also likely to be sensitive to ammonia toxicity.

13.15 On this basis, I am not able to discount the presence of Sphaerids or other freshwater bivalves at the zone, or sub-catchment scale for most areas of the catchment, and would not recommend raising the Change 6 proposed limit without singularly more information.

13.16 However, I have previously noted that\textsuperscript{101} total ammoniacal nitrogen concentrations are generally low in the Tukituki catchment, and, in my experience, only become an issue in relation to specific activities or point-source discharges. In that situation, site-specific investigations could be undertaken to confirm or otherwise the presence of Sphaerids. I agree with Dairy NZ’s suggestion that setting a catchment-wide limit based on the inability to discount the presence of a given type of organism is a conservative approach.

\textsuperscript{100} Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Section 5.9, p52 to 56
\textsuperscript{101} Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Section 6.10, p89
approach. I also note that the proposed chronic ammonia limits are based on the ANZECC trigger values, and, as explained in paragraph 13.11 should be used as such. Having considered these points, I recommend that wording to the Change 6 limit be amended to require that further assessment, consistent with the provisions of the ANZECC Guidelines, be required should the concentration in Table 5.9.1.A be exceeded.

13.17 With regards to the averaging period as raised in paragraph 13.13(b), the total ammonia-N concentration in Change 6 Table 5.9.1.A is proposed in relation to chronic, i.e. long-term, exposure. In the water quality limits report, I made the recommendation that this limit should be assessed against the average concentrations occurring over a period of at least four days, thus the limit could be expressed as, for example, a 4-day average, a 7-day average or, as used in the USEPA chronic ammonia criterion, a 30-day average concentration. In practice, the frequency of monitoring varies significantly between applications such as state of the environment monitoring (typically monthly) and monitoring of point-source discharges. In this context it is difficult to define an averaging period that can realistically be monitored in every situation. The amendments I recommend in the preceding paragraph require that a specific assessment of risk be undertaken if the concentration threshold is exceeded. This process would allow the definition of case-specific monitoring and compliance requirements, as well as an assessment of the presence of Sphaerids or other freshwater bivalves. I recommend that assessment against that trigger value be undertaken against a high percentile of the monitoring results, such as the 95th percentile.

13.18 In conclusion, I recommend that the wording relative to total ammonia nitrogen be amended to read:

"99% species protection level for total ammoniacal nitrogen, as stipulated in the most recent version of the ANZECC Guidelines and as tabulated in Schedule XXIII"

And be linked with the same footnote as the "Other Toxicants" as recommended in paragraph 13.12:

"For clarity this limit sets that the risk evaluation process set out in the ANZECC Guidelines will be followed on the basis of the specified
protection level (99% or 95%). It does not mean that default trigger values defined in the ANZECC Guidelines will be used as limits”.

14. WATER QUALITY DEFINITION

14.1 A number of submissions have raised the point that setting limits that in principle allow the increase in the concentration of some water quality determinands (for instance nitrate nitrogen) may contravene objectives of the National Policy Statement for Freshwater Management (NPSFM).

14.2 Whilst the wider question relative to meeting or contravening objectives of the NPSFM is beyond the scope of a technical brief of evidence, some technical considerations are relevant, and I comment on them in the paragraphs below.

14.3 To form a view on whether water quality is adversely affected by changes to its chemical composition, and therefore not maintained, requires in my opinion an understanding of what constitutes water quality, how this relates to the water quality limits setting process and how changes in water quality may be interpreted within a water quality limits framework.

14.4 The United Nations (UN Water) use the following definition of water quality:

“From a management perspective, water quality is defined by its desired end use. Consequently, water for recreation, fishing, drinking, and habitat for aquatic organisms require higher levels of purity, whereas for hydropower, quality standards are much less important. For this reason, water quality takes on a broad definition as the “physical, chemical, and biological characteristics of water necessary to sustain desired water uses”.

14.5 In my view this definition is consistent with the water quality frameworks recently developed or currently being developed in New Zealand: identify uses and values, then identify limits that maintain sufficient water quality to sustain desired uses and values. This is also what I understand the NPSFM requires.

14.6 In my opinion, water quality in the context of resource management should be viewed in this context, and changes in the level, cover, concentration, etc. of the different determinands should, purely from a technical point of view, be

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102 Including Environmental Defence Society Inc (#304), Forest and Bird Central Hawke’s Bay Branch (#23 & 234).
considered in the context of whether or not they cause an effect that compromises the uses and values of the resource in question, i.e. the water quality. I acknowledge that there are diverging views on this topic, but in my opinion, these views are expressed from a philosophical and/or cultural point of view rather than a purely technical one, and I do not have the expertise to comment on these aspects.

14.7 Viewed from a technical perspective, provided the toxicity limits Dr Hickey has derived are not exceeded, I do not believe an increase in DIN in Tukituki River will result in any material increase in periphyton growth, or adversely affect ecological or recreational river values, and therefore it may occur without contradicting an overall objective of “maintaining water quality”. Conversely, in the specific context of the Tukituki River, a moderate reduction in DIN would do little to reduce the growth of periphyton, and therefore would do little to improve “water quality”.

15. **RWSS ENVIRONMENTAL FLOW OPTIMISATION PROCESS**

15.1 The Environmental Flow Optimisation process was initiated in late 2012, following the conclusion of the RWSS’s feasibility studies. I assembled the project team\(^{104}\) and led the production of the report that summarises the study’s findings (report K4). I summarise below the key reasons for initiating this project and what its findings were.

15.2 Approximately 40.3 million cubic metres (Mm\(^3\)) of water had been set aside during the feasibility stage of the project for environmental purposes, composed of:

- (a) 38.8 Mm\(^3\)/year to maintain a minimum residual flow of 1.23 m\(^3\)/s at the toe of the dam, and
- (b) 1.5 Mm\(^3\) per year to provide for 4 flushing flows of 10.5 m\(^3\)/s (10 hour duration) per year;

15.3 The project team identified that there were potential opportunities for the RWSS to provide additional water for irrigation or environmental purposes, and the Environmental Flow Optimisation project was initiated in response to the following considerations:

\(^{104}\) Composed of Dr Roger Young (Cawthron Institute), Mr Rob Waldron (HBRC), Mr John Hansford (Tonkin and Taylor Limited) and myself.
(a) The volume of water set aside for environmental purposes during the feasibility studies (40.3 Mm$^3$) is a significant volume of water and options for the best use of this water for environmental purposes should be considered;

(b) Full uptake of the RWSS's irrigation water is not expected to occur from the start of the Scheme. Similarly, a 4 Mm$^3$ allowance was made for sedimentation, which is likely to not be fully utilised for approximately 20 years. Some water is therefore likely to be available during the early years of the RWSS, some of which could be used for environmental purposes;

(c) The volume of water provisioned for irrigation during the feasibility study (95.8 Mm$^3$) was based on full uptake of the RWSS water, with a nominal 1 in 20 years security of supply. This meant that even assuming full uptake, not all the water retained in the dam will be used for irrigation in most years. Again, some of this water could theoretically be used for environmental purposes;

(d) The two key environmental issues facing the Tukituki river are (1) extreme summer low flows and (2) excessive periphyton growth in the lower Tukituki River;

(e) It appeared clear that stored water could, on principle at least, be used to combat these two issues, by (1) supplement the natural flow of the river during low flows ("low flow supplementation") and (2) provide flushing flows to aid in the control of excessive periphyton growths in the lower Tukituki River.

15.4 The process and studies the project team went through are presented in the K4 report, and are not repeated here, but key conclusions are presented below.

15.5 The potential effects of the Scheme on river low flow periods were assessed and a key conclusion of the report is that the Scheme may result in negative effects on low flows, both from an ecological and a resource use perspective. These effects may, or may not eventuate, depending primarily on the level of uptake by current water abstractors and the potential effects of the irrigation water “return”$^{105}$. These aspects, as well as the proposed mitigation by way of

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$^{105}$ RWSS Folder 3, Report K4, p31.
consent conditions, are discussed in Section 6 of Dr Young’s evidence. I have read Dr Young’s evidence and agree with his recommendations on this point.

15.6 With regards to the provision of “augmented” flushing flows, and on the basis of information set out in the K4 report, the key conclusions I reached are:

(a) Four flushing flows per season of approximately 1 Mm³ each can be delivered very reliably by the Scheme;

(b) If released over an otherwise low flow situation (based on Change 6 proposed minimum flows), these flushing flows are predicted to provide very efficient flushing in the Makaroro and Waipawa rivers. In the lower Tukituki River, the flows are predicted to reach approximately 35 m³/s at the top of the lower corridor to just under 27 m³/s near the bottom of the catchment at Red Bridge. Whilst these flows are not expected to result in significant movement of bed sediment, they are expected to result at least in the removal of the drifting/floating and deposited algae, which are particularly detrimental to recreational use of the river and the detaching and deposited Phormidium mats, which are the key source of public health risk associated with this cyanobacteria. Data collected by NIWA also indicates that nuisance periphyton growths were rarely observed at flows above 23 m³/s and never at flows above 34 m³/s.

(c) There is significant opportunity to enhance the environmental benefits brought by these flushing flows by managing the timing of their release to “piggy back” on natural minor freshes. By using the flushing flow triggers now incorporated in the proposed consent conditions, modelling predicts that about half of the flushing flows will exceed 36 m³/s at Red Bridge, and about 30% will exceed 43 m³/s. These flows are expected to result in increasingly efficient removal of the accumulated algae and cyanobacterial biomass.

(d) Flushing flow “triggers” have been defined to provide clarity about when the flushing flows would be released. The base principle is to release a

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106 RWSS Folder 3 of 7, Report K4, p24.
107 Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Appendix E, p227
108 Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Appendix F, p264
109 RWSS Folder 3 of 7, Report K4, p21 and Figure 10 p22
110 RWSS Folder 2, Tab 2 p10, HBRC Consent WP120371M (Makaroro Damming, Take, Diversion and Discharge) Proposed condition 11.
flushing flows every 30 days (unless natural freshes negate the need for an artificial flushing flow). The triggers are based on a day count associated with river flow at Red Bridge. The count starts on 1 December and is reset every time the daily average flow reaches 50 m³/s at Red Bridge. Once the count reaches 20 days, and up to 30 days, a flushing flow will be released on the back of any natural fresh event between 20 and 50 m³/s in size. If the day count reaches 30 days, then a flushing flow is released on that day.

(e) The 30 days period used above is intended to “interrupt” periphyton accrual periods when they reach 30 days during the critical December to March period, and thus provide an opportunity that would not otherwise exist to contribute to progress towards Change 6’s periphyton reduction objectives (Objective TT1(c)).

(f) Given the likely environmental benefits brought by the flushing flows, I made the recommendation that these flushing flows be committed to by the RWSS to provide certainty. This recommendation was adopted and included in the set of proposed consent conditions, a revised version of which is produced by Mr Daysh.

(g) I note that, although the modelling was undertaken on the basis of two “envelopes” of “primary” and “secondary” flushing flows with different levels of priority, these considerations have not been carried through in the consent conditions. The consent conditions give all four flushing flows the highest level of priority after the residual flow. Under these consent conditions, the only situation where four flushing flows would not be delivered would be when there are sufficient natural flushing flows in the river so that additional flushing flows are not required. Modelling indicates that, in practice this is likely to occur, but only on an infrequent basis.

15.7 Some submitters 111 have raised the question that the effectiveness of flushing flows is not fully understood or proven. Apart from the converging lines of data and expert opinion-based evidence as summarised in paragraph 15.6, I agree that monitoring data of actual flushing flows would be very useful and would assist the optimisation of their use, and have recommended that detailed monitoring of periphyton abundance be undertaken before and after flushing.

111 Including Chambers, B. (#335), Robson, A. (#259)
flows (p23 of report K4). These monitoring requirements are contained in proposed consent conditions\(^{112}\).

15.8 Mr Brian Chambers\(^{113}\) also raises the point that in his personal experience, periphyton and cyanobacteria growths appear in the Tukituki subsequently to summer rainfall. Rainfall-induced runoff will entrain contaminants from the landscape into streams and rivers, in particular sediment, phosphorus\(^{114}\) and microbiological indicators of faecal contamination (\textit{E. coli}). Sudden inputs of phosphorus during summer are likely to accelerate periphyton growth. However, whilst this mechanism is logical with regards to rainfall-induced increases in flow, the water released from the dam during flushing flows will be of the same quality as the water released for irrigation and residual flows, i.e. expected to contain low concentrations of nutrients. In my opinion, the proposed flushing flows will not exacerbate periphyton growth in the period following their passage.

15.9 Some submitters\(^{115}\) seek that the triggering of flushing flows be based, not on the hydrological regime as proposed, but on water quality determinands, such as periphyton, nutrient concentrations and/or water temperature.

(a) I am not certain I understand the rationale for triggering flushing flows on water temperature. During summer low flows, water temperature rises to levels that can be detrimental to aquatic life, particularly in the lower Tukituki River. The water released during the flushing flows is expected to be of a lower temperature than the river water, particularly when flows in the river are otherwise low (i.e. when water temperatures are at their highest). The flushing flows should therefore have a beneficial effect on aquatic life by providing some relief from high water temperatures. However, this effect will be very transitory in nature, and thus flushing flows will not be able to durably influence water temperature in the river;

(b) I do not agree that triggering flushing flows based on nutrient concentrations would be particularly useful. Given the variability in nutrient concentrations (particularly in relation to river flow) and th\(^{112}\) RWSS Folder 2, Tab 2 p10, HBRC Consent WP120371M (Makaroro Damming, Take, Diversion and Discharge) Proposed condition 12,
\(^{113}\) Chambers, B. (#335)
\(^{114}\) Mechanisms of phosphorus transport and mitigation are described in Dr McDowell’s evidence.
\(^{115}\) Including Ngāti Kahungunu Iwi Incorporated (#359)
typical frequency of water quality monitoring (monthly), I do not see what practical advantages there would be in this approach;

(c) The triggering of flushing flows based on actual periphyton growth is however a potentially useful suggestion. On the one hand, there would be little point in releasing a flushing flows solely based on flow records if there was no periphyton issue to manage; on the other hand, it could be sensible to trigger a flushing flow earlier, in response to a significant issue indicated by monitoring results. This could be particularly relevant in a situation where a health risk is identified in relation to depositing Phormidium mats. However, there would be a need to define clear, objective triggers to ensure clarity and enforceability of the consent conditions. Triggers would also have to be able to spread the flushing flow capacity (i.e. the 4 Mm³) across the critical summer period (December to April). The flow-related triggers included in the proposed consent conditions have the advantage of being clear, objective and enforceable. They also present the advantage of integrated management with the Change 6 water quality targets and they spread the flushing flows across the critical summer period.

(d) On balance, I recommend maintaining the flushing flows triggers as set in proposed conditions. However, it may be sensible to allow a degree of flexibility, or discretion by the Scheme operator to trigger or not trigger flushing flows depending on the actual state of periphyton in the lower river at the time.

15.10 Some submitters¹¹⁶ also seek more flushing flows (8), and flushing flows in the Mangaonuku and Kahakahuri Streams. Dr Young addresses these aspects in his evidence.

16. RWSS OVERALL WATER QUALITY ASPECTS

16.1 A number of potential water quality and aquatic ecology effects have been identified in relation to the RWSS proposal. The assessment of effects has been primarily undertaken by the Cawthron Institute, and are addressed in Dr Young’s evidence. However, I will comment on the potential effects of the land use changes associated with the Scheme on nutrients and periphyton, as I

¹¹⁶ Including Ngāti Kahungunu Iwi Incorporated (#359)
have commented on these aspects with regards to Change 6. The following aspects are relevant.

16.2 Modelling undertaken by Dr Rutherford indicates that in-stream inputs of nitrogen and DIN concentrations will increase as a result of the implementation of the RWSS, even under a scenario that includes N mitigation\textsuperscript{117}. For the same reasons I explain in Section 9, this increase in itself is not predicted to result in increases in periphyton\textsuperscript{118} (including \textit{Phormidium}\textsuperscript{119}) growths in the vast majority of stream and river reaches potentially affected by the Scheme. This assessment is supported by the findings of the two expert workshops held in relation to Change 6 and the TRIM modelling undertaken by Dr Rutherford.

16.3 DRP is predicted to increase as a result of increased losses from land being supplied water by the RWSS, if no specific P mitigations are in place\textsuperscript{120}.

16.4 I understand from Mr Wheeler’s evidence that Oversee has limited capacity to model P mitigation. By modelling P mitigation measures able to be modelled with Oversee, the RWSS is predicted to result in an overall near-neutral position. However, the modelling also predicts that P inputs to streams would still increase in some sub-catchments\textsuperscript{121}.

16.5 In my opinion, increases in P inputs to streams would be likely to increase the risk of periphyton growth in at least some of these sub-catchments, resulting in water quality degradation.

16.6 Dr McDowell has recommended that pursuing a P-neutral position on a sub-catchment by sub-catchment basis was wiser than on a farm-by farm basis (as was originally proposed). It is also my understanding that this does not negate obligations the properties being supplied water by the RWSS may have under Change 6 (or any subsequent review thereof). In other words, it is my understanding that “RWSS” properties in priority sub-catchments will have the same obligations than any other property under Change 6’s Policy TT5. The evidence of Dr McDowell and Mr Heath describe the proposed P management framework and Mr Millner presents the outcomes of recent case studies in the Ruataniwha Plains. Ms Mulcock describes the overall RWSS and farm nutrient

\textsuperscript{117} RWSS Folder 4, Tab4, Report M4, p8.
\textsuperscript{118} Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Appendix E, p226, response to Question 7.
\textsuperscript{119} Uytendaal and Ausseil, 2013- Change 6 Folder 4, Tab 1, Appendix F, p264.
\textsuperscript{120} RWSS Folder 4, Tab4, Report M4.
\textsuperscript{121} RWSS Folder 4, Tab4, Report M4.
management framework, and how it has been incorporated into consent conditions.

16.7 I am not qualified to comment on whether the P neutral position can, or will, be achieved on a sub-catchment basis, however, I can comment on how this might affect water quality. As indicated earlier in this evidence, failure to adequately control P inputs to streams and rivers represents the key risk associated with the Change 6 proposed nutrient management approach in the Tukituki catchment. This risk remains, whether the RWSS proceeds or not; and as I have explained in Section 9, I do not believe that this risk can realistically be materially mitigated by a different nutrient management approach (such as reducing nitrogen inputs), largely due to the catchment’s characteristics. However, if the Scheme is indeed able to be developed on the basis of being neutral at the sub-catchment scale, and further contribute to P reductions in priority sub-catchments, then I am of the opinion that the Scheme will not result in material negative effects on periphyton growth. I note that Dr. Young has drawn a similar conclusion in his evidence.

16.8 I have previously explained the rationale for the flushing flows that are being proposed as part of the development of the RWSS, and how they have been incorporated in the set of proposed consent conditions. In my opinion, these flushing flows will provide significant benefits to the river and its users. Importantly, this opportunity to manage periphyton growth with artificially released flows in the river reaches located downstream of the dam currently does not exist, and cannot exist without a water storage facility of some description, and the benefits provided by the flushing flows would be (if implemented) a net environmental benefit associated with the RWSS. I note that Dr Young draws a similar conclusion in his evidence.

17. **RWSS WATER QUALITY MONITORING AND MANAGEMENT PROPOSED CONSENT CONDITIONS**

17.1 A number of water quality monitoring, modelling and adaptive management requirements have been identified and incorporated in the proposed consent conditions. I will describe the key components of these requirements in relation

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122 The proposed flushing flows will travel down the Makaroro, Waipawa and then Tukituki Rivers, and will therefore not affect any other river reaches (such as the Tukituki River upstream of its confluence with the Waipawa River) or tributaries.
to water quality. Dr Young describes the elements relating to aquatic ecology. The key water quality elements are:

(a) The water quality performance standards and monitoring requirements associated with the construction phase;

(b) The water quality monitoring requirements and management regime of water quality within the proposed reservoir;

(c) The water quality monitoring, modelling and management regime associated with production land use.

17.2 For clarity, wherever I refer to specific condition numbers in my evidence, I refer to the conditions as per the May 2013 RWSS RMA Application suite, Folder 2, Tab 2. In his evidence, Mr Daysh presents a “redlined” set of proposed consent conditions, which reflect my recommendations.

Construction phase

17.3 Water quality performance standards in relation to construction activities are set out in Schedule One condition 6(iv) and 6(v). These performance standards are directly aligned with Change 6 POLTT5, which sets limits associated with point-source discharges, for water quality determinands that are directly relevant to construction activities, i.e. changes in water clarity and QMCI. The other water quality determinands of POLTT5, such as total ammonia-nitrogen, ScBOD₅ and POM are not, in my experience relevant to construction activities.

17.4 The performance standards set out an exclusion period of 9 hours for in-river work. This is consistent with consistent with Policy TT3(2)(b) and the technical recommendations I gave on p51 of the technical water quality limits report.

17.5 Proposed monitoring requirements are set out in Schedule One, conditions 34 (dam) and 35 (river intake structures). The wording of these conditions reflects my recommendations.

17.6 For the dam site, condition 34 requires annual monitoring of QMCI, and that water turbidity be monitored continuously at two sites, respectively upstream and downstream of the dam construction site. It also requires that in-situ water clarity measurements and deposited sediment visual estimates be made and samples taken and analysed for turbidity and total suspended solids (TSS)
fortnightly (at random times). The intention of the fortnightly sampling is two-fold:

(a) The water clarity measurements will enable direct assessment of compliance with the 20%\textsuperscript{123} water clarity change performance standards set in condition 6(v);

(b) Water clarity can be correlated to turbidity or TSS concentrations. However, the relationship is generally site-specific. The taking of concurrent TSS/clarity/turbidity measurements will enable, with time, the establishment of a rating curve, enabling the use of continuous turbidity monitoring as a “proxy” for continuous water clarity monitoring. It is noted that this continuous turbidity monitoring is not intended to be a compliance tool, but rather a management trigger.

17.7 For the river intake sites, condition 35 requires the same monitoring as for the dam site, with the exception of the continuous turbidity measurement. In my view, the continuous monitoring requirement is consistent with the scale and duration of the proposed construction activity at the dam site, but is not necessary at the river intake sites.

17.8 With regards to reporting and management in relation to the water quality performance indicators

(a) Condition 36 requires that the consenting authority (HBRC) be notified if a breach of the water clarity performance standard is identified by monitoring;

(b) Condition 37 sets out the response in the event the water clarity performance standard is breached, either at the dam or the river intake sites. With regards to water quality specifically it requires:

(i) further water clarity monitoring daily for 10 working days after the breach occurs;

(ii) an ecological assessment if breaches are detected in more than two consecutive days.

\textsuperscript{123} The dam site being located in Zone 4, the performance standard is 20% change in water clarity.
(c) Conditions 38 requires that a monitoring report be prepared annually on the results of the monitoring undertaken.

17.9 In my opinion this suite of monitoring, associated with triggers and further monitoring and notification if the triggers are exceeded, as well as annual reporting, is adequate to detect and assess the potential effects from the construction activities on water clarity, as well as the potential effects on deposited sediments and consequential effects on macroinvertebrate communities.

17.10 I have not identified any submissions raising concerns or queries in relation to these conditions specifically.

18. RESERVOIR MONITORING

18.1 Conditions 13 to 16 of Consent application WP120371M (Makaroro Damming, Take, Diversion and Discharge) set the water quality monitoring, management and reporting requirements for the reservoir, namely:

(a) Condition 13 requires the implementation of a monthly water quality monitoring programme, which includes water quality sampling at three representative depths, and on-site measurements at regular depths from the surface to the bottom of the reservoir (depth profiles) of key reservoir water quality determinands. It also requires the annual calculation of the Trophic Level Index (TLI)\textsuperscript{124};

(b) Condition 14 requires the installation of an aerator, as well as additional monitoring designed to manage the utilisation of the aerator. Essentially, the monthly depth profile results will be compared to the temperature and dissolved oxygen triggers set in Table 2. Table 2 contains a cascade of triggers that will determine when additional (more frequent) monitoring is required and when the aerator should be turned on.

18.2 I developed these conditions based on the conclusions and recommendations set by Dr Max Gibbs in the Reservoir water quality modelling report\textsuperscript{125}, and they were subsequently reviewed by Dr Gibbs. I understand that other key recommendations of Dr Gibbs, including in particular those that relate to the

\textsuperscript{124} The Trophic Level Index, or TLI is a measure of the trophic status of lakes in New Zealand. Its calculation is based on four main trophic indicators: water clarity, chlorophyll a, total nitrogen and total phosphorus.

\textsuperscript{125} RWSS Folder 5 (Assessment Reports), report A2.
depth of water intake in the reservoir have been incorporated in design specifications.

18.3 I have not identified any submissions raising concerns or queries in relation to these conditions specifically. Submissions relating to the potential effects of the discharge of water from the dam on water quality are addressed in Dr Young’s evidence.

19. LAND USE WATER QUALITY CONDITIONS

19.1 Schedule Three\textsuperscript{126} sets the proposed conditions for Production Land Use utilising water from the Scheme. It contains a number of conditions relating to water quality monitoring, modelling, management response and reporting. I will comment on conditions 5 to 20 of Schedule Three.

19.2 Condition 5 specifies that the land use activities covered by the different consent conditions shall be undertaken so as to ensure that the in-stream nitrate-nitrogen concentration limits set in Change 6 Table 5.9.1.B for Zones 1, 2, 3 and 5 are not exceeded at any of the monitoring sites set in condition 6.

19.3 Condition 6 sets requirements for a water quality monitoring programme. This programme is intended to work in tandem with HBRC’s state of the environment monitoring programme, in order to avoid duplication of monitoring effort. The key underlying principle of this monitoring programme is to establish a baseline, detect changes in water quality associated with RWSS land use activities, and assess compliance with water quality limits and progress towards water quality targets. Key elements of this monitoring programme are:

(a) The monitoring sites were selected to be located:

(i) on main streams and rivers traversing the proposed irrigation “command” areas,

(ii) both upstream and downstream of the irrigation command areas;

(b) Monitoring is to commence at least 24 months prior to any irrigation water being supplied by the RWSS, in order to establish a “pre-RWSS” baseline at sites not monitored previously;

\textsuperscript{126} RWSS RMA Application Suite, Part D Proposed Conditions, p71-85
(c) A comprehensive suite of water quality determinands is to be monitored, including nutrients, periphyton (including cyanobacteria), water clarity/turbidity, microbiological indicators (\textit{E. coli}) macroinvertebrate communities and deposited sediment cover.

19.4 As explained in the evidence of Ms Mulcock, RWSS are now proposing a condition requiring properties being supplied by the Scheme to be collectively “P-neutral” in each main sub-catchment as defined in Change 6 Schedule XIV. Having considered this proposed change, and its implications for water quality monitoring, I have reviewed the proposed water quality monitoring programme and make the following recommendations. These recommendations are generally destined to place a monitoring site at (or close to, allowing for access) the bottom of each main sub-catchment. I recommend that:

(a) A monitoring site be added on the Tukipo River upstream of its confluence with the Makaretu River;

(b) A monitoring site be added on the Maharakeke Stream upstream of its confluence with the Makaretu River;

(c) The monitoring site on Tukipo River at Makaretu Road be moved to the point where the Tukipo crosses State Highway 50 (Tukipo at SH50);

(d) A monitoring site be added on the Mangatewai Stream at SH50, given known high DRP concentrations in this stream.

(e) A monitoring site be added on the Makaretu River upstream of its confluence with the Maharakeke Stream. Dr Uytendaal informs me that accessing the Makaretu immediately upstream of its confluence with the Maharakeke Stream requires wading across the Tukipo River or the Maharakeke Stream, and is thus not possible under high flow conditions. On this basis I recommend that, when access to the site is rendered unsafe due to high flow conditions, sampling be undertaken at an alternative location accessible at all river flows, located approximately 2km upstream of the at Speedy Road.

19.5 An updated table of proposed water quality monitoring sites is presented in Exhibit OMNA 1.
19.6 I note that some submitters have sought that monitoring be undertaken at a sub-catchment scale. The monitoring programme I recommend, associated with the monitoring programme that will be undertaken by HBRC (as described by Dr Uytendaal) will ensure that a water quality monitoring site is established at the bottom of each main sub-catchment 2, 3 and 5 (apart from the Makaretu River for the reasons explained above).

19.7 Proposed conditions 7 to 10 relate to in-stream nitrate-nitrogen limits. The intention is to use a combination of monitoring, predictive modelling and management response in order avoid in-stream nitrate-nitrogen concentration limits being exceeded.

(a) Condition 7 makes use of a “trigger” concentration, set at 80% of the in-stream nitrate-nitrogen concentration limits. If the “trigger” concentration is reached or exceeded at any of the monitoring locations, this condition requires the Scheme to assess, via modelling, whether the continued land use (on land being supplied water by the Scheme) is likely to cause actual exceedances of the in-stream nitrate-nitrogen concentration limits;

(b) Condition 8 sets out the response in the situation where the above assessment does indicates that continued land use is likely to lead to an exceedance of the in-stream limits at some time in the future. In that situation, this condition sets that the Scheme must require its participants within the groundwater catchment of the monitoring point in question to identify and implement on-farm nitrogen leaching mitigation measures. The condition also requires the modelling of the proposed mitigations in order to assess their effects on in-stream concentrations;

(c) Condition 9 sets out the response in the situation where the modelling indicates that the continued land use is not likely to lead to an exceedance of the in-stream limits at any time in the future. In this situation, this condition requires that the model be run annually until in-stream concentrations are less than 80% of the limit.

(d) Condition 10 requires reporting of the above to the consenting authority.

19.8 The proposed approach is based on a combination of monitoring and predictive modelling. Given the long lag-times associated with groundwater transport of nitrate nitrogen in the Ruataniwha Plains, predictive modelling constitutes in my
view the best available tool to identify “risk” areas and activities, i.e. areas where there is a higher risk of certain land use activities causing an exceedance of the proposed in-stream limits. The underlying philosophy is to use this risk forecast to allow for the development and implementation of on-farm N mitigation measures early enough in risk areas in order to avoid actual exceedances of in-stream nitrate.

19.9 Condition 12 to 14 set out the approach in relation to the microbiological indicator *E. coli*. 

(a) Condition 12 requires that the land use activities be undertaken so that they don’t cause exceedances of Change 6’s proposed *E. coli* concentration limits/ in surface water (as set out in Change 6, table 5.9.1.A) or groundwater (as set out in Change 6, table 5.9.2).

(b) Condition 13 requires that:

(i) any exceedances should be followed by additional monitoring, and, 

(ii) if the exceedance is confirmed by monitoring, that an assessment be undertaken of the likely causes and sources of the exceedances.

(c) Condition 14 that if properties that receive water from the Scheme are identified to be the cause, or a significant contributor to, the measured exceedances, then the Scheme shall identify actions to be taken by property owners, and procure that these actions are implemented as soon as practicable.

19.10 I note that some sub-catchments within the proposed irrigation area currently do not meet some or all of the proposed *E. coli* limits, such as the Tukipo River, the Porangahau Stream and the Tukituki River at SH2. In these situations it is not possible for the consent holder to meet the limits (which should more properly be regarded as targets), and I recommended that condition 12 be amended to account for this.

19.11 More to the point, the current exceedances mean that there is the potential for the further monitoring and assessment of sources required under condition 13 to be triggered on a frequent basis, regardless of actual effects caused by land use that is supplied water by the RWSS. The *E. coli* water quality limits are expressed as the 95th percentile concentration calculated over a minimum of 20
samples. I recommend that the assessment of compliance with these limits/targets be undertaken annually, ideally after the end of the main recreation season (November to April), i.e. in June each year. If triggered, the assessment of causes/sources should be undertaken during the following 12 months and reported on the following year in June.

19.12 With regards to groundwater quality, Condition 15 requires that a groundwater monitoring plan (GMP) be developed and implemented by the RWSS, with an aim to characterise the state and trends of groundwater quality in existing bores utilised for the supply of human drinking water. Condition 15(c) requires that the consent holder undertake an assessment of the risk to groundwater quality of existing bores utilised for the supply of human drinking water.

19.13 Condition 16 requires that if the monitoring results obtained under condition 15 exceed 80% of the nitrate concentration in the New Zealand drinking water Standard nitrate, or if the risk assessment undertaken under condition 15c indicates that the nitrate concentration standard has the potential to be exceeded, then the RWSS shall identify actions to be taken by property owners, and procure that these actions are implemented as soon as practicable.

19.14 Condition 17 sets out the required response in case nitrate concentrations do end up exceeding the drinking water standard in a bore utilised for the supply of human drinking water, and the RWSS is contributing to nitrate concentrations in that bore. In this situation, the consent holder shall investigate the sources of nitrate and the potential for modified land use practices by property owners supplied with water from the RWSS to improve downstream groundwater quality; and either provide treatment to the existing drinking water source or an alternate supply of water.

19.15 Conditions 18, 19 and 20 relate to the potential for the RWSS to result in groundwater mounding. They require that a Groundwater Mounding and Drainage Monitoring Plan be prepared (condition 18), be submitted to HBRC for certification (condition 19) and be implemented (condition 20). Condition 20 requires that the Scheme implement engineered drainage if high groundwater levels caused by the scheme cause adverse effects on existing land uses or in-ground infrastructure.

19.16 I note that Dr Baalousha has undertaken a modelling assessment of the risk of groundwater mounding associated with the Scheme, and presented the results
in his evidence. I suggest that the information produced by Dr Baalousha should be utilised for the development of the Groundwater Mounding and Drainage Monitoring Plan.

Olivier Ausseil
5th September 2013
20. EXHIBITS

EXHIBIT OMNA 1: PROPOSED WATER QUALITY MONITORING SITES
### Table 6

<table>
<thead>
<tr>
<th>Tukituki Water Management Zone (as defined in Proposed Regional Plan Change 6)</th>
<th>Monitoring Site</th>
<th>Grid Reference (At or About) (E &amp; N: NZTM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zones 1 and 5</td>
<td>Tukituki River at Tamumu Bridge</td>
<td>1914766/5570121</td>
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<tr>
<td></td>
<td>Tukituki River at Red Bridge</td>
<td>1936720/5596441</td>
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<tr>
<td></td>
<td>Papanui Stream at Camp David Middle Road</td>
<td>1917836/5581620</td>
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<tr>
<td></td>
<td>Papanui Stream at Pourerere Road</td>
<td>1911285/5569830</td>
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<td>Zone 2</td>
<td>Waipawa River at SH2</td>
<td>1906330/5571900</td>
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<td></td>
<td>Waipawa River at SH50</td>
<td>1894737/5581847</td>
</tr>
<tr>
<td></td>
<td>Waipawa River below Irrigation intake</td>
<td>1890992/5584215</td>
</tr>
<tr>
<td></td>
<td>Mangaonuku Stream at Tikokino Rd</td>
<td>1901319/5576606</td>
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<tr>
<td>Zone 3</td>
<td>Tukituki River at SH50</td>
<td>1886319/5574049</td>
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<td></td>
<td>Maharakeke at Limeworks Road</td>
<td>1894118/5563820</td>
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<td></td>
<td>Tukipo River at Makareto Road</td>
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<td>Mangatewai Stream at SH50</td>
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<td>Kahahakuri Stream at Springhill</td>
<td>1888901/5582700</td>
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<td>Kahahakuri Stream at Scenic Road</td>
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<td>Tukituki River at SH2</td>
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<td>Porangahau Stream at Oruawhara Rd</td>
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<td>Maharakeke Stream at U/S Maharakeke Confluence</td>
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<td>Tukipo River at U/S Makareto Confluence</td>
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<tr>
<td></td>
<td>Tukipo River at SH50</td>
<td>1884777/5570703</td>
</tr>
</tbody>
</table>

**Advisory Notes:**

i. A suitable location for the Papanui Stream at Middle Road monitoring site is being investigated and it is possible that a location located downstream of Camp David will be selected.

ii. High flow conditions can prevent safe access to the Makaretu at U/S Maharakeke Monitoring site. Under such conditions, sampling shall be
undertaken at the following location: Makaretu River at Speedy Road (1894421/5567602 – NZTM).